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SHIP OBSERVATIONS TEAM

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SUPPORT INFRASTRUCTURE

Review of other satellite data telecommunication systems

(Submitted by Mr David Meldrum, Chairperson of the DBCP)

Summary and purpose of document

This document, prepared by Mr David Meldrum (Chairperson of the DBCP) and Mr Pushkar Wadke (Scottish Association for Marine Science) provides an overview of the current status of mobile satellite systems, as well as their actual or potential application to data buoy operations and data collection which was updated in October 2006. This information is also applicable to a large extent to other types of *in situ* marine observing systems, such as shipboard systems.

ACTION PROPOSED

The Ship Observations Team is invited to:

(a) Note and comment on the information, as appropriate;

(b) Make recommendations regarding the use of mobile satellite systems for ship data collection applications;

(c) Request a further update of the document to be prepared for the SOT-V.

Appendix: A. Overview of Mobile Satellite Systems with Possible Data Buoy Applications - Update 2006

DISCUSSION

1. INTRODUCTION

Mobile satellite systems (MSS) may be classified according to orbit altitude, which are as follows:

- GEO - geostationary earth orbit, approx altitude: 35 000 km
- MEO - mid-altitude earth orbit, approx altitude: 10 000 km
- LEO - low earth orbit, approx altitude: <1 000 km

The LEOs can be further sub-divided into Big LEO and Little LEO categories. The difference between the two categories are that the “Big” LEOs will offer voice, fax, telex, paging and data capability, whereas “Little” LEOs will offer data capability only, either on a real-time direct readout ('bent pipe') basis, or as a store-and-forward service.

Since the satellite footprint decreases in size as the orbit gets lower, the LEO and MEO systems require larger constellations than the GEO satellites in order to achieve global coverage and avoid data delays., However, less energy is generally required for the LEO and MEO satellite communication because of the shorter average distance between transmitter and satellite. Some systems implement several high-gain antennas to generate ‘spot beams’ therefore reducing the requirement of the mobile to have a complex antenna and/or high output power. At present, there is a movement towards utilizing much smaller less expensive satellites. After minisats and microsats, now there is talk about nanosats, picosats and even femptosats - credit-card-size satellites.

Because of the commercial forces driving the implementation of the new systems, many systems will focus primarily on landmasses and centres of population, and will not offer truly global or polar coverage. In general, these systems will not be acceptable for global ocean monitoring. Furthermore, whilst the technical capabilities for the new MSS currently exist, delays are inevitable, due to problems with spectrum allocation, licensing (in each country where the service will be offered), company financing, and availability of launch vehicles and ground stations.

It is unlikely that all of the planned systems will overcome all of the above-mentioned obstacles. Indeed, major financial difficulties have overwhelmed a number of systems such as Iridium (having collapsed and been re-launched), Orbcomm, Globalstar and the New ICO (having been in and out of Chapter 11 bankruptcy protection in the US. Mergers) are becoming increasingly common, as market reality forces system planners to cut their losses and pool resources.

From a technical point of view, some systems do offer significantly enhanced capabilities as compared to existing methods. The potential advantages of these systems include two-way communication, more timely observations, and greater data rates and volumes. Some systems may also prove to be considerably less expensive than existing channels. However, dangers exist for data buoy users of most Mobile satellite systems, in that they will generally be small minority users of the system, with consequent lack of influence with regard to pricing. The arrangements for data distribution are also unlikely to be tailored towards data buoy applications, in particular, those that require data insertion on the GTS.

2. DESCRIPTION OF CANDIDATE SATELLITE SYSTEMS

The following paragraphs describe the salient features of those systems that might have a data buoy application. In many cases, systems are at an early planning stage, and reliable technical information on which to base an evaluation is unavailable. This section is provided in Annex A of this document in a summarised tabular form. Systems, which are deemed to have failed have been removed from the main text, but remain in the summary table.

