Messaging, Internet of Things, and Positioning Determination Services via Small Satellite Constellations

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Abstract

The focus of the satellite application market for many years has been on broadband services and especially on video services provided by large high-powered satellites located in geosynchronous earth orbit (GEO). This type of service, known in the parlance of the International Telecommunication Union (ITU) as broadcast satellite service (BSS), has been the top source of revenues. Companies providing direct broadcast satellite services have, in fact, produced over 70% of satellite service income. Today there is a burgeoning new market associated with digitally networked services that small satellite constellations might be able to provide with particular skill. Some of these services require only thin data streams.
and can be provided by quite small and cost-effective satellite networks. Others may demand much higher data rates and thus may be serviced by significantly higher data rates.

The focus of this particular chapter is on messaging, machine-to-machine (M2M), automatic identification services (AIS), and new forms of satellite-based Internet of Things (IoT) services. These are the new types of services that much small satellite constellations with lower bit rates can provide. These new systems such as Orbcomm, Kepler, Spire, Else, Kineis, ELO, and others can be deployed at much lower cost than the bigger mini-satellite systems seeking to provide broadband services. They can also operate to much lower-cost omnidirectional ground terminals.

It is possible that mini-satellite constellations with much higher-throughput rates optimized for 5G services and video via over the top data streaming services will create very large new multibillion dollar markets. These types of services, however, will be provided by larger types of small satellites configured to operate in higher data rate constellations. These services will be reserved for either GEO high-throughput satellites or mini-satellite constellations. This gigabit per second market, if served by small satellites, will be reserved for those megaconstellations being implemented by OneWeb, SpaceX’s Starlink, LeoSat, Boeing, Thales, and others.

This chapter concentrates on the interactive satellite messaging services that deal in megabits per month rather than process information in gigabits/second.

Keywords
Automatic identification services (AIS) · Data relay services · Else constellation · Eutelsat LEO for Objects (ELO) · Geolocation · International Telecommunication Union (ITU) · Internet of Things (IoTs) · Kepler · Kineis · Messaging · Machine-to-machine (M2M) · Orbcomm · Position determination · Spire · VHF data exchange services (VDES)

1 Introduction

The Surrey Space Centre, now known as Surrey Space Technology Limited (SSTL), played a key role in the early development of small satellites with advanced digital processing and storage capability that could provide messaging and store and forward services. These “Surrey sats” could provide messaging relays to support remote locations such as medical clinics, oil platforms, and remote mining sites and collect data from ocean buoys and score of other locations. These low-cost satellites that operated at low data rates did not require sophisticated or expensive ground terminals.

The idea that small and efficient satellites might be able to assist with messaging and location tracking continued with the GeoStar network that operated in geosynchronous orbit and then with the Orbcomm small satellite constellation that was
deployed at the same time as the first systems for mobile satellite communications. The Orbcomm system, first developed by the Orbital Sciences Corporation, allowed trucking companies, shipping lines, rental car companies, bus companies, and others to stay in touch via messaging services. Additional capabilities that were added to provide GNSS capabilities via the GPS network augmented the messaging services with navigational and geolocation services as well.

In the world of cubesat and nanosat technology, there are today a number of systems that are deploying or developing new capability to deploy quite small satellites to use messaging or machine-to-machine (M2M) services for a much wider range of data relay services at modest data rates. These new networks are not seeking to compete with broadband high-throughput systems such as SpaceX, OneWeb, and many other companies that are now deploying. The emphases of these data relay satellite systems are messaging, machine-to-machine communications, geolocation, automatic identification services, and Internet of Things data relay. Some of the systems that are now providing these services or are planned for such services in the near term are discussed in this chapter. The presentations explain the various types of services offered, technical and service challenges and competitive options, and finally regulatory or standards issues that pose issues with regard to the provision of such services.

