Odyssey System Overview

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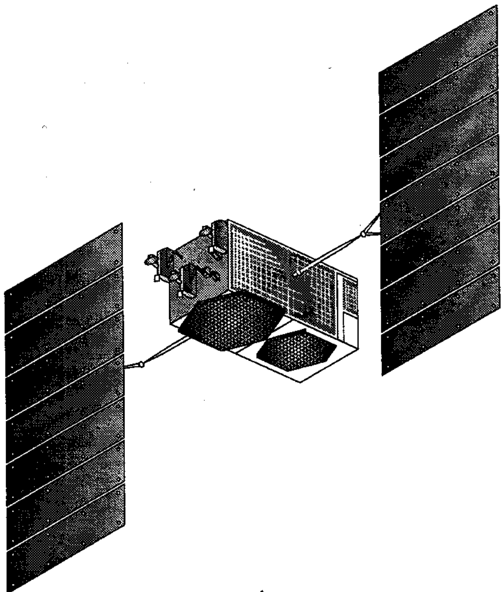


Abstract

The spectacular growth of cellular telephone networks has proven the ubiquitous demand for personal communications. Large regions of the world are too sparsely populated to be economically served by terrestrial cellular communications and geography frequently prohibits the installation of terrestrial networks. Furthermore, there are also many regions of the world which lack a basic telecommunications infrastructure, whether wireline or wireless. The Odyssey System is an economical approach for providing high quality, wireless, communications services worldwide via satellites. A constellation of 12 satellites will be orbited in three planes, each inclined at fifty degrees, at an altitude of 10,354 km (5591 nautical miles) to provide seamless coverage of the globe. The Odyssey orbit lends itself to high line-of-sight elevation angles that minimize obstructions by terrain, trees and buildings. Each satellite generates a multibeam antenna pattern that divides its coverage are into a set of contiguous cells. The communications system architecture employs spread spectrum CDMA on both the uplinks and the downlinks which optimize the use of the mobile link spectrum. Signal processing is accomplished on the ground at the satellites' earth stations. The satellites' „bent

Sadržaj

Spektakularan prodor celularne telefonske mreže je dokazao sveprisutnu potrebu za personalnim komunikacijama. Mnogi delovi sveta su isuviše retko naseljeni da bi bili ekonomično opsluženi zemaljskim celularnim komunikacijama, a i geografska struktura često ne dozvoljava instaliranje zemaljskih mreža. Takođe, u mnogim delovima sveta nije rešeno pitanje osnovne telekomunikacione infrastrukture, bilo žične ili bežične. Sistem Odisej je jedan ekonomičan pristup za obezbeđivanje bežičnih komunikacionih usluga visokog kvaliteta širom sveta putem satelita. Konstelacija koju čini 12 satelita imaće orbite u tri ravni, svaka sa inklinacijom od 50 stepeni, na visini od 10.354 km (5591 nautička milja), da bi se obezbedilo potpuno pokrivanje planete. Orbita Odiseja je nagnuta prema liniji optičke vidljivosti sa velikim elevacionim uglovima koji minimizuju prepreke usled terena, drveća i zgrada. Sa svakog satelita vrši se emitovanje pomoću antene sa višestrukim snopom, koji deli njegovu oblast pokrivanja u šet susednih ćelija. Arhitektura komunikacionog sistema je na bazi proširenog spektra sa CDMA i na vezi ka satelitu (uplink) i na vezi od satelita (downlink), što optimizuje korišćenje spektra mobilne veze. Obrada signala je izvedena na zemlji u zemaljskim satelitskim stanicama. Satelitski transponderi uprošćavaju projektovanje mreže satelita i omogućavaju

pipe" transponders simplify the space segment design and provide the flexibility to exploit future enhancements in vocoder and waveform technologies. The ground network will employ a minimum of earth stations worldwide connected via leased lines. Calls to and from Odyssey handsets will be routed globally employing the Odyssey network and the existing Public Switched Telephone Networks (PSTNs). Localities will be able to regulate Odyssey traffic via local „Gateways" connected to the Odyssey System.

Introduction

The demand for wireless services is growing at ever-increasing rates and continues to exceed the forecast. The worldwide compound annual growth rate for cellular services has risen from 50% in 1993, 57% in 1994 to 71.4% in 1995 according to US Department of Commerce data. In 1993, Economic Management Consulting International, Inc. (EMCI) estimated that the worldwide number of wireless users would be 46 million in 1994, the actual number according to the US Department of Commerce was 52 million (Figure 1). Forecasts range from 122 million subscribers in 1999 (cellular) (EMCI) to as many as 400 million subscribers in 2000 (cellular, Personal Communications Systems (PCS), and fixed wireless) (Herschel Shostech Associates).

fleksibilno istraživanje budućih proširenja u pogledu kompresije govora i primene pogodnih talasnih oblika signala. Zemaljska mreža će se sastojati od minimuma zemaljskih stanica širom sveta povezanih pomoću iznajmljenih linija. Pozivi ka i od Odisejevih korisnisničkih aparata biće globalno preusmeravani putem mreže sistema Odisej i putem postojećih javnih komutaconih telefonskih mreža (Public Switched Telephone Networks - PSTNs). Lokalno nadležne službe će biti u mogućnosti da regulišu saobraćaj u sistemu Odisej lokalnih pristupa (gateways) povezanih na sistem Odisej.

Uvod

Potreba za bežičnim telekomunikacionim uslugama raste sve većom brzinom i nastavlja da prevazilazi sve prognoze. Ukupan godišnji procenat porasta celularnih servisa u svetu je porastao od 50% u 1993., 57% u 1994. na 71.4% u 1995. god. prema statistikama (US Department of Comerce data). U 1993.godini Economic Management Consulting International, Inc. (EMCI) je procenio da će svetski broj korisnika bežičnih servisa biti 46 miliona u 1994., tačan podatak prema US Department of Commerce je 52 miliona (Slika 1). Prognoze se kreću od 122 miliona pretplatnika u 1999. (celularni sistemi) (EMCI), do čak 400 miliona pretplatnika u 2000. (celularni sistemi, personalni komunikacioni sistemi (PCS) i fiksni bežični sistemi) (Herschel Shosteck Associates).

Global Cellular Subscribers (Millions)

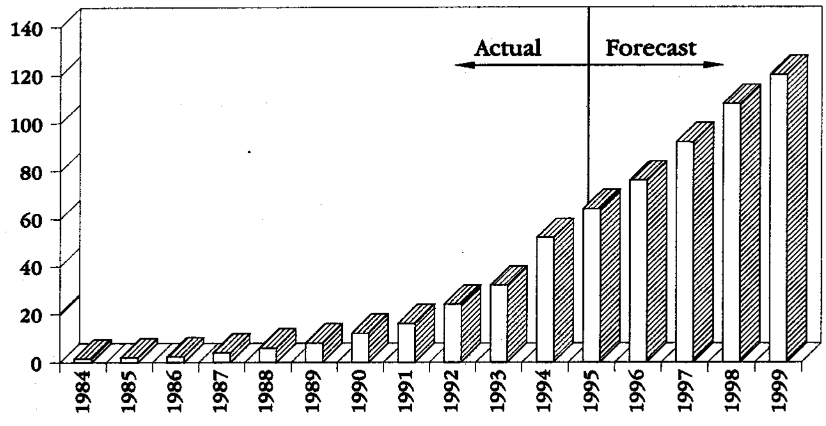


Figure 1. Global cellular subscribers
Source: EMCI, US Department of Commerce

Slika 1. Broj pretplatnika u celularnoj mreži
Izvor: EMCI, US Department of Commerce

In spite of the rapidly growing demand for wireless services, there are many areas of the world where terrestrial wireless solutions are not economically viable because either: (1) population densities are too low to support a commercial cellular network; or (2) geographic conditions make a terrestrial-based cellular solution too

Uprkos naglom porastu potreba za bežičnim servisima, postoji mnogo područja u svetu gde zemaljska bežična rešenja nisu ekonomična, jer je: (1) gustina naseljenosti isuviše mala da podrži komercijalnu celularnu mrežu, ili (2) geografski uslovi čine rešenja zasnovana na zemaljskom celularnom sistemu previše skupim ili daju costly or of poor coverage and service quality. For example in the United States, cellular systems covered only 37% of the Landmass in 1993 and it is expected that as much as 50% of the United States landmass, in which over 13 million people reside, will remain without cellular service indefinitely. Additionally, because of the widely differing cellular standards around the world, currently there is no global roaming capability for cellular users. Many populated regions, particularly developing countries, have little or no telecommunications infrastructure. For example, 1994 data shows that India has 1.07 telephone lines per 100 inhabitants. Indonesia, 1.33 (as compared with 60.17 in the United States). The Odyssey System has been designed to overcome these problems and to help satisfy unmet global demand for wireless services.

Satellite Communications

For nearly 30 years satellites have been used to provide communications to many regions of the world. Nearly all of these satellites have been located in geostationary orbit so that the ground antennas could remain fixed on their location. User terminals were either fixed ground stations with large dish antennas or large portable terminals with antennas that pointed at the GEO satellites.