2.1 Little LEOs

2.1.1 Argos

Argos has been used by the oceanographic community for more than two decades, and is a dependable, true-polar, operational data collection and platform location system. Traditionally, the communication is one-way only (at 400 baud), with practicable data rates of the order of 1 kbyte per day. Transmissions by the mobile in this mode are unacknowledged by the system and therefore have to incorporate redundancy if data transfer is to be assured. The system enjoys a particularly clean part of the spectrum (401.65 MHz), with minimal interference from other users. Until now, Argos has flown as an attached payload on the NOAA 'TIROS' weather satellites, but also flew on board the short-lived Japanese ADEOS-II vehicle. Projected launches on board the European METOP and future US NPOESS platforms mark an important diversification of service provision.

Current enhancements to the Argos on board equipment ('Argos-2') include increased receiver bandwidth and sensitivity, allowing low power transmitter frequencies to be segregated from higher power transmissions. Next generation Argos equipment ('Argos 3') will fly on the three MetOp satellites, with MetOp-1 due to be launched during this session. Future launches are planned for 2010 and 2014. Argos-3 features two-way communication with Platform Messaging Transceivers (PMTs), and offers uplink data rates of up to 4.8 kbits/s. The downlink feature allows the Argos-3 instrument to send an acknowledgement signal to the PMT once the data is received error-free, thus permitting the PMT to avoid unnecessary repetition of the same message. Platform remote control and programming is also possible, as users have the opportunity to send short messages (up to 128 bits) to their platforms via the Downlink Message Management Centre (DMMC).

The system is one of few that offer true global coverage, and currently has no commercial requirement to recover the costs of the launch or space segment equipment. The first of the Argos-2 satellites was launched in May 1998, and been followed by NOAA-L (NOAA-16, September 2000), NOAA-M (NOAA17, June 2002) and NOAA-N (NOAA-18, May 2005); NOAA-N' will follow in 2009. The current operational constellation consists of NOAA-17 and NOAA-18, although data from up to three additional satellites continues to be collected. New direct readout stations continue to be commissioned, bringing the current total of operational stations to 49. Recent additions included the following stations: Cape Ferguson (Australia, NOAA), Seoul (Korea, Korean Meteorological Agency), Taiwan (National Taiwan Ocean University), Rothera (Antarctica, British Antarctic Survey), Lima (Peru, CLS Peru) and Miami (USA, NOAA). This continues the programme of improving data timeliness by exploiting the use of Argos in 'bent-pipe' mode.

2.1.2 Orbcomm

Orbcomm was awarded the first FCC Little-LEO licence in late 1994. The satellites consist of discs about one metre in diameter prior to deployment of solar panels and antenna. Two satellites were launched into polar orbit during 1995, using a Pegasus rocket piggy-backed on to a Lockheed L-1011 aircraft. After a prolonged period of launcher problems, 35 satellites are now in orbit, making up the complete constellation - although Orbcomm have been awarded a licence for an expansion to a 48 satellite constellation. Of these satellites, 30 are currently operational. The A, B, C and D planes are set at a 45° inclination and therefore have poor coverage at high latitudes. Only two satellites (in the F and G planes) set at a 70° inclination, offer a near-polar service, and these have proved to be unreliable. In March 2005, the company announced a new launch programme that would carry an Automatic Identification System (AIS) payload, transmitting ship identification and position for use by the US Coast Guard. In July 2006, Orbcomm ordered 6 satellites from OHB System AG. The satellite buses and launch procedures will be handled by Omsk, Russia, with Orbital Sciences Corporation (OSC) providing the communication payloads and AIS processing.

The system offers both "bent-pipe" and "store-and-forward two-way" messaging capabilities, operating in the VHF band (138-148 MHz). User terminals are known as 'Subscriber Communicators' (SCs). Early results with the system were quite encouraging, although data buoy implementations seem to have decreased in favour of increased usage of Iridium for higher bandwidth applications.