2 Orbcomm

The Orbcomm initial system was deployed in the 1990s. At that time this type of small commercial messaging satellite constellation represented a completely new start-up enterprise seeking to develop a new market. The Orbital Sciences Corporation provided the launch services, designed and manufactured the satellites, and was responsible for the marketing of the new global messaging services. Although it had a very innovative satellite design, low launch costs, and other positive attributes, it was an entirely new type and thus a high-risk undertaking. It had the difficulty of starting a new global messaging service from scratch where the intended customer base around the world had little appreciation of the value that could be derived from the new services provided. Further Orbcomm had little experience in marketing its service to customers who might most benefit from these services. The end result was that it went bankrupt. All of the somewhat parallel mobile satellite communication ventures, namely, Iridium, Globalstar, and ICO, also failed financially and so went bankrupt.

Orbcomm was reorganized under new management, and this messaging service gradually became financially viable. Currently a second generation of packet-switched (M2M) messaging satellites, as manufactured by Thales Alenia, has now been deployed at a cost of $240 million. This second-generation spacecraft is described by Orbcomm as offering up to six times the data throughput capacity and up to twice the transmission rate of the earlier satellites. This second generation of satellites was initially deployed as a network of 18 satellites. The second generation of Orbcomm satellites also has an L-band package that allows satellite-
based automatic identification services. System failures with the second generation of Orbcomm satellites (OG2), however, have reduced this second-generation network size significantly. The current network combines both first- and second-generation satellites, but 80% of the traffic is now on the second-generation satellites. There is also a cooperative agreement with Inmarsat to provide mutual support for services. A third generation of satellites is now under active study (Henry 2017a) (see Fig. 1).

Although the basic service is described as machine-to-machine (M2M) messaging, the range of services described under this general “umbrella” is now quite large, sophisticated, and geared to various industries. Over time many types of industries in areas such as transportation, product shipment, mining and resource extraction, etc. have learned the value of the various satellite services now on offer by Orbcomm and other messaging satellite service providers. The Orbcomm satellite services have also become more refined and diversified to respond to various types of market needs. The Orbcomm offerings now break down into three categories of (i) Web Applications, (ii) Radio Frequency Identification/Real-Time Location Services (RFID/RTLS), and (iii) IoT Solutions for Remote Monitoring and Control.

Under Web Applications Orbcomm offers services that include:

**Road Transport.** (i) Fleet management for trucks, trailers, and refrigerator units; (ii) CargoWatch (for trailers and chassis); and (iii) ReeferTrak (to provide compliance with regulatory requirements as well as optimized temperature levels for fuel savings).

**Intermodal Transport** This typically involves shipping, air, rail, and truck operations. This provides sub-options such as (i) Reefer Connect, (ii) Vessel Connect, (iii) Cargo Watch Security, and (iv) Fleet Edge (this last offering is designed to
support various types of equipment telematics-related services and data interactions).

The second broad category of messaging service that Orbcomm now provides is **RF Identification (RFID)/Real-Time Location Services (RTLS)**. This type of service is broken down into:

(i) **RFID Software** (for both manufacturing and inventory control)
(ii) **AssetWatch** (to provide for asset safety and security and inventory control)

The third area that is also now growing the most rapidly as a market is **IoT Solutions for Remote Monitoring and Control**.

In this satellite messaging arena, Orbcomm offers an entire toolkit of services as well as hardware options. These offerings range from a turnkey type of comprehensive service that provides software and hardware. There are also other types of satellite messaging services as well as more discrete satellite services or hardware options.

These offerings in the IoT Solutions area include:

**DeviceCloud**: This allows interactive communications with connected devices in a customer’s system. This proprietary system, as provided by Orbcomm, creates a single interface to manage multiple networks and devices.

**Application Enablement Platform known as iApp**: iApp is an application enablement platform that Orbcomm claims can reduce the time, cost, and complexity of deploying high-performance RFID as well as sensor-enabled IoT applications. This can allow RFID and IoT applications to be communicated with interactively and on a global scale with only modest delays. With the second-generation OG2 satellite messaging connections, times have continued to improve with delays being measured in seconds or at most a few minutes.