Today the logical extension of satellite services to personal communications implies the use of hand-held telephones. The astonishing improvements in microcircuits and radio technologies over the past decade have made possible the packaging of an entire satellite earth station into a hand-held telephone. Equally as important is the development of voice compression technologies which enable the transmission of digitized speech. at relatively low data rates.

Demand for Mobile Communications Service

It is critical to remember that communications is a service business. Provision of economical and quality service is essential. Service rates are an important factor which determine the success of any mobile satellite business. We get some insight into the economic elasticity of mobile communications service by looking at two segments: Cellular and INMARSAT. After 16 years INMARSAT has over 40,000 subscribers paying an average rate of $7.50 per minute. Cellular, after 12 years, has over 71 million subscribers paying an average service rate less than $0.83 per minute (considering roaming charges). Recognizing the importance of providing a low cost service

nepovoljne rezultate u pokrivanju i kvalitetu servisa. Na primer, u Sjedinjenim Državama, celularni sistemi su pokrivali samo 37% površine države u 1993. i očekuje se da će čak 50% površine Sjedinjenih Država, u kojoj živi preko 13 miliona ljudi, ostati bez celularnog servisa neodređeno dugo. Takođe, zbog velikih razlika u standardima za celularne službe širom sveta, trenutno nema mogućnosti globalnog kretanja za korisnike. Mnoge naseljene oblasti, naročito zemlje u razvoju, imaju malo ili ništa od telekomunikacione infrastrukture. Na primer, podaci za 1994. god. pokazuju da Indija ima 1.07 telefonskih linija na 100 stanovnika, Indonezija 1.33 (za poređenje sa 60.17 u Sjedinjenim Državama). Sistem Odisej je projektovan da prevaziđe ove probleme i da zadovolji potrebu za globalizacijom bežičnih servisa.

Satelitske komunikacije

Već skoro trideset godina satelitima se obezbeđuju komunikacije mnogim delovima sveta. Skoro svi ovi sateliti bili su locirani u geostacionarnoj orbiti tako da su antene na zemlji mogle ostati fiksne na svojim lokacijama. Korisnički terminali su bili ili fiksne zemaljske stanice sa velikim paraboličnim antenama (dish antennas) ili veliki portabl terminali sa antenama uperenim ka GEO satelitima.

Danas logičko proširenje satelitskih servisa na personalne komunikacije sugeriše upotrebu ručnih telefona. Neverovatna poboljšanja u mikrokolima i radio tehnologijama u poslednjih deset godina omogućila su pakovanje kompletne zemaljske stanice u ručni telefon. Podjednako važan je razvoj u tehnologijama za kompresiju govora koje omogućuju prenos digitalizovanog govora relativno malim brzinama prenosa.

Potreba za mobilnim komunikacionim servisima

Važno je zapamtiti da komunikacije predstavljaju posao davanja usluga. Dobit od ekonomične i kvalitetne usluge je suština. Cena usluga je važan faktor koji odlučuje o uspehu bilo kog posla u mobilnim satelitskim komunikacijama. Možemo steći uvid u ekonomsku elastičnost mobilnih komunikacionih servisa poređenjem dva segmenta: Celularne sisteme i INMARSAT. Posle 16 godina INMARSAT ima preko 40,000 pretplatnika koji plaćaju prosečnu cenu od $7.50 po minuti. Celularni sistemi, posle 12 godina, imaju preko 71 milion pretplatnika koji plaćaju prosečnu cenu usluga manju od $0.83 po minuti (računajući globalno kretanje kroz mrežu). Priznavanje značaja obezbeđivanju jeftinih usluga je ključ za uspeh u razvoju personalnih komunikacionih sistema pomoću is one key to success in developing PCSS. TRW has performed market surveys with 6100 participants. The data from this survey also shows strong demand for a universal satellite based service. It is estimated that the Odyssey service cost will be less than one dollar per minute with a subscriber base of approximately 8 million subscribers. At higher service rates we would expect a sharp drop in the number of subscribers, which may not sufficiently support a business of this magnitude.

Odyssey Market Segmentation

The Odyssey System will provide continuous worldwide telecommunications services to virtually all regions of the globe, providing the flexibility to address a broad range of telecommunications market segments. Based upon market research, the expected market demand for Odyssey System services can be broken into two major market segments - fixed wireless and mobile:

Fixed Wireless Market

Many regions around the world are unable to support the costs associated with the development of a terrestrial wireline telephone system. Odyssey fixed wireless terminals that can provide an immediate capability to regions in which there is no existing infrastructure at a fraction of the cost will be available.

Mobile Market

The Odyssey mobile market has been divided into 4 market segments. In addition to basic telephone services, it is expected that some level of enhanced services will be provided in all of these .markets.

- *Cellular Extension*

There are regions of the world where no cellular coverage exists due to costs associated with geographic limitations or low population densities. Odyssey would serve as a complement to existing cellular operators to provide extended coverage in these regions, rather than the operators building or expanding their existing cellular infrastructure.

- *Cellular Complement*

Currently, cellular users are unable to utilize their cellular network when they roam into areas where there is either no cellular coverage or when the available cellular service is not compatible with their own. The Odyssey System will be able to fill this gap, enhancing users' existing cellular capability.

satelita (PCSS). TRW je obavila istraživanje tržišta na 6100 učesnika. Podaci ovog istraživanja potvrđuju oblik ove elastičnosti u blizini cena za celularni sistem. Istraživanje takođe pokazuje jaku potrebu za univerzalnim servisima na bazi satelitskih sistema. Procenjeno je da će cene usluga u Odisej sistemu biti manje od jednog dolara po minuti sa pretplatničkom osnovom od otprilike 8 miliona pretplatnika. Sa većim cenama servisa očekivali bismo nagli pad broja pretplatnika, koji neće biti dovoljan za održavanje posla ovih razmera.

Podela tržišta sistema Odisej

Sistem Odisej će obezbeđivati stalne telekomunikacione servise širom sveta, praktično svakoj oblasti na planeti, obezbeđujući fleksibilnost u obraćanju velikom broju segmenata telekomunikacionog tržišta. Na osnovu istraživanja tržišta, očekivana potražnja za servisima Odisej sistema na tržištu može biti podeljena u dva glavna tržišna segmenta - fiksni bežični servisi i mobilni:

Tržište fiksnih bežičnih servisa

Mnoge oblasti u svetu nisu u mogućnosti da podnesu trošak razvijanja zemaljskog žičnog telefonskog sistema. Odisej fiksni bežični terminali mogu obezbediti servis za oblast koja nema postojeću infrastrukturu za mnogo manju cenu.

Tržište mobilnih servisa

Tržište mobilnih servisa za sistem Odisej je podeljeno u 4 tržišna segmenta. Uz osnovne telefonske servise, očekuje se da će neki dodatni servisi biti obezbeđeni u svim ovim tržištima.

- *Proširenje celularnog sistema*

Postoje oblasti u svetu u kojima ne postoji celularna pokrivenost zbog neisplativosti usled geografskih ograničenja ili male gustine naseljenosti. Odisej će služiti kao komplement postojećim operatorima celularnih sistema, da bi obezbedio dodatno pokrivanje u ovim oblastima. U tom slučaju, operatori neće morati da grade novu i proširuju postojeću celularnu nfrastrukturu.

- *Komplement celularnog sistema*

Trenutno, korisnici celularnog sistema nisu u mogućnosti da koriste svoju celularnu mrežu kada pređu u oblasti u kojima ili nema celularne pokrivenosti ili kada je raspoloživi celularni servis nekompatibilan sa njihovim servisom. Odisej sistem će moći da premosti ovaj nedostatak, povećavajući postojeće mogućnosti korisnika celularnih sistema.

- *Private Network Services*

Private network services will be provided to closed user groups that typically are not connected to the public switched telephone network. Such groups are expected to include police, fire, customs, and the military, all of which require wide are coverage.

- *Privatni servisi u mreži*

Privatni servisi u mreži biće obezbeđeni zatvorenoj grupi korisnika koji tipično nisu povezani sa javnom komutacionom telefonskom mrežom. U očekivane grupe ubrajaju se: policija, vatrogasci, carinici i vojska, od kojih svi zahtevaju široku oblast pokrivanja.

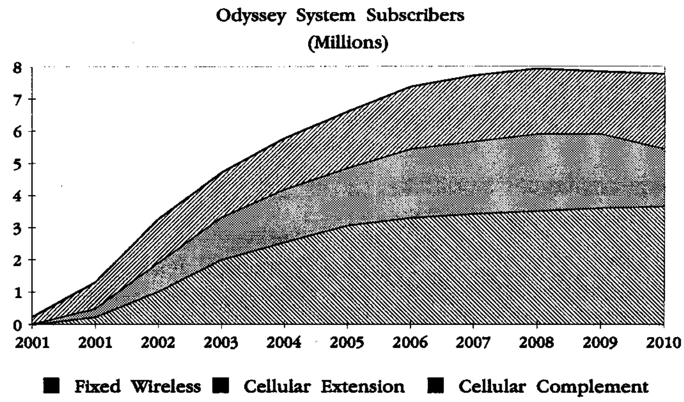


Figure 2. Odyssey System market segments

Slika 2. Tržišni segmenti sistema Odisej

- *Short Message Services*

The Odyssey System will be able to provide a short message service to System handsets. This service will be similar to existing alphanumeric paging services and will be based on the GSM short message service application.