The message structure currently consists of packets transmitted at 2400 bps (scheduled to rise to 4800 bps), and the coverage is now global and near continuous between the polar circles. Messages are acknowledged by the system when correctly received and delivered to a user-nominated mailbox. The platform position is determined, if required, using propagation delay-data and Doppler shift, or by an on-board GPS receiver. Position accuracy without the GPS is similar to that offered by Argos (i.e., km-scale).

The limitations on the store-and-forward mode messages (known as globalgrams) have become apparent, with the SC originated messages limited to 229 bytes and the SC terminated messages limited to 182 bytes. Each SC can theoretically have a maximum of 16 globalgrams stored on each satellite. Currently, satellites will not accept or process globalgrams when in view of a ground ('gateway') station. As messages have to be designated as globalgrams or "bent-pipe" by the SC at the moment of origination, this presently limits the flexibility of the system to adapt to different coverage situations. However, work-arounds do exist, and it is expected that the next generation of SCs will be able to adapt more readily to the changes in satellite communications mode.

Authorised transceiver manufacturers include Elisra (Stellar), Quake and MobiApps. All manufacturers offer units with integral GPS. Quake sells a fully integrated unit, which features a built-in antenna, as well as GPS. Prices of most units are falling, with models now available around $500 or less.

The ground segment has continued to expand, and there are now active stations in Italy, Morocco, Argentina, Brazil, Curacao, Japan, Malaysia and Korea, in addition to the four in the US. However, the Japanese station is not available for international registrations. Further, potential sites have been identified in Russia, Ukraine, Philippines, Botswana, Australia and Oman, although these have yet to be implemented. Sixteen international service distribution partners have been licensed thus far. Non-US customers have faced considerable difficulties because of the absence of ground stations, lack of spectrum licensing and the presence of other in-band users. However, the situation is improving.

Orbcomm has suffered financial difficulties in the past, and filed for 'Chapter 11' bankruptcy protection in September 2000. The parent company, Orbital Sciences Corporation, has put together a new consortium to run Orbcomm. The outstanding debts are believed to stem largely from the system rollout phase, with net running costs being of much smaller concern. Industry confidence in Orbcomm continues to grow, largely because of the commitment of many third-party equipment and system manufacturers to the success of the system, and evidence of increasing service take-up by a diverse range of customers. Such confidence is exemplified by the United States Coast Guard, who recently awarded Orbcomm a contract within their automatic ship identification (AIS) programme.

2.1.3 Vitasat/Gemnet

Vitasat/Gemnet was a 36 + 2 satellite constellation proposed by the CTA Commercial systems. Their experimental satellite was the failed Vitasat launch in 1995. The CTA is reported to have been taken over by Orbital Science Corporation (the parent organisation of Orbcomm), and the 36-satellite Gemnet component has been cancelled. However, the volunteer VITA organisation still exists and currently has one satellite in orbit, with plans to rent bandwidth on two other existing satellites (HealthSat-2 and UoSat-12). This proposal received FCC clearance in December 2000, and the company has now brought HealthSat-2 on line. The main mission is to offer low-cost messaging services to developing countries.

2.1.4 Faisat

Final Analysis Communication Services, Inc. has planned this 32 (+ 6 spare) satellite constellation to provide data messaging services, principally aimed at small messages (i.e., ~100 bytes), but with support for larger messages as well. It will operate in both bent-pipe and store-and-forward modes. The first satellite launch (on the Russian Cosmos vehicle), was scheduled for early 2000, but to date no information or details have been reported. Further, launches were to have occurred roughly twice a year. The system received FCC authorisation in April 1998. A test satellite (also part of the Vitasat system) was launched in 1997. Despite the apparent lack of activity, the website continues to be updated. Moreover, the assets and license of the company were sold to New York Satellite Industries LLC in 2002 as Final Analysis Inc. was terminated in bankruptcy.