**Orbcomm Provided IoT Hardware**: It is possible to obtain via Orbcomm a range of tracking and monitoring capabilities. The types of hardware that can be purchased or leased include programmable terminals and sensors and compatible satellite modems that allow a variety of telematics solutions. These various hardware offerings are designed with suitable software to operate under different international standards.

It is possible to sign up for a complete end-to-end IoT deployment that includes both the service and the hardware. These comprehensive end-to-end offerings include a suite of cloud-based software as a service (SaaS) capabilities. It is possible to operate these from a platform as a service (PaaS) basis. The purpose of these Orbcomm offerings is to allow near real-time reporting on the status of assets. Thus Orbcomm and other newer entries into the satellite messaging service industry can provide global tracking and managing of assets for many different types of industries with goods and materials widely distributed around the world (ORBCOMM 2019). These other satellite messaging services will be described below. Many of these new
systems that are concentrating on IoT service or automatic identification service are presented below.

Orbcomm has the advantage of many years of experience. Over that time Orbcomm has become less and less an operator of small satellite constellation. Instead it has become a provider of services – and specialized telematics and data networking or geolocation hardware – to those involved in transportation and other industries such as mining, manufacturing, and other industries that are concerned with efficient management of assets – especially organizations that have resources widely deployed all over the globe and where supply chain efficiencies have become quite important.

This detailed reporting on Orbcomm services as provided above in many ways might be seen as a model for the types of satellite messaging services that can be expected to be offered by other small satellite systems now being deployed. The Orbcomm satellite experience in terms of developing tools and interactive capabilities well suited to client industries is a useful paradigm for a number of new companies now seeking to provide M2M messaging services via small satellite constellations to support safety and security, inventory control, interactive IoT services, automatic identification services, and position determination and geolocation updates.

3 Satellite-Based Automatic Identification Services (S-AIS)

The established small satellite constellation, Orbcomm, is now equipped via an L-band package to provide satellite-based automatic identification services (S-AIS). Nevertheless, Orbcomm is not unique or predominant in this satellite service area. It has strong competition from several other satellite service providers including from entities operating with new nanosat constellations which have shown innovation in this area such as more extensive coverage, very rapid domain identification capabilities as well as cost reductions for the service.

exactEarth, in particular, has deployed a near real-time network that now operates from a second-generation hosted payload capability installed on the Iridium Next constellation for this purpose. exactEarth has joined with the Harris Corporation to create the payloads and with Iridium to deploy its AIS payloads on the Iridium Next 66 host platforms that are employed to provide this global service.

Currently there are 58 operational exactEarth payloads plus 7 spares that are flying as hosted payloads on the Iridium Next system to form the exactEarth RT constellation. This second generation of the exactEarth constellation is capable of rapid domain identification for ships and ocean-going vessels (exactEarth’s Revolutionary Global Real-Time Maritime Tracking and Information System now Fully-Deployed n.d.).

Automatic identification system (AIS) is a global standard for ship-related messaging services operating in the VHF band and 161 and 162 MHz. This service is designed to avoid collisions and aid search and rescue (SAR) operations and maritime domain awareness through near-instantaneous ship and other vessel
tracking. AIS was ruled to be a mandatory safety and security service for all ships and vessels for A and B types of service under the International Maritime Organization’s (IMO) International Convention for the Safety of Life at Sea (SOLAS). This Convention was adopted and entered into force in 1974. Satellite-based automatic identification service (S-AIS) allows for global coverage in remote areas, such as isolated oceanic and arctic regions. It complements terrestrial AIS and coastal radar coverage. This service is particularly important to enhance AIS connectivity in arctic and more isolated ocean areas where satellite access is largely the only available option (see Fig. 2).

The problem for the future is that the VHF band is only able to support very limited bandwidth services because of the now very intense use of spectrum between 30 and 300 MHz on a global basis. The very narrow bands available for the automatic identification service is on Channel A 161.975 MHz (87B) and Channel B 162.025 MHz (88B). Thus the offerings such as the VHF data exchange service cannot be expanded. The only option is more efficient coding that allows more bits/Hz to be transmitted.