Figure 2 shows the expected market breakout for the Odyssey system users (in millions of users).

Odyssey System Design Requirements

The Odyssey System design is market driven to meet the requirements of personal, mobile telephone users. Mobile users expect reliability and manufacturability of products, available service with high voice quality, and above all, affordable costs. The critical system design requirements that drive the Odyssey System design are:

- *Low Cost service*
  - *Low cost handsets/fixed terminals*
  - *Minimum life-cycle circuit costs*
    - ° *Few satellites and earth stations*
    - ° *No on-board processing or crosslinks*
    - ° *Long lived satellites*
    - ° *Highly efficient circuit utilization*
- *High Quality of Service*
  - *Coverage of all global land masses*
  - *High elevation angle service*

- *Servisi kratkih poruka*

Odisej sistem će biti u mogućnosti da obezbedi servise kratkih poruka korisničkim aparatima u sistemu. Servis će biti sličan postojećem alfanumeričkom paging-u i biće baziran na primeni GSM servisa kratkih poruka

Slika 2 prikazuje očekivani presek tržišta sistema Odisej (u milionima korisnika)

Zahtevi pri projektovanju sistema Odisej

Projektovanje Odisej sistema je uslovljeno tržištem da bi se zadovoljili zahtevi korisnika personalnih mobilnih telefona. Korisnici mobilnih servisa očekuju od proizvoda pouzdanost i ponovljivost proizvodnje, raspoloživi servis sa visokim kvalitetom prenosa govora, i najviše od svega, pristupačne cene. Zahtevi koji su odlučujući za projekat sistema Odisej su:

- *Niska cena usluga*
  - *Jeftini korisnični aparati/fiksni terminali*
  - *Minimalne cene hardvera u toku ekspoatacionog ciklusa*
    - ° *Mali broj satelita i zemaljskih stanica*
    - ° *Na satelitu se ne vrši obrada signala i nema međusobnih veza između satelita*
    - ° *Dugovečni sateliti*
    - ° *Visoka efikasnost iskorišćenja kola*
- *Visok stepen kvaliteta servisa*
  - *Pokrivenost celokupnog kopna*

- *High degree of satellite diversity*
- *Competitive voice encoding: MOS3.5*
- *Acceptable levels of voice delay*
- *Low risk of call dropout*

- *Service Features*
  - *Voice and data communications*
  - *Full set of GSM supplementary services*
  - *Global roaming capability*
  - *Low power handset meeting health and safety standards*
  - *Handset size and battery life equal to current cellular capabilities*
  - *Dual mode compatibility with terrestrial cellular systems*
- *Rapid Deployment*
  - *Minimum number of satellites and Earth stations*
  - *Minimize development with transponding satellites and extensive use of commercially available ground segment equipment*
  - *Minimize schedule risk resulting from a launch failure*

Using these design requirements, a satellite constellation has been selected and the Odyssey System design has been developed to offer the best solution to global, mobile communications services. This unique system design was awarded a patent from the US Patent Office in 1995.

Satellite Altitude and Constellation Selection

Selecting an appropriate altitude and constella- tion architecture for satellite systems with global cover- age is a complex process that involves trade-offs and considera- tion of numerous factors. Some of these factors include:

- *Number of satellites*
- *Satellite field of view*
- *Payload complexity*
- *Spacecraft power*
- *Satellite lifetime*
- *Line-on-sight elevation angle*
- *Diversity coverage*
- *Handset power*
- *Spacecraft antenna size*
- *Cost of each satellite*
- *Effect of Van Allen belt radiation*
- *Satellite launch flexibility*
- *Propagation delay*
- *System reliability*

In the past, communications satellites have typically been located in geostationary orbits (GEO). These orbits simplify

- *Rad pod velikim elevacionim uglom*
- *Visok stepen satelitskog diverzitija*
- *Efikasno komprimovanje govora MOS3.5*
- *Prihvatljiv nivo kašnjenja govora*
- *Mali rizik gubitka poziva*

- *Karakteristike*
  - *Prenos govora i podataka*
  - *Kompletni GSM servisi*
  - *Mogućnost globalnog pokrivanja*
  - *Korisnički aparati male snage u skladu sa zdravstvenim i sigurnosnim propisima*
  - *Dimenzije i trajnost baterija u korisničkom aparatu isti kao u aparatima trenutnog celularnog sistema*
  - *Dual mode kompatibilnost sa zemaljskim celularnim sistemima*
- *Kratko vreme puštanja sistema u rad*
  - *Minimalni broj satelita i zemaljskih stanica*
  - *Minimizuje razvoj sa transponderskim satelitima i opsežnim korišćenjem komercijalno raspoložive zemaljske opreme*
  - *Minimizuje rizik odstupanja od plana zbog neuspelog lansiranja*

Koristeći ove projektne zahteve, izabrana je konstelacija satelita i Sistem Odisej je razvijen sa ciljem da ponudi najbolje rešenje za globalne, mobilne komunikacione servise. Ovaj jedinstveni sistem je patentiran 1995.

Visine satelita i izbor konstelacije

Usvajanje odgovarajuće visine i konstelacije za satelitski sistem sa globalnim pokrivanjem je složen proces koji zahteva kompromise i uzimanje u obzir brojnih faktora. Neki od njih obuhvataju:

- *Broj satelita*
- *Zona pokrivanja satelita*
- *Složenost hardvera na satelitu*
- *Snaga motora letilice*
- *Elevacioni ugao*
- *Pokrivanje sa diverzitijem*
- *Snaga korisničkog aparata*
- *Veličina antene na satelitu*
- *Cena svakog satelita*
- *Efekat radijacije zbog Van Allen-ovih pojasa*
- *Fleksibilnost lansiranja satelita*
- *Kašnjenje usled prostiranja*
- *Pouzdanost sistema*

U prošlosti, komunikacioni sateliti su tipično bili locirani u geostacionarnim orbitama (GEO). Ove orbite uprošćavaju sistemske operacije i infrastrukturu zemaljske stanice. Tri system operations and the ground station infrastructure. Three or four GEO satellites can provide single satellite coverage service to the entire world. Unfortunately, the geostationary orbit is 36,000 km above the surface of the earth. Transmissions through a GEO satellite introduce propagation time delay that is confusing and inefficient for interactive communications. Today, GEO satellites are used mostly for video transmission and much less commonly for interactive voice services. In addition to the propagation time delays that are inherent in GEO satellite systems, the power required to send a signal to a GEO altitude is much higher than that required for the lower orbits. Furthermore, because of the stationary position of GEO systems, a user may often encounter obstacles in the line of sight to the satellites that hinder link completion. The solution to the GEO problem is to locate the satellites in lower orbits, either Low Earth Orbit (LEO) or Medium Earth Orbit (MEO).

LEO systems require large numbers of satellites to provide uninterrupted service (up to 66 satellites for global coverage). Because of their low altitude, the coverage area of a single satellite in LEO is very small. Furthermore, the satellites are passing overhead rapidly, staying in view of a user for approximately 10 minutes. In order to maintain continuity through a call, LEO satellites must either employ complex satellite crosslinks, or utilize hundreds of ground stations spanning the globe. Additional issues with a LEO satellite constellation are:

- *Long deployment times*
- *Short satellite lifetimes*
- *High cost per circuit year*
- *Large ground infrastructure*
- *Complex operations*
- *Low elevation angles*
- *Poor diversity coverage*
- *Extensive handover processing*

Odyssey Orbit

The Odyssey constellation features 12 satellites at an altitude of 10,354 km with four satellites in each of 3 orbit planes inclined at 50 degrees. Orbiting the satellites in MEO places them between the Van Allen radiation belts and allows for a wider field of view the LEO satellites. Figure 3 shows the relative orbits of GEO, MEO and LEO satellites.

The Odyssey constellation provides continuous global coverage with a high degree of dual satellite visibility. This means that a mobile user has at least one satellite in view above 20 degrees elevation angle at all times,

ili četiri GEO satelita mogu za ceo svet obezbediti servis sa pokrivanjem od strane jednog satelita. Nažalost, geostacionarna orbita je 36,000km iznad površine zemlje. Prenos preko GEO satelita unosi vreme kašnjenja usled propagacije koje otežava interaktivnu komunikaciju. Danas, GEO sateliti se najviše koriste za video prenos, a mnogo manje za interaktivne govorne servise. Pored vremena kašnjenja usled propagacije, koje je neizbežno u sistemima sa GEO satelitima, snaga potrebna da se pošalje signal na visinu GEO satelita je mnogo veća od potrebne snage za niže orbite. Pored toga, zbog stacionarnog položaja GEO sistema, korisnik može često naići na prepreke na pravcu prema satelitu, koje otežavaju uspostavljanje veze. Rešenje za problem GEO sistema je da se sateliti postave u niže orbite, tako imamo: niske orbite - Low Earth Orbit (LEO) ili srednje orbite - Medium Earth Orbit (MEO).