2.1.5 Gonets

Two GONETS LEO messaging systems have been proposed by the former Soviet Union, using both UHF and L/S-band communications channels. Both systems will offer true global coverage from high inclination 1400 km orbits. One system, GONETS-D, already has 8 satellites in orbit, and plan to add another 36 in the near future. To date, no operational experience has been reported. Further, a series of GONETS-D1 (1 to 6, 12 to 14) satellites were launched to provide UHF and L/S-band communications channels. As per the latest update, an additional satellite, GONETS-D1M1, was launched in December 2005. This is first of a fleet of 12 satellites in 4 planes to provide Russian agencies with mobile email and a short messaging system.

2.1.6 AprizeSat

Aprize, formerly known as LatinSat, is a recent store-and-forward system which uses low power 'nanosatellites' (20 cm cubes) in polar orbits to communicate with small user terminals. The satellites employ passive attitude stabilization, and are said to be relatively inexpensive to construct and launch. Mobiles establish 2-way communication with the satellites at 402 MHz, message traffic currently being downloaded to a single ground station in Bermuda. The LatinSat-A & B were launched in December 2002, and LatinSat-C& D in June 2004, and were targeted at asset tracking Plans to include a 48-satellite constellation and a more extensive ground station network. Little further is known at present.

2.2 Big and Broadband LEOs

2.2.1 Iridium

Iridium filed for Chapter 11 bankruptcy protection in August 1999, and underwent financial restructuring. Financial difficulties continued, and the system ceased operation in April 2000. At that time, Iridium had its complete constellation of 66 satellites, plus spares in orbit, and offered a true global service through a network of ground stations, which were backed up by inter-satellite links. The system has since been rescued from planned de-orbiting and resurrected by the US Department of Defense. A commercial service has also been re-launched. Most Iridium phones are data capable, and will communicate with a standard modem; throughput is approximately 2400bps. The component parts of some mobile phones are now being repackaged as stand-alone modems. A short burst data (SBD) service (i.e., ~ 1900 bytes max per message) was introduced in late 2002, as well as a dropout-tolerant directs Internet connection at up to 10kbps.

Of particular interest to data buoy operators, were the early days of Iridium, which was the Motorola L-band transceiver module, designed to be easily integrated with sensor electronics via a standard serial interface. This product has now re-appeared as the Motorola 9522 modem, and is capable of both dial-up and data-only modes of operation.

The SBD service offers an easily implemented solution for the transfer of a few kbytes of data per day, transactions taking place as conventional e-mails and attachments. The system is bi-directional, and messages may also be queued for the mobile. The cost is currently $1.50/kbyte, plus a monthly fee. The new 9601 SBD modem offers simple interfacing, compact size and modest prices (about $400), and has a recently upgraded maximum message size of 340 bytes. Dial-up remains the better option for larger volumes of data, with costs capable of falling below $0.1/kbyte. Energy costs are also low for both modes of access (i.e., ~ 20J/kbyte), largely because of continuous satellite availability and the implementation of spotbeams to reduce the mobile transmitter power requirement.

A new 'near broadband' product has also been announced, expected to offer transfer rates of approximately 100kbps at an undisclosed cost. Discussions are also underway regarding special tariffs for scientific and environmental users, and CLS have entered the arena as potential service providers (Value Added Resellers) for this category of use.

2.2.2 Globalstar

Globalstar was Iridium's main competitor in the mobile satellite telephony market. The company's voice and data products include mobile and fixed satellite units, simplex and duplex satellite data modems and flexible service packages. After a difficult start in September 1998, when 12 satellites were lost in a single launch failure, Globalstar now has its complete 48-satellite constellation in space, and commenced a limited commercial service in the US in October 1999. Service has since been expanding to other regions, and was available in the United Kingdom in mid-2000. Globalstar differs significantly from Iridium in that for a call to be made, the user must be in the same satellite footprint as a gateway station. There is no inter-satellite relay capability as in Iridium. Therefore, this means that coverage will not be truly global, especially in the short-term as far fewer gateways have been built than originally planned. Although Globalstar was currently in a much stronger financial position than any of its competitors, only 55,000 subscribers had been signed by late 2001, and the company laid off half of its work force in August 2001. Globalstar subsequently filed for Chapter 11 bankruptcy protection in February 2002. The company has now been taken over by the Thermo Capital Partners LLC. Recently in March 2006, Globalstar announced to have 200,000 customers using their satellite voice and data services. Moreover, Globalstar has also announced an agreement with Qualcomm to manufacture its current and next generation handset, and has signed agreements with two prospective launch providers to launch its eight spare satellites (planned for early 2007).