The exactEarth constellation claims the following capabilities with regard to S-AIS domain identification for ocean-going vessels: (i) global average satellite revisit coverage of under 1 min; (ii) customer data latency under 1 min; (iii) reliable detection of both Class A and Class B AIS messages; (iv) tracking of large populations of small vessels with suitably equipped with AIS transceivers (this is known for the exactEarth-Harris service as exactTrax™); and (v) support for the future evolution of AIS to provide VHF data exchange service (VDES) and other initiatives in the maritime VHF band (exactEarth: Real Time Global Ship tracking n.d.) (as noted above the limited frequency spectrum available in L-band limits any great expansion of VDES).

In addition to exactEarth, the Spire small satellite constellation has developed a capability to provide global S-AIS services. In the case of Spire, it provides not only

Fig. 2  Graphic showing satellite reception of S-AIS signals from ships on the high seas. (Graphic courtesy of the European Space Agency)
domain identification for ships and vessels but also data analytics that projects with
good accuracy where a ship will be at the time of the next location update. There are
also several other start-ups that are seeking to provide S-AIS services via new
cubesat-type constellations.

There are detailed market studies that have projected that global shipping and
demand for S-AIS services will continue to grow. One of these market analyses is the
insight report known as the “Satellite-Based Automatic Identification Systems
Market 2025 – Global Analysis and Forecasts by Type (Class A Transponder and
Class B Transponder) and Applications (Ship, Defense, Aerospace, and Intelligence
and Security).”

The question is whether this market is sufficiently large and diverse enough to
sustain a growing number of small satellite constellations. Most systems such as
Orbcomm, Spire, and several others have seen the S-AIS market as a source of
incremental revenue, but exactEarth has seemed to focus on this service as a primary
source of revenue (Satellite-Based Automatic Identification Market 2025 n.d.).

The market demand and size for S-AIS have been seen to be in flux. This market
is currently still small and largely depends on governments contracting to obtain the
S-AIS data in order to track shipping and vessel activity and provide for at sea safety
and security. In many cases governments depend on coastal radar for tracking
shipping movements within 100 miles (160 km) of their shores. Thus some govern-
ments see S-AIS as an optional service. Shipping lines are still seeking to prove that
their savings in fuel, shortened port stays, and safety and security are sufficient to
pay for such services.

The Canadian government contract services is a case in point. It awarded an initial
contract to exactEarth S-AIS service provider in 2014 in the amount of $19 million
(Canadian) or ($14.5 million US), but after fierce competition between Orbcomm
and its Canadian subsidiary Skywave Mobile Communications for the renewal of
this contract, it was determined that the Canadian requirements for data were to be
severely cut back. The reduction of some $7 million in revenues (or $600,000 per
month) represented about 25% of exactEarth revenues at the time. This major loss of
revenues resulted in a major reduction in the stock price of exactEarth that is offered
on the Toronto Stock Exchange. As more constellations join Orbcomm, Spire, and
exactEarth to compete for AIS-type service (i.e., the Else nanosat constellation, the
new Eutelsat LEO for Objects (ELO) constellation, the French Kineis constellation,
and others), the profitability of quite so many messaging, IoT, and truly small
satellite constellations may come into increasing question (de Selding 2016).

4 Other Systems for Messaging, IoT, AIS, and Lower-Data Rate Services

The idea behind many of the true small satellite constellations now being planned is
that they can be deployed for a modest cost. Some estimates have been as low as $50
million and most at a cost of around a quarter of a million. Low cost alone is not
sufficient. The key question is whether a low-cost small satellite system operating at
low data rates can find sufficient market and revenue streams to sustain their
operation. Some of these systems have started with test satellites funded by kick-starter programs on the Internet, and others have been funded by satellite companies operating geosynchronous satellite systems but envision that LEO constellations might be key to providing data services requiring low-latency transmission times. Each of the following small satellite constellations provides useful insight into these new systems and the thought process behind their planning and implementation.