LEO sistemi zahtevaju veliki broj satelita da bi se ostvario neprekidan servis (do 66 satelita za globalno pokrivanje). Zbog male visine na kojoj su postavljeni, oblast pokrivanja pojedinačnog satelita je vrlo mala.Osim toga, sateliti se vrlo brzo kreću, ostajući u vidnom polju korisnika oko 10 minuta. Da bi zadržali kontinuitet veze, LEO sateliti moraju primeniti složene satelitske međuveze ili koristiti stotine zemaljskih stanica širom planete. Dodatni problemi kod LEO satelita su:

- *Dugo vreme puštanja sistema u rad*
- *Kratak vek satelita*
- *Visoka cena sistema prema periodu eksploatacije*
- *Glomazna zemaljska infrastruktura*
- *Složene operacije*
- *Mali elevacioni uglovi*
- *Slabo pokrivanje sa diverzitijem*
- *Opsežna obrada prosleđenih poziva*

Orbita sistema Odisej

Konstelacju sistema Odisej karakteriše 12 satelita na visini 10,354 km, pri čemu su po četiri satelita postavljena u svaku od 3 orbitalne ravni nagnute pod uglom od 50 stepeni. Postavljanjem orbita satelita u srednje orbite (MEO) između Van Allen-ovih radionih pojaseva omogućava veću oblast pokrivanja nego kod LEO satelita. Slika 3 pokazuje relativne orbite GEO, MEO i LEO satelita.

Konstelacija sistema Odisej omogućava neprekidno globalno pokrivanje sa visokim stepenom dualne satelitske pokrivenosti. Ovo znači da korisnik mobilnih servisa ima najmanje jedan satelit u vidnom polju sa elvacionim uglom većim od 20 stepeni sve vreme, i dva satelita u vidnom

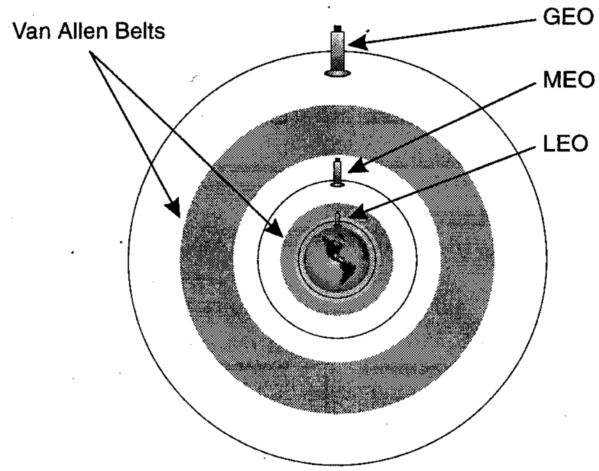


Figure 3. Relative orbits of LEO, MEO and GEO

Slika 3. Relativni položaji orbita za LEO, GEO i MEO satelitske sisteme.

and two satellites in view above 20 degrees elevation angle more than 88% of the time, virtually guaranteeing link completion. In addition to a much lower system cost, this patented architecture and orbit configuration provides several distinct advantages over GEO and LEO orbits:

- The propagation time delay is reduced to less than 100 milliseconds, imperceptible in human conversations, as compared with 270 milliseconds for GEO systems.
- The satellite's orbital position places it between the Inner and Outer Van Allen Radiation Belts, reducing the radiation shielding required on the satellite. In this environment the satellite is designed for a 15 year on-orbit lifetime (versus a 5-7 year lifetime expected in Low Earth Orbits).
- Only nine satellites are required to provide global coverage. In addition, initial service to several regions can be started with only six satellites. This relatively small constellation can be developed and launched in a short time ensuring that service will be provided quickly to market with a lower probability for launch failures and schedule delays than LEO systems requiring large numbers of launches.

Table 1 gives a comparison of some of the characteristics of LEO, MEO and GEO satellite systems.

	LEO	MEO	GEO
Per Circuit Cost	Medium to High	Low	Medium
Ground Segment Cost	Medium to High	Medium	Low
Satellite Lifetime (Years)	5 - 7.5	10 - 15	10 - 15
Operational Complexity	High	Medium	Low
Global Roaming	Requires interconnection of many ground stations or satellites	Requires interconnection of a few ground stations	Not available
Typical Voice Delay	Imperceptible	Imperceptible	Noticeable to user
Call Handoff	Frequent	Infrequent	None

Table 1. Comparisons of satellite systems

polju sa elevacionim uglom većim od 20 stepeni u više od 88% vremena, što praktično garantuje ostvarenje veze. Pored značajno manje cene sistema, ova patentirana arhitektura sistema i konfiguracija orbita imaju još nekoliko značajnih prednosti nad GEO i LEO orbitama:

- Kašnjenje usled propagacije je smanjeno na ispod 100 milisekundi, što je nemoguće primetiti u ljudskom razgovoru. Ovo kašnjenje kod GEO sistema iznosi 270 ms.
- Orbitalni položaj satelita je između unutrašnjeg i spoljašnjeg Van Allenovog radijacionog pojasa, što smanjuje zahtevani radijacioni štit na satelitu. U ovakvoj sredini satelit je projektovan za 15 godina eksploatacije (za razliku od 5-7 godina očekivane eksploatacije LEO sistema).
- Samo devet satelita je potrebno za globalno pokrivanje. Takođe, za započinjanje usluga dovoljno je samo šest satelita, kojima će se obezbediti pokrivanje nekoliko oblasti. Ova relativno mala konstelacija se može razviti i pustiti u rad u kratkom roku, sa sigurnošću da će usluge biti brzo raspoložive na tržištu, sa manjom verovatnoćom neuspešnih lansiranja i odlaganja roka nego što zahtevaju LEO sistemi, kod kojih je potreban veliki broj lansiranja.

U Tabeli 1. prikazano je poređenje nekih od karakteristika LEO, MEO i GEO satelitskih sistema.

	LEO	MEO	GEO
cena uređaja	srednja do visoka	niska	niska
cena opreme na zemlji	srednja do visoka	srednja	niska
vek satelita (godina)	5-7.5	10-15	10-15
složenost funkcionisanja	visoka	visoka	niska
globalna komunikacija	zahteva međuveze preko mnogo zemaljskih stanica ili satelita	zahteva međuveze preko nekoliko zemaljskih stanica.	nije raspoloživa
tipično kašnjenje govora	neprimetno	neprimetno	primetno
gubitak poziva	čest	redak	nikad

Tabela 1. Poređenje satelitskih sistema

Odyssey System Architecture

The Odyssey System is designed to provide economical, high quality, personal communication services from medium earth orbit (MEO) satellites. Services will include voice, data, and short message services. The system will provide a link between mobile subscribers and the public switched telephone network (PSTN) via dedicated ground stations and local gateways (Figure 4.). Each satellite will illuminate its assigned region with a 61 multibeam arrangement. For intercontinental calls, the Odyssey System will route calls through the Odyssey ground network established between the Odyssey ground stations.

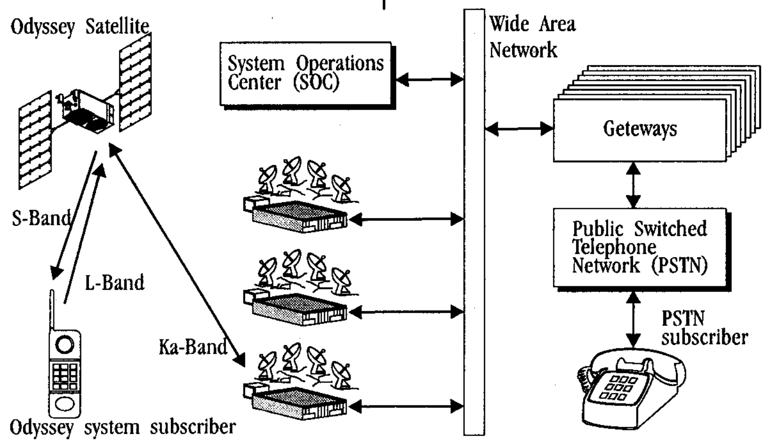


Figure 4. Odyssey system overview

The gateways ate the interface between the Odyssey System and the PSTN in each local area. The gateways will allow each local region to manage the Odyssey service in its own area.