Data services at 9600 bps are now currently available, using a dedicated modem. Further, Globalstar announced that it has partnered with satellite communications ocean software and hardware company (OCENS), to launch a comprehensive suite of data services. This would now improve data compression rates with effective data transfer speeds of up to 56 kbps. Globalstar also has a second-generation system planned, said to involve 56 LEO satellites and 5 GEO satellites. Launch was planned to begin in 2006, but little else is known regarding the planned enhancements of this system.

2.3 MEOs

2.3.1 New ICO

New ICO (formerly ICO Global Communications) was the third of the three main players in the global satellite telephony market. However, it also has suffered severe financial difficulties, and filed for Chapter 11 bankruptcy protection in August 1999 (just two weeks after Iridium). The system, formerly known as Inmarsat-P, but now fully autonomous, will use a constellation of 12 MEO satellites backed by a 12-station ground segment to provide a truly global voice, fax, data and messaging service. The goal of the system is to complement and be inter-operable with existing digital cellular telephone networks. Prior to filing for bankruptcy protection, the first launch was planned for late 1999, with commercial service roll out scheduled for the third quarter of 2000. The company emerged from Chapter 11 protection in May 2000, and the first satellite was launched in June 2001, referred to as "F2", which currently provides data gathering services. The New ICO is currently using one gateway ground station equipped with five antennas, located in the United States to monitor F2. New ICO also owns a facility in Itaborai, Brazil, at which certain gateway equipment for the MEO system is located. In addition, they have ten MEO satellites in storage under an agreement with Boeing Satellite Systems International, Inc., most of which were in advanced stages of completion prior to the termination of work under the satellite agreements. No further information regarding New ICO's launch schedule is available at the present time.

When the complete constellation is in service, two satellites will always be visible from any point on the earth's surface; data rate will be 9600 bps. Many large manufacturers were engaged in developing dual mode ICO/cellphone handsets. An ICO 'engine' was also to be defined for the benefit of third-party equipment manufacturers (OEMs).

In particular, New ICO is now putting a far greater emphasis on next-generation mobile satellite service (MSS), and recently authorized to offer MSS services throughout the United States using a geostationary earth orbit. This issue is further discussed at a later stage in this report.

2.4 GEOS

2.4.1. Inmarsat D+

This is an extension of the Inmarsat D service using the new (spot-beam) Inmarsat Phase 3 satellites and small, low-power user terminals. The system was initially designed as a global pager or data broadcast service, with the return path from the mobile used only as an acknowledgement. Inmarsat D+ permits greater flexibility, but the uplink packets are still limited to 128 bits. The first ground station has been implemented in the Netherlands by the existing Inmarsat service provider (Station 12), but useful technical information has been difficult to obtain. The only remaining manufacturer of the Inmarsat D+ transceiver seems to be Skywave. The Skywave unit includes an integral antenna and is specifically designed for low power applications.

The service may prove particularly attractive to National Meteorological Services (NMSs), as protocols already exist with Inmarsat service providers for the free transmission of observational data to meteorological centres for quality control and insertion on to the GTS. Inmarsat, given its assured multinational backing and established infrastructure, is also extremely unlikely to disappear.