## 5 Spire

Currently Spire Global Inc. characterizes its business operations in a much different way than when it first started. Today it indicates that its role is focused on data analytics related to tracking of global data sets derived from the tracking of maritime, aviation, and weather patterns. Its main focus shifted from data messaging and provision of AIS type services when it received major contracts in the weather data analysis areas. The breakthrough award came from the European Galileo project to conduct longer-term weather data analytics. This contract over time is potentially worth $2.7 billion (Sheetz 2018). This Galileo Award was preceded by 3 months by a much smaller award from NASA for a weather data and observations analysis contract. This NASA contract was, however, likely a critical antecedent to the European award (Mohney 2018).

Spire Maritime was launched as a new business unit at the end of 2018 and officially announced in February 2019. The purpose of this is to focus on use of L-band systems to collect automatic identification service information on a global basis using its Lemur 2 constellation of a 100 deployed nanosats to identify the names and ownership of all ships at sea and their routes on a near-instantaneous basis. Further they will seek to generate predictive data as well in order to provide historical data on vessel usage or cargo shipping patterns. The purpose of Spire Maritime analytics will be to help enforcement against illegal fishing, smuggling, drug running, polluting activities, etc. as well as to assist with more efficient routing of ships and vessels and provide for accurate tracking of cargo and improved safety and security on the high seas.

The idea is to seek to “reinvent the maritime world” through the use of data analytics. The leadership of Spire Maritime has state its goal to be “to create new technologies for the maritime industry under the guide of seasoned leaders. Spire Maritime will utilize technologies like machine learning to deliver real-time data and insights that raise the bar in the maritime world” (Spire Announces a New Business Unit for Maritime Data and Analytics n.d.).

It also uses its 100 satellite constellations of Lemur 2 satellites, the third largest constellations in the world in terms of operational satellites, to operate hosted payloads for automatic dependent surveillance broadcast (ADS-B) for airline tracking and safe navigation and security. (Note: the Iridium Next 66 satellite constellation now is the host platform for 58 ADS-B operational units plus 7 spares).

Spire thus lists its services to include (i) Spire Sense Cloud (satellite and terrestrial AIS); (ii) Spire AirSafe (satellite ADS-B); (iii) Spire Stratos (GPS-RO and GPS-R); and (iv) Orbital Services The main focus is the environmental and weather data...
analytics or Spire Stratos, although with its 100 satellite constellation deployed in orbit, it is a serious provider of all these services (Spire Global n.d.).

Spire was the first to launch its multiunit cubesats from the NanoRacks launch dispenser from the International Space Station (ISS), and it has also used a wide range of other launchers to get its large fleet to orbit. Since the Lemur satellite constellation only has a lifetime of 2–3 years, it is in need of rather constantly manufacturing new satellites at its joint facility with Clyde Space in Scotland, as well as to provide for deorbiting of defunct spacecraft (see Fig. 3).

6 Kepler

The Kepler constellation is a much more straightforward story in that this start-up had a clear commercial focus on creating a global small satellite constellation for messaging and highly efficient M2M services. Its prime market focus is seen as Internet of Things connectivity for very small and compact transceivers the size of credit cards. Its mission statement emphasizes that the system that they are designing, building, launching, and operating is “satellite communications simplified.” Kepler Communications website states that their ambition is designed to “integrate our satellite connectivity solutions into your global operations and communicate like never before....to provide connections from small sensors to large ocean going vessels so that ‘One Standard IoT’ can be made available everywhere” (Kepler n.d.).

The emphasis of the Kepler offering is on a simple cellular link via a compact transceiver to provide connectivity for Internet of Things (IoTs) units. This is, in fact, a credit card-sized transceiver that runs on an AA-sized battery for years. This type of IoT-designed Kepler link is geared to provide service at up to 1 megabit capacity per ground transceiver per month for data collection and control messaging. In many ways this capability is similar to that provided by tradition supervisory control and data acquisition (SCADA) systems that operate with pipelines, elevators, or
utility operations. The Kepler constellation is uniquely designed for global connectivity including satellite service and coverage even in the polar regions (Kepler Services n.d.) (see Fig. 4).