Economical design is important so that the subscriber service charge is priced in line with terrestrial service charges. Economy is achieved through low investment cost, a major consideration for all satellite programs because the production and launch of reliable satellite networks is a very expensive business. Numerous elements of the Odyssey System design help to achieve lower costs:

- *MEO orbit requires fewer Earth stations satellites, launches and replacements*
- *Longer spacecraft life cycles dramatically reduce overall system costs*
- *Simplified design reduces expensive technology insertion*
- *Ground segment maximizes use of existing commercial equipment and existing PSTN infrastructure*

Frequency Plan

Mobile link frequencies for satellite based personal mobile communications were designated at the 1992 WARC. Uplink transmissions from user to satellite are

Arhitektura sistema Odisej

Sistem Odisej je projektovan da obezbedi ekonomične, visoko kvalitetne usluge personalnih komunikacija upotrebom satelita u srednjoj orbiti (MEO). Na raspolaganju će biti usluge prenosa govora, podataka i servisi kratkih poruka. Sistem će obezbediti vezu između pretplatnika u mobilnom sistemu i javne komutirane telefonske mreže (PSTN) preko posebnih zemaljskih stanica i lokalnih pristupa (Slika4). Svaki satelit će obasjavati svoju oblast sa 61 zračećim snopom. Za interkontinentalne pozive, sistem Odisej će preusmeravati pozive kroz zemaljsku mrežu sistema Odisej, uspostavljenu između njegovih zemaljskih stanica. Lokalni pristupi su interfejsi između sistema Odisej i PSTN u svakoj lokalnoj oblasti. Lokalni pristupi će omogućiti svakoj lokalnoj nadležnoj službi da upravlja uslugama Odisej sistema u svojoj oblasti.

Slika 4. Prikaz sistema Odise

Pri projektovanju važno je voditi računa o ekonomičnosti sistema tako da cene usluga budu u skladu sa cenama usluga zemaljskih sistema. Pošto su proizvodnja i lansiranje pouzdanih satelitskih mreža veoma skupi, kod satelitskih programa je glavna tačka razmatranja isplativost, koja je postignuta kroz niske cene investicija. U projektovanju sistema Odisej, brojni elementi dovode do postizanja niže cene:

- *MEO orbita zahteva manje zemaljskih stanica , satelita, lansiranja i zamena*
- *Duži period eksploatacije satelita drastično smanjuje ukupnu cenu sistema*
- *Uprošćeno projektovanje smanjuje primenu skupih tehnologija*
- *Zemaljski deo sistema maksimalno koristi postojeću komercijalnu opremu i postojeću PSTN infrastrukturu*

Plan korišćenja frekvencija

Frekvencije za personalne mobilne komunikacije pomoću satelita su određene na 1992 WARC. Prenos u smeru od korisnika ka satelitu je u L-opsegu (1610 do 1626.5

conducted at L-band (1610 to 1626.5 MHz), while downlink transmissions are at S-band (2483.5 to 2500 MHz).

The Odyssey signaling method will be spread spectrum (CDMA), which has been proven in numerous government applications and is an emerging commercial standard. Spread spectrum permits sharing of the frequency spectrum by multiple service operators. In contrast, FDMA or TDMA signaling requires extensive frequency coordination between multiple operators. Furthermore, CDMA enables an efficient use of the mobile link spectrum through its higher spectrum reuse than FDMA and TDMA.

Transmissions between the ground station(s) and the satellites take place at Ka-band. Spectrum was allocated at WRC-95 for those feeder link transmissions. The frequency plan divides the feeder link spectrum into groups of sub-bands called channels and the channels can be dynamically switched between the feeder links and the mobile link beams (or cells). In the return direction the composite signals received from the different cells are frequency-division-multiplexed (FDM) prior to translation from L-band to Ka-band. Conversely, in the forward direction, the satellite demultiplexes the FDM uplink transmission into its component sub-band signals following translation from Ka-band to S-band. The feeder link bandwidth is 300 MHz in both the forward and return directions.

Odyssey Space Segment

Spacecraft Design

The spacecraft platform will be derived from the TRW Advanced Bus development program. This new TRW Advanced Bus is successfully being used on several new satellite programs, including NASA's Total Ozone Mapping Spectrometer (TOMS) and the Lewis Spacecraft and is the basis of TRW's Earth Observation System satellite platform. Design of the satellite takes advantage of TRW's experience in building complex communications spacecraft systems such as the US Navy's FLTSATCOM (provides worldwide mobile fleet communications) and NASA's Tracking and Data Relay System (TDRS).

TRW is also a leader in satellite payload technology. Recently, the MILSTAR satellite completed its first round of on-orbit tests. The MILSTAR satellite carries the most complex communications payload in space. TRW designed and developed the MILSTAR payload using extensive experience in microelectronics and systems engineering design. The Odyssey Payload was designed to be much less complex than the on-board processing and cross link technology of MILSTAR to minimize costs and schedule.

The Odyssey spacecraft is illustrated in Figure 5. Three Ka-band antennas are gimbals mounted on the aft panel with the S and L band antennas mounted on the earth

MHz), dok je prenos u suprotnom smeru u S-opsegu (2483.5 do 2500 MHz).

U sistemu Odisej primenjen je metod komunikacije sa proširenim spektrom (CDMA), koji je dokazan u brojnim vojnim primenama i teži da postane komercijalni standard. Komunikacija sa proširenim spektrom dozvoljava zajedničko korišćenje spektra od strane više korisnika. Sa druge strane, FDMA ili TDMA zahtevaju stalnu koordinaciju frekvencija između više korisnika. Pored toga, CDMA omogućava efikasno korišćenje spektra mobilne veze kroz bolje iskorišćenje spektra nego FDMA i TDMA.

Prenos između zemaljske stanice i satelita (feeder link) vrši se u Ka-opsegu. Za ovu vrstu veza spektar je dodeljen na WRC-95. Plan frekvencija deli spektar feeder linka u grupu podopsega zvanih kanali, i kanali mogu biti dinamički dodeljivani feeder linku ili mobilnim vezama (ćelijama). U povratnom smeru kompozitni signal primljen iz različitih ćelija je frekvencijski multipleksiran (FDM) pre translacije iz L-opsega u Ka-opseg. U direktnom smeru, satelit demultipleksira FDM signal u njegove komponente iz podopsega, a zatim ih prevodi iz Ka- opsega u S-opseg. Propusni opseg feeder linka je 300MHz i u direktnom i u povratnom smeru.

Deo sistema Odisej u svemiru

Projektovanje satelita

Projekat satelitske platforme proizaći će iz razvojnog programa TRW (Advanced Bus development program). Ovaj sistem je već uspešno korišćen na nekoliko novih satelitskih programa, uključujući NASA Total Ozone Mapping Spectrometer (TOMS) i Lewis Spacecraft i osnova je TRW-ove satelitske platforme za zemaljski sistem osmatranja (Earth Observation System). Projektovanje satelita koristi svo iskustvo TRW-a u izgradnji složenih komunikacionih satelitskih sistema kao što je US Navy FLTSATCOM (obezbeđuje mobine komunikacije u celom svetu) i NASA Tracking and Data Relay System (TDRS).

Takođe, TRW zastupa vodeću tehnologiju u izradi satelitske opreme. Nedavno je MILSTAR satelit završio prvi krug testova u orbiti. MILSTAR satelit nosi najsloženiju satelitsku opremu u svemiru. TRW je projektovao i razvio satelitsku opremu za MILSTAR koristeći opsežno iskustvo u mikroelektronici i projektovanju sistema. Da bi se minimizirali troškovi i rokovi. satelitska oprema sistema Odisej je projektovana da bude znatno manje složenosti, bez obrade signala na satelitu i međuveza između satelita koji su, na primer, zastupljeni u sistemu MILSTAR.

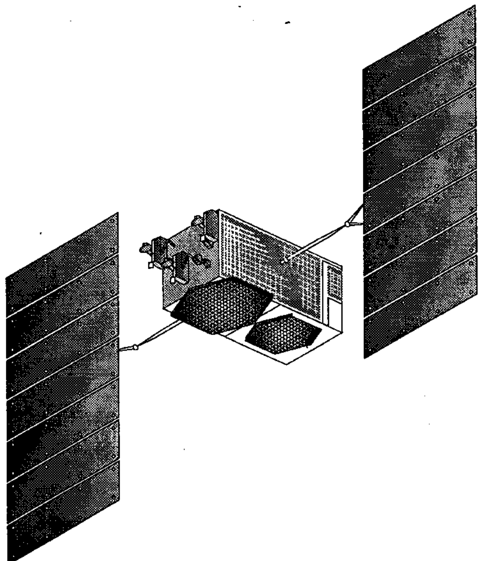


Figure 5. Odyssey satellite in deployed configuration

Slika 5. Konfiguracija satelita sistema Odisej

facing panel. The spacecraft points the S and L-band antennas by dynamic steering of the satellite body. Solar Arrays are kept pointed toward the sun by use of single axis solar array drives. The satellite can be launched singly on the Delta, Soyuz, or Long March, and two at a time on Proton or Ariane 5. The Odyssey spacecraft has a dry mass of approximately 4865 pounds and a spacecraft power load of 6177 watts at end of life.

The effects of the radiation environment have been analyzed for the Odyssey satellite. The Van Allen Belts of trapped electrons and protons are only one source of potentially damaging ionizing radiation which affect low altitude satellites. The selected Odyssey orbit puts the satellites between the outer and inner Van Allen Belts. Solar flares are another source of radiation. The Odyssey solar arrays and electronic components are exposed to radiation levels that are somewhat higher than for geostationary orbit. Analysis has been completed to size the electronic assemblies shielding and solar arrays of the Odyssey satellites to tolerate the radiation environment for more than a 15 year mission. New TRW designs in solar arrays and electronic component assemblies have kept the weight of these components to a minimum.