2.4.2 Inmarsat Broadband Global Area Network (BGAN)

Inmarsat Broadband Global Area Network (BGAN) offers a mobile communication service, which provides both voice and broadband data simultaneously through a portable device, on a near-global basis. The BGAN service is accessible via a range of small, lightweight satellite terminals with an option of single user or a small team. The terminals may be connected to a laptop through wired or wireless connections including BlueTooth and WiFi. The BGAN delivers Internet and intranet content and solutions, video-on-demand, videoconferencing, fax, e-mail, phone and LAN access at speeds of up to 492 kbps. Moreover, it supports both circuit-switched and packet-switched voice and data services. It uses the new (spot-beam) Inmarsat-4 (I-4) satellites, which were launched in late 2005. The first two of three I-4 satellites are commercially operational in Inmarsat's Indian and Atlantic Ocean regions, with coverage extending across North and South America, Europe, Africa and the Far East. The third launch of the Inmarsat-4 has yet to be determined.

There are many different airtime price plans available with the BGAN service, some of them cost less then a dollar for a low-cost voice call for a minute, combined with high-speed data and Internet connectivity, in a 'go anywhere' satellite terminal. The service is distributed by some of the leading distributors such as: BT (UK), France Telecom Mobile Satellite Communications (France), Stratos (USA), Telenor Satellite Services (Norway and USA), etc.

2.4.3 New ICO (MSS/ATC service)

On 24 May 2005, the FCC granted New ICO a request to modify their reservation of spectrum for the provision of MSS in the United States using a GEO satellite system, rather than a MEO satellite system. Their MSS/ATC System infrastructure is expected to include: (i.) one orbiting GEO satellite, which will utilize a "bent pipe" architecture, (ii.) a ground-based beam forming (GBBF) equipment that is expected to be located at the gateway ground station, (iii.) a land-based transmitting/receiving station, (iv.) a core switching/routing segment, (v.) an ancillary terrestrial component, and finally (vi.) end-user equipment capable of supporting satellite-only and dual-mode (satellite/terrestrial) services.

Initial steps have been taken wherein New ICO has entered into a contract with Loral for construction of GEO in January 2005. Loral has completed the satellite critical design review in May 2005, and physical construction of the satellite is currently underway. The launch for the same is planned for July 2007.

The GEO satellite is designed to provide continuous service coverage primarily in all 50 states in the United States, as well as Puerto Rico and the U.S. Virgin Islands. If appropriate regulatory approval is granted by other countries, the GEO satellite is also capable of providing service outside of the United States, throughout many parts of North America.

2.4.4 GOES, METEOSAT, etc.

These GEOs exist primarily to collect and disseminate weather imagery, but do also support low-rate data collection systems. Access to the satellites is controlled by pre-allocated time-slots, and the

service is largely free. The requirement for significant transmitter powers and/or directional antennae has tended to restrict applications to larger data buoys, although some success has been reported with lower power installations. The MTSAT1R, MTSAT 2 METEOSAT 9, GOES-13 were the satellites which were launched in the years 2005 and 2006 for meteorological studies.

2.4.5 Inmarsat Mini-M, Inmarsat C and Mini-C, Thuraya, ACes, AMSC, etc.

These advanced GEOs offer voice-band communications using compact handsets or laptops by implementing high-gain steerable spot beams to achieve sufficient link margin. Data services may be available using a modem connection on the handset. Coverage is generally regional and not advertised for oceanic areas.

5. USEFUL WEB SITES

5.1 General information

Little LEO status, launch dates	*http://centaur.sstl.co.uk/SSHP/const_list.html*
Constellation overview	*http://www.ee.surrey.ac.uk/Personal/L.Wood/constellations/*
The Satellite Encyclopedia	*http://www.tbs-satellite.com/tse/online/*
General satellite news/gossip	*http://www.hearsat.org/*
Satellite news	*http://www.spacedaily.com/*
General space news	*http://www.space.com/spacenews/*