Payload Design

Odyssey incorporates a 61 beam architecture for both the forward and return links. In the return link each of the 61 receive beams will be fed to low noise amplifiers (LNA), upconverted to Ka-band, amplified by a high power amplifier or TWTA, and then directed to the Ka-band base station antenna. The forward link will be the complement of the return link. The Ka-band signal will be received from the base station antenna, down converted, filtered, amplified by solid state power amplifiers (SSPAs) and directed to the S-band antenna.

Satelit u sistemu Odisej je predstavljen na slici 5. Tri antene u Ka opsegu su zglobno montirane na panele, a antene u S i L opsegu montirane su na zemlji i uperene ka panelu. Satelit se usmerava ka ntenama u S i L opsegu dinamičkim okretanjem tela satelita. Površine solarnih ćelija se drže usmerene ka suncu upotrebom motora za rotaciju oko jedne ose. Sateliti mogu biti pojedinačno lansirani sa raketama Delta, Soyuz ili Long March ili se mogu lansirati dva odjednom korišćenjem raketa Proton i Ariane 5. Satelit sistema Odisej ima neto masu od blizu 4865 funti i pogon od 6177 W za ukupan eksploatacioni vek.

Za satelite sistema Odisej izvršena je analiza radijacije okoline. Van Allenovi pojasevi zarobljenih elektrona i protona su samo jedan od izvora potencijalno agresivnog jonizujućeg zračenja koji ugrožavaju satelite na malim visinama. Izabrana orbita sistema Odisej postavlja satelite između spoljašnjeg i unutrašnjeg Van Allenovog pojasa. Drugi izvor radijacija je Sunce. Površine sa solarnim ćelijama i elektronske komponente sistema Odisej izložene su nešto većem nivou radijacije nego geostacionarni sateliti. Izvršene su analize potrebnih dimenzija štita za grupe elektronskih komponenata i dimenzija površina solarnih ćelija, da bi sistem Odisej izdržao u takvom okruženju više od 15 godina. Novi TRW projekat površina sa solarnim ćelijama i grupisanja elektronskih komponenata sveo je težinu ovih delova na minimum.

Projektovanje satelitske opreme

Sistem Odisej koristi i za odlaznu i za dolaznu vezu arhitekturu sa 61 snopom zračenja. U dolaznoj vezi svaki od 61 prijemnih snopova prolazi kroz malošumni pojačavač, up-konvertor u Ka-opseg, pojačavač snage ili TWT pojačavač i biva usmeren ka anteni bazne stanice u Ka- opsegu. Odlazna veza je komplementarna dolaznoj.

All communication processing is performed on the ground, simplifying the design of the payload on the satellite. This „bent pipe" system also has the advantage of allowing different mixes of fixed and mobile terminal signals to be routed through the Odyssey satellite to accommodate various regional demands. The „bent pipe" design also gives the Odyssey System. the capability of updating the communication formats with future developments in communication technology.

Satellite Lifetime

The „total cost of ownership" depends on all capital and operating expenditures over a fixed period. For example, cellular facilities are typically depreciated over a 7-year period. Geostationary satellites are currently designed for lifetimes of ten or fourteen years. Experience has shown that the electronics designs and backup techniques support these durations. Lower altitude satellites, however, experience shorter lifetimes due to more frequent temperature cycling, constant battery cycling and degradation by atmospheric deterioration such as exposure to ionized oxygen. Odyssey will be designed for 15 years on-orbit lifetime which significantly reduces the life-cycle costs of the Odyssey System. This lifetime can be achieved due to the significant benefits of the Medium Earth Orbit.

Odyssey Constellation Landmass Coverage

Each satellite's 61 multibeam antenna pattern divides its assigned coverage region into a set of contiguous cells. The total area visible to a satellite will typically include one or more regions of significant population density, together with other regions (oceans areas for example) that have few, if any, potential subscribers. Consequently, the satellite antennas are designed to provide coverage either to the entire field-of-view, or, when necessary, to only a portion of the total area visible to the satellite. The antennas are mounted on the satellite body. During the period that a satellite is assigned to a particular region, the satellite attitude is controlled so that the antennas are pointed in the desired direction to optimize coverage. This patented approach is called „directed coverage" and is different than most satellites which merely keep the antenna beams pointed straight down to the earth (nadir pointing). Figure 6. shows an example of directed coverage. In this case, much of the satellite field of view is over the oceans. By slewing the satellite and aiming the antennas at the coast of China, millions of users are now in the satellite's field of view, thus helping to maximize use of the space assets.

Each Odyssey satellite will remain in view of a caller for well over an hour. Telephone calls are therefore

Signal u Ka-opsegu stiže iz antene bazne stanice, zatim se down-konvertuje, filtrira, pojačava poluprovodničkim poja-čavačima snage i usmerava ka antenama u S-opsegu.

Sva obrada komunikacionih signala vrši se na zemlji, čime je uprošćena oprema na satelitu. Prednost ovakvog transparentnog sistema („bent pipe") je što dozvoljava preusmeravanje različitih kombinacija signala iz fiksnih i mobilnih terminala preko satelita sistema Odisej, čime se mogu zadovoljiti različiti konfiguracioni zahtevi. Ovaj koncept takođe omogućava usavršavanje komunikacionih postupaka u skladu sa budućim razvojem komunikacione tehnologije.

Vek trajanja satelita

Cena vlasništva sistema zavisi od ukupno uloženog kapitala u sistem i veka trajanja sistema. Na primer hardver celularnih struktura ima trajnost oko 7 godina. Geostacionarni sateliti su danas projektovani za životni vek od 10 do 15 godina. Iskustvo je pokazalo da se projektovanjem elektronskih sklopova i primenom tehnika rezerve trajnost uređaja produžava. Sateliti u niskoj orbiti, međutim, imaju znatno kraći vek trajanja zbog velikih temperaturnih varijacija, stalnog obnavljanja baterija i degradacije zbog atmosferskih uticaja, kao što je izloženost jonizovanom kiseoniku. Sistem Odisej je projektovan za vek trajnosti od 15 godina u orbiti što značajno smanjuje life-cycle cenu sistema. Ovo produženje veka sistema je postignuto zahvaljujući dobrim osobinama srednje orbite.

Konstelacija sistema Odisej i pokrivanje kopna

Dijagram zračenja antene na svakom satelitu sastoji se od 61 snopa, gde je svakom snopu dodeljena oblast pokrivanja. Ukupna površina koju „vidi" satelit će tipično obuhvatati jednu oblast ili više oblasti značajne gustine naseljenosti zajedno sa ostalim oblastima (na primer okean) koje imaju malo potencijalnih pretplatnika. Kao posledica toga, satelitske antene su projektovane da pokrivaju ili celo vidno polje, ili ako je potrebno, samo deo površine vidnog polja. Antene su montirane na telo satelita. Tokom perioda kada je satelit dodeljen određenoj oblasti, visina satelita je kontrolisana tako da antene budu usmerene u zeljenom smeru i da se postigne optimalno pokrivanje. Ovaj pantentirani pristup nazvan je „direktno pokrivanje" („directed coverage"), i razlikuje se od drugih satelita kod kojih je antena okrenuta pravo ka zemlji (nadir pointing). Slika 6. pokazuje primer direktnog pokrivanja. U ovom slučaju, okeani zauzimaju veliki deo vidnog polja satelita. Pomoću odgovarajućeg položaja antene satelita su usmerene ka obali Kine, čime je

Strana 18

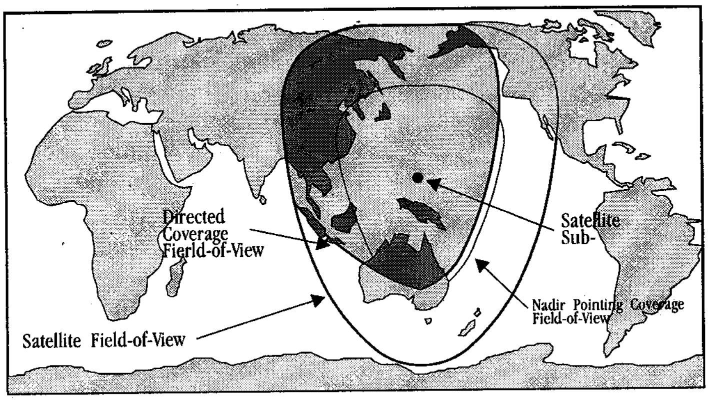


Figure 6. Satellite beam pattern over Asia

Slika 6. Dijagram zračenja satelitske antene

infrequently handed over from satellite to satellite, reducing the probability of a dropped call. This avoids a major communications synchronization problem inherent in LEO systems which must frequently handover telephone calls from satellite to satellite (approximately every 10 minutes).

Considerable study has been applied to the definition of the optimum coverage patterns to best service the global market. The coverage area of the full Odyssey System is all of the populated landmass of the world excluding the polar regions. Each satellite employs a 42 degree field of view, and the constellation phasing provides continuous coverage and substantial diversity coverage above 20 degrees elevation angle. Each satellite will be visible over any region for almost two hours, but will be only used during intervals that provide the highest elevation angles (typically 60 to 90 minutes). The satellite body steering of the S and L-band antennas provides considerable flexibility for defining service areas to match demand.

Elevation Angles

Perhaps the most important advantage of the Odyssey MEO orbit is high view angles or elevation angles. Two Odyssey satellites will be visible almost anywhere in the world at all times which leads to high line-of-sight elevation angles, thereby minimizing obstructions by terrain, trees and buildings. Geostationary satellites provide attractive view angles at latitudes near the equator, but very low view angles at high latitudes. With LEO constellation, a large number of satellites is required to provide global coverage even at low elevation angles. Therefore, the constellation chosen by the competing systems in LEO provide relatively low view angles most of the time. Odyssey, in Medium Earth Orbit, has view angles averaging 45 to 55 degrees at all latitudes, better than both LEO and GEO systems on a worldwide average. With the full constellation, a minimum line-of-sight elevation angle of 20 degrees can be guaranteed to at least one satellite 100% of the time. This is a major benefit to the user

obezbeđeno pokrivanje za milione korisnika. Time je maksimizirano korišćnje raspoloživih resursa.

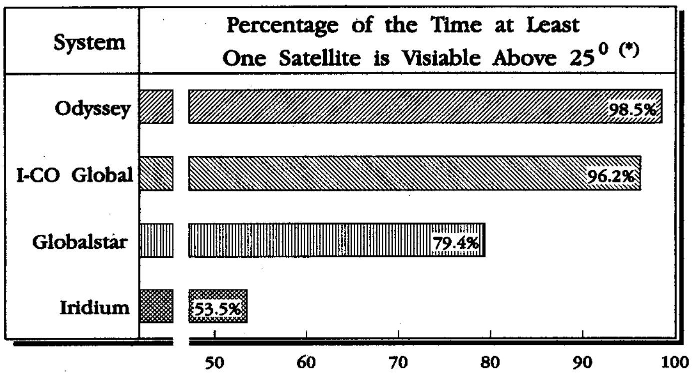
Svaki satelit sistema Odisej će ostati u vidnom polju korisnika više od jednog sata. Telefonski pozivi su zato retko predavani između satelita, čime se smanjuje verovatnoća gubitka poziva. Na taj način je izbegnut glavni problem sinhronizacije svojstven LEO sistemima kod kojih se predavanje poziva drugim satelitima često vrši (prosečno svakih 10 minuta).

Izvršeno je opsežno razmatranje optimalnog plana pokrivanja da bi se najbolje opslužilo globalno tržište. Oblast pokrivanja kompletnog sistema Odisej je svo naseljeno kopno izuzimajući polarne oblasti. Svaki satelit vidno polje sa prostornim uglom od 42 stepena, i izabrana konstelacija obezbeđuje stalnu pokrivenost sa jednim i značajnu diverziti pokrivenost sa dva satelita za elevacione uglove veće od 20 stepeni. Svaki satelit će biti vidljiv skoro dva sata u bilo kojoj oblasti, ali će biti korišćen samo u intervalima kada su elevacioni uglovi najveći (tipično 60 do 90 minuta). Okretanje tela satelita pri usmeravanju antena u S i L opsezima značajno olakšava definisanje oblasti pokrivanja da bi se ispunio zahtev.

Elevacioni uglovi

Vrlo veliki elevacioni uglovi su možda najznačajnija prednost srednje orbite (MEO) u kojoj se nalazi sistem Odisej. Dva satelita sistema Odisej biće vidljiva bilo gde u svetu u svakom trenutku pod velikim elvacionim uglovima. Time je smanjen uticaj prepreka na terenu, drveća i zgrada. Geostacionarni sateliti daju pogodne elevacione uglove na geografskim širinama blizu ekvatora, ali vrlo male elevacione uglove na većim geografskim širinama. Sa LEO konstelacijom, veliki broj satelita je potreban da bi se ostvarilo globalno pokrivanje čak i pod malim elevacionim uglovima. Zato, konstelacije izabrane u vodećim LEO sistemima pružaju male elevacione uglove u najvećem delu vremena. Sistem Odisej, u srednjoj orbiti

Figure 7. Relative elevation angles



(*) Performance is averaged over the range 0^0 to 70^0 latitude, where the vast majority of the Earth's population resides. Figures are based on the Company's coverage analysis on the planned space segment of each system.

Slika 7. Poređenje satelitskih sistema prema elevacionim uglovima

since obstructions from trees, buildings and terrain can be avoided and less link margin is required in the communications link budget. Figure 7 shows the percentage of time at least one satellite is visible above 25^0.

Odyssey User Segment

The Odyssey User Segment consists primarily of the user handset and the fixed wireless terminal. The fixed wireless terminal is basically the same as a handset, however it will utilize a larger antenna and be able to transmit more power.

The Odyssey user terminal will be a modified version of a cellular handset, which can operate at either cellular or satellite frequencies. The handset antenna will provide for the omnidirectional transmission and reception of the signals.

The handset will transmit approximately 0.5 Watt average - adequate for both voice and digital data transmission. Although the Odyssey orbital altitude is greater than LEO, satellite antenna gain compensates for the greater path loss. The transmit power level provides an appropriate margin against loss due to fading effects. It is important to point out that since the Odyssey System operates with high elevation angles of greater than 20 degrees, less margin is required for path loss parameters than with very low orbiting systems which must operate at shallow elevation angles.

Odyssey handsets will be compatible with terrestrial cellular signal formats. This will be achieved by the addition of microelectronic chips to existing handset designs to produce interoperability with both cellular systems and Odyssey. The chip sets will be matched to the standards of various regions of the world. For example, in Europe, the handsets will be interoperable with GSM. In the US., the handsets will be interoperable with the

- MEO, ima elevacione uglove koji su u proseku 45 do 55 stepeni na svim geografskim širinama, bolje od svih GEO i LEO sistema. Sa kompletnom konstelacijom, minimalni elevacioni ugao od 20 stepeni je garantovan bar jednom satelitu u 100% vremena. Ovo je glavna dobit za korisnika, jer se prepreke usled drveća, zgrada i terena mogu izbeći i time se smanjuje rezerva koja je potrebna za rad veze. Slika 7. pokazuje procenat vremena kada je bar jedan satelit vidljiv pod elevacionim uglom većim od 25^0.

Deo sistema Odisej ka korisniku

Deo sistema Odisej ka korisniku se sastoji od korisničkog aparata i fiksnog bežičnog terminala. Fiksni bežični terminal je po funkciji isti kao korisnički aparat, međutim koristi veću antenu i može da prenese veću snagu.

Korisnički terminali sistema Odisej će biti modifikovane verzije terminala u celularnom sistemu, koji mogu da rade i na frekvencijama celularnog sistema i na frekvencijama satelitskog sistema. Antene na korisničkom aparatu su omnidirekcione za prijem i predaju signala.

Prosečna snaga aparata će biti 0.5 W, i za prenos govora i za prenos digitalnih podataka. Iako je orbita sistema Odisej viša od LEO orbite, dobitak antene na satelitu kompenzuje slabljenje usled duže putanje signala. Nivo predajne snage obezbeđuje odgovarajuću marginu za feding. Važno je istaći da pošto sistem Odisej radi sa elevacionim uglovima većim od 20 stepeni, potrebna je manja margina za slabljenje usled prostiranja nego kod sistema u vrlo niskoj orbiti koji moraju da rade pod malim elevacionim uglovima.

Korisnički aparati sistema Odisej biće kompatibilni sa odgovarajućim aparatima u zemaljskim celularnim sistemima. Ovo će se postići tako što će dodavanjem mikroelektronskih čipova u postojeće aparate dobiti

American Digital Standard (ADS) or Advanced Mobile Phone Service (AMPS). Finally, the Odyssey handset will meet all of the communication system design requirements, most importantly - low cost, small size and reliability.

Odyssey Ground Segment

The Odyssey ground segment provides the voice and data services to the user through the Odyssey satellites. It interconnects the Odyssey mobile subscribers to the PSTN through the Odyssey Earth Stations and local gateways. The ground segment will provide the interconnections and database operations necessary to offer the subscribers global roaming that is transparent to the user. The main components of the ground segment are the Odyssey Earth Stations (OESs), the primary and backup System Operations Centers (SOC), the local Gateways, and the Odyssey Ground Network (OGN).

Seven OESs provide the RF links to the satellite constellation. The constellation is controlled from a centralized SOC. Commands and telemetry to and from the satellite are routed through the OES RF links. System planning and management is also provided from the SOC. It also manages all service operations and the overall OGN.

The Gateways will provide the connectivity between the Odyssey System and the country/area specific PSTNs. A Gateway will be the location where a subscriber's home location register (HLR) information will reside. The HLR will contain the data that the Odyssey System uses to locate the service subscribers, whether they are in their local area or roaming outside their local subscription area. The Gateway can scale the services according to the requirements of the local subscribers or the services which the local Odyssey service provider wishes to offer.