5.2 Specific operators

AprizeSat	*http://www.aprizesat.com*
Argos	*http://www.cls.fr/* *http://www.argosinc.com/*
Final Analysis	*http://www.finalanalysis.com/*
Globalstar	*http://www.globalstar.com/*
GOES	*http://www.goes.noaa.gov/*
Inmarsat	*http://www.inmarsat.com/*
Inmarsat BGAN	*http://broadband.inmarsat.com/*
Iridium	*http://www.iridium.com/*
LEO SAT Courier	*http://www.satcon-de.com/*
METEOSAT	*http://www.esa.int/specials/ESOC/mso/meteosat.html*
ICO	*http://www.ico.com/*
Orbcomm	*http://www.orbcomm.com/*
Ocean DataLink (ODL)	*http://www.viasat.com/*
Thuraya	*http://www.thuraya.com/*

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Appendix: 1

APPENDIX A

OVERVIEW OF MOBILE SATELLITE SYSTEMS WITH POSSIBLE DATA BUOY APPLICATIONS - UPDATE 2006

System	Status*	Date (if known)	Orbit type	Buoy position	Message type	Terminal size	Power (W)	Comments
APRIZESAT	Operational		Little LEO	GPS required	data: TBD	Handheld	7	4 nanosatellites in orbit, 2-way comms, directed at asset tracking
ARGOS	Operational		Little LEO	Doppler Shift	data: 32 bytes	Handheld	1	Various enhancements, including 2-way messaging with PMTs, are scheduled under Argos 3. Launch of MetOp-A scheduled in Oct 06.
ECCO (CCI Global)	Cancelled (pre-op)		LEO	GPS required	voice/data	Handheld	TBD	12 equatorial satellites planned by 2003. Status questionable – merged with the ICO-Teledesic Global
ELLIPSO	Cancelled		Big LEO	GPS required	voice/data	Handheld	TBD	17 satellites in highly elliptical orbits, serving major land masses. Status questionable – merged with the ICO-Teledesic Global
EYESAT	Experimental		Little LEO	GPS required	data: 60 bytes	Handheld	5	1 satellite 1995, principally for radio amateurs
E-SAT			Little LEO	GPS required	data: TBD	TBD		6 satellites for utility metering (initially aimed at Continental US only)
FAISAT	Cancelled	2002	Little LEO	GPS required	data: 128 bytes	Handheld	10	38 satellites 2000+ Test satellite launched 1997. Final Analysis Inc. is terminated in bankruptcy and assets sold to New York Satellite Industries LLC.
GEMNET	Cancelled (pre-op)		Little LEO	GPS required	data: no maximum	Laptop	10	1st satellite 1995 - launch failure 36 satellites by ???
Globalstar	Operational	1999	Big LEO	GPS required	voice/data: no maximum	Handheld	1	48 satellites + spares (constellation complete). 2nd generation system comprising of 56 LEO satellites and 5 GEO satellites. Planned launch from 2006 onwards. Launch of their eight spare satellites, planned for early 2007. Financial difficulties.

GOES, Meteosat, GMS	Operational		GEO	GPS required	data: various options	Laptop	10	5 satellites; directional antenna desirable NOAA / ESA / Japanese met-satellites.
GONETS-D	Pre-operational. On-hold		Little LEO	GPS/ Glonass	Data	Handheld	TBD	8 satellites in orbit, 36 more planned. Most probably test satellites.
GONETS-D1	Operational		Little LEO	GPS/ Glonass	Data	Handheld	TBD	9 satellites in orbit.
GONETS-D1M1	Operational		Little LEO	GPS/ Glonass	Data	Handheld	TBD	Launched in December 2005. First of a fleet of 12 satellites in 4 planes.
GONETS-R	Cancelled (pre-op)		Little LEO	GPS/ Glonass	Data	Handheld	TBD	48 satellites planned. Lack of commercial interest.
INMARSAT-C	Operational		GEO	GPS required	data: no maximum	5.5 kg	15	Steered antenna not required.
INMARSAT-D+	Operational		GEO	GPS required	data: 128bytes uplink, 8 bytes downlink	Handheld	1	Global pager using existing Inmarsat-3 satellites. Note: very oriented to downlink.
INMARSAT-Mini-M	Operational		GEO	GPS required	voice/data: no maximum	Laptop	1	Mobile phone using regional spot-beams.
INMARSAT-Mini-C	Operational		GEO	Built-in GPS/	email data	Handheld	1	Steered antenna not required. Typically used in remote-monitoring and, in combination with web-based tracking.
ICO (New ICO)	20 MHz Licensed allotted	Dec 2005	MEO	GPS required	voice/data: no maximum	Handheld	1	Global voice and packet data services. 12 satellites planned, only one launched so far. They have 10 satellites in advanced stages of completion.
ICO (New ICO)	Planned	May 2005	GEO	GPS required	voice/data: no maximum	Handheld	TBD	One GEO orbiting satellite to be launched in July 2007. Initially would cover US States.
Iridium	Revived	July 2005	Big LEO	GPS preferred	voice/data: no maximum	Handheld	1	66 satellites plus 7 backup, and had 11 orbital storage.
IRIS/LLMS	Experimental On hold		Little LEO	Doppler + Ranging	data: up to few kbytes	Handheld	1	1 satellite in orbit. Belgian messaging system part of an ESA research programme.

LEO One	Licensed On hold	Service mid 2003	Little LEO	GPS required	data: uplink 9600bps, downlink 2400bps	Handheld	Max 7	48 satellite constellation, store and forward + 8 spares. No polar sats.
LEO SAT Courier	Planned On hold?	Service 2003+	Big LEO	GPS required	Data / voice	Handheld	1-5	72 satellites.
OCEAN-NET	Experimental		GEO	Moored	no maximum	Large		uses moored buoys + Intelsat.
Ocean DataLink (ODL)	Experimental On hold?		GEO	GPS	no maximum	Handheld	TBD	uses Intelsat.
Odyssey	Cancelled (pre-op)		MEO	GPS required	voice/data: no maximum	Handheld	1	12 satellites were planned.
Orbcomm	Operational	1998	Little LEO	Doppler or GPS	data: no maximum	Handheld	5	35 satellites in orbit, 30 operational, expansion to 48 sats licensed. 6 satellites from OHB System AG.
SAFIR	Pre-operational On hold		Little LEO	Doppler or GPS	data: no maximum	Laptop	5	2 satellites in orbit.
Signal	Planned On hold?		Big LEO		voice/data			48 satellites planned.
SkyBridge	Cancelled (pre-op)	Service 2002+	Big LEO	GPS required	Broadband	Larger than handheld		80 satellites planned, recycling GEO spectrum allocations
Starsys	Cancelled (pre-op)		Little LEO	Doppler + ranging	data: 27 bytes multiple msgs	Handheld	2	12 satellites 1998+ 24 satellites 2000+.
Teledesic	Cancelled (pre-op)	Service Late 2004	Big LEO	GPS required	Broadband			
Temisat	Experimental		Little LEO		Data			7 satellites planned for environmental data relay. 1 satellite launched 1993.

Thuraya	Operational		GEO	Integral GPS	Voice/data	Handheld		Thuraya 1 & 2 with multiple spot beam satellite in orbit (over Middle East), Thuraya 3 planned.
Vitasat	Pre-operational, on-hold		Little LEO	GPS required	Data			2 satellites in orbit, 2 more planned.
WEST	Planned On hold	Service 2003+	MEO	GPS required	Broadband			9 satellites planned.

*Status of systems is categorized according to seven groups:

Planned:	Little is known about the system except a name, notional type, and services to be offered. Mostly not licensed, although some may be.
Licensed:	System has been licensed by a national or international regulatory agency (in most cases the FCC), but no satellites have been launched.
Experimental:	System has one or more satellites in orbit for experimental purposes (not usually part of the final constellation). Includes new systems planning to use existing satellites.
Pre-operational:	System is in process of launching, or has launched, its constellation but is not yet offering full services. Some limited evaluation service may be available.
Operational:	System has full or nearly full constellation in place and is offering readily available service to external users (not necessarily commercial).
Cancelled:	System has been cancelled, either before satellites launched (pre-op) or after (post-op).
On hold:	No progress reported or scheduled.