The OGN will be a leased private network interconnecting the SOC, all the OESs, and the Gateways. It will employ an SS7 signaling network architecture and have the capability to transfer multiplexed voice and data.

Multiple routing options are supported by Odyssey. Most calls will be directed via a gateway to the PSTN. Calls to parties outside the user's local area (the area covered by the same OES as the user) can be directed through the OGN to the Odyssey Gateway in the target callee's area, or through the PSTN as a long distance call. Odyssey to Odyssey calls will be handled completely through the OES(s). The OES also provides all of the signal processing for the Odyssey System relieving the satellite from

univerzalni aparat i za celularni sistem i za Odisej. Kompleti čipova biće prilagođeni standardima različitih oblasti u svetu. Na primer, u Evropi, aparati će biti kompatibilni sa GSM. U Americi aparati će biti kompatibilni sa američkim digitalnim standardom (ADS) ili nadgrađenim servisima mobilne telefonije (AMPS). Konačno, aparati sistema Odisej će ispuniti sve projektne zahteve za komunikacioni sistem, a najvažniji su: niska cena, male dimenzije i pouzdanost.

Zemaljski deo sistema Odisej

Zemaljski deo sistema Odisej obezbeđuje servise prenosa govora i podataka krajnjim korisnicima preko satelitskog dela sistema Odisej. On povezuje pretplatnike mobilog sistema Odisej sa javnom komutacionom telefonskom mrežom (PSTN) preko zemaljskih satelitskih stanica sistema Odisej i lokalnih pristupa. Zemaljski deo će obezbediti međusobno povezivanje i povezivanje sa bazama podataka, što će korisnicima pružiti globalno kretanje po mreži. Glavne celine zemaljskog dela sistema Odisej su: zemaljske satelitske stanice sistema Odisej (OES), glavni i rezervni sistemski operativni centar (SOC), lokalni pristupi (local gateways) i zemaljska mreža sistema Odisej (OGN).

Sedam OES obezbeđuju RF vezu sa konstelacijom satelita. Konstelacija je kontrolisana iz centralizovanog SOC. Komande i telemetrija ka i od satelita su preusmeravane kroz OES i RF veze. SOC takođe vrši planiranje sistema, upravljanje, organizuje sve servisne operacije i upravlja celokupnom OGN.

Pristupi će obezbediti mogućnost povezivanja sistema Odisej sa određenom PSTN. Na samom pristupu će postojati registar lokacije za pretplatnika (HLR), koji će sadržati informacije pomoću kojih će sistem Odisej pratiti pretplatnike, bilo da su u svojoj lokalnoj oblasti, bilo da se kreću po drugim oblastima. Na pristupu se mogu podesiti vrste servisa koje odgovaraju lokalnoj pretplatničkoj grupi ili koje lokalni davalac usluga sistema Odisej želi da ponudi.

OGN će biti privatna iznajmljena mreža koja povezuje SOC, sve OES-ove i pristupe. Za njihovu komunikaciju koristiće se SS7 arhitektura mreže i mogućnost prenosa multipleksiranog govora i podataka.

Sistem Odisej nudi brojne mogućnosti preusmeravanja poziva. Većina poziva će preko pristuopa biti preusmerena ka javnoj telefonskoj mreži PSTN. Pozivi izvan korisnikove lokalne ćelije (ćelija pokrivena istim OES kao i korisnik) mogu biti usmeravane kroz OGN do pristupa sistema Odisej ka ciljnoj lokalnoj oblasti, ili kroz PSTN kao performing any signal processing. Because the switching and processing technologies are located on the ground rather than in space with the satellites, the system is easily upgraded and signal formats changed as growth and technology innovations occur.

Concluding Remarks

The Odyssey system has been designed to meet market demand and requirement. The design uses a constellation that allows for high quality mobile communications while reducing the number of satellites, the overall system cost and the complexity of the system. This patented, unique approach helps to ensure that the development of Odyssey will be on schedule and that Odyssey will be able to offer competitive service pricing.

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Resume

Roger Rusch's career spans more than 30 years of the space age. He studied physics and astronomy at Iowa State University. He and his professors watched and tracked the first satellites flashing through the sky in the early morning hours.

međugradski poziv. Pozivi od Odiseja ka Odiseju predavaće se kompletno kroz OES-ove. U OES-u se takođe vrši sva obrada signala, tako da se satelit oslobađa od vršenja bilo kakve obrade signala. Zbog činjenice da je komutacioni i procesorski deo sistema kompletno lociran na zemlji, sistem je lak za nadgradnju i formati signala se mogu menjati u korak sa aktuelnim tehnologijama.

Zaključak

Sistem Odisej je projektovan da zadovolji zahteve tržišta. Koristi se konstelacija satelita koja pruža mobilne komunikacije visokog kvaliteta, pri čemu se smanjuje broj satelita, ukupne cene sistema i složenost sistema. Patentiran, jedinstven pristup uverava nas da će razvoj sistema Odisej biti u roku i da će sistem Odisej moći da ponudi svetske cene usluga.

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Biografija

Roger Rush - Čovek čija karijera postoji više od 30 godina u veku osvajanja svemira. Studirao je fiziku i astronomiju u Ajovi (Iowa State University). Zajedno sa svojim profesorima provodio je rane jutarnje časove prateći kako prvi sateliti bljeskaju nebom.

By 1965 he was helping to build the first global television network with TRW's INTELSAT III satellites. While attending graduate school at the University of Southern California he managed the construction and launch of Hughes' INTELSAT IV F-4 satellite which brought back television images from Nixon's trip to China. He was Chief Systems Engineer for COMSTAR I, the first commercial communications satellite series built for AT&T and GTE.

In 1975 he moved to Ford Aerospace (currently Space Systems Loral). His international team designed, bid and won, then developed the INTELSAT V series of satellites. These were the first 3-axis stabilized satellites for INTELSAT. He spent ten years with the program and is proud of the outstanding reliability record of all the satellites in this series.

Since 1985 Roger has been creating new concepts for satellite communications at TRW. He is one of the three TRW inventors who were issued two patents in 1995 for a Medium-Earth-Altitude Satellite-based Cellular Telecommunications System. These patents are at the heart of OdysseyTM system. OdysseyTM will provide Mobile Satellite Service from the altitude of about 10,000 kilometers, called Medium earth Orbit or Intermediate Circular Orbit.

He is currently Vice President, Systems Engineering for OdysseyTM Telecommunications International Inc., responsible for technical and regulatory aspects of the business. TRW with Teleglobe and other strategic partners is developing the OdysseyTM system which will provide global service to personal telephones before the end of the century.

Mr. Rusch graduated in Physics from Iowa State University. He has also received M.S.M.E. and M.S.E.E. (Communications Theory) degrees from the University of Southern California. He has been on numerous advisory panels including the National Academy of Sciences and has published many technical papers on communications satellites.

Mr. Rusch can be reached on the internet at RogerRusch@aol.com

1965. pomagao je u izgadnji prve globalne televizijske mreže sa TRW-ovim INTELSAT III satelitima. Dok je pohađao post-diplomske studije u Južnoj Kaliforniji upravljao je konstruisanjem i lansiranjem Huges INTELSAT IV F-4 satelita koji je preneo sliku Nixonove posete Kini. Bio je vodeći sistemski inženjer u COMSTAR I, prvoj komercijalnoj satelitskoj seriji koju su izgradili AT&T i GTE.

1975. prelazi u Ford Aerospace (danas Space System Loral). Njegov internacionalni tim projektanata je dizajnirao, konkurisao i osvojio, a zatim i razvio satelitsku seriju INTELSAT V. Proveo je deset godina na ovom programu i ponosan je na izvanredne rezulate postignute na pouzdanosti ove serije satelita.

Od 1985. bavi se osmišljavanjem novih koncepata satelitskih komunikacija u TRW. On je jedan od tri pronalazača u TRW koji su izdali dva patenta u 1995. godini za celularne komunikacione sisteme koji koriste satelite u srednjoj orbiti (Medium-Earth-Altitude-Satelite-based Cellular Telecommunications Systems). Ovi patenti su srce sistema Odisej™. Sistem Odisej će pružati mobilne satelitske servise sa visine od oko 10,000 km, što je nazvano srednjom orbitom zemlje ili srednjom cirkularnom orbitom.

On je trenutno potpredsednik odeljenja za sistemski inžinjering projekta Odisej i odgovoran je za tehničke i regulativne aspekte posla. TRW sa Teleglobe-om i drugim strateškim partnerima razvija sistem Odiseja koji će pružiti globalni servis personalnim telefonima do kraja ovog veka. G. Rush je diplomirao fiziku na univerzitetu u Ajovi. Stakao je tekođe diplome magisra mašinstva i magistra elektotehnike (teorije komunikacija) na univerzitetu u Južnoj Kaliforniji. Učestvovao je na brojnim konsultativnim tribinama uključujući i Akademiju nauka i objavio je puno tehničkih radova o komunikacionim satelitima.

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