In addition, Kepler with its S-AIS capability is also able to offer fleet and route tracking, alerts to any route variations, asset monitoring, and other services that are similar to those offered by Orbcomm, exactEarth, and other small satellite constellation discussed in this article.

7 The Else Nanosat Constellation

This project is a joint venture of Astrocast of Switzerland and Yahsat/Thuraya of Emirates. Around the world operators of geosynchronous-based satellite networks such as Intelsat, SES, Thuraya, Eutelsat, and Telesat are exploring how they might diversify into LEO-based constellations and capture data networking services that require low latency or minimal delay in their transmitted services. The Else nanosat system is to be operated by Yahsat. Yahsat now operates GEO satellite systems. This includes the Thuraya system which is a large GEO based system for mobile satellite communications services. The Else constellation represents the way that Yahsat is examining a way to enter the LEO constellationa market by means of a lower-data rate nanosat constellation. (Henry 2017b).

Astrocast that has designed and manufactured nanosats previously is manufacturing the Else small satellites. Thuraya, now owned by Yahsat, is providing the capital financing and also sharing its expertise in marketing satellite services in the Middle East, Africa, and elsewhere.
The idea is to use limited L-band capacity to provide M2M messages via the Astrocast 64 satellite constellation. This constellation will consist of eight satellites located in eight planes. The terminal design for messaging from the ground will be even smaller than the Kepler system. Its currently proposed size is about the size of a stamp, and its L-band antenna will be about the same size. It can be battery operated or connected to a local power source. Its current objective is to be able to relay messages to its customers operations center within a 10–15 min time period (Henry 2017c) (see Fig. 5).

**8 Eutelsat for LEO Objects (ELO)**

Eutelsat has purchased from Tyvak International a number of nanosats for the purpose of providing a low-data rate Internet of Things (IoT) service. This represents yet another instance of a large GEO operator seeking to find ways to enter the LEO constellation market but not necessarily making a large capital investment to do so.

This project will be drawing on the technology currently used by Sigfox to operate a land-based low-power wide area network (LPWAN) messaging system. Sigfox and other similar operators use their WAN-based systems to provide asset tracking, environmental monitoring, and tracking of utility meters such as for water, electricity, natural gas meters, and other systems controlled by supervisory control and data acquisition (SCADA) networks. The range of coverage for these low-powered WAN networks with connectivity to nearby gateway or nodes is typically in the range of 10 km and at the outside is usually 20 km. This range is insufficient to provide coverage in areas such as the desert, jungles, mountainous terrains, and oceans. This is where a global constellation becomes quite useful. Although GEO systems are adept at many services, this type of data collection...
from very small terminals connected to Internet of Things-enabled devices and SCADA-like systems is difficult. This type of service at L-band is well suited to LEO constellations. In short the LEO constellation two test satellites will test this type of service before the full constellation is deployed (see Fig. 6).

Yohann Leroy, Eutelsat’s deputy CEO and chief technology officer, has explained the reasoning behind the ELO constellation initiative as follows:

“There are fundamental differences from a technical standpoint between the broadband market and the IoT market, which is a narrowband market. … The only way to transmit megabits per second with satellites that move through the sky is to have a tracking – and necessarily expensive – antenna on the ground. [For IoT], when you only need to transmit a few kilobits per second and not megabits per second, omnidirectional – and much cheaper – antennae are sufficient” (Henry 2019). This logic also means that the terminals and their antenna and their power sources can also be quite small.

9 Kineis

There is another important French nanosat constellation that is in active planning. This system is to augment and then replace the seven-satellite Argos system that has been in operation since 1978. It will use L-band systems for messaging, M2M, and IoT connectivity. The new system is to be known as Kineis. This is to be a 25-satellite constellation that will draw on the experience gained by the Argos satellite system that has been providing messaging services to a world community of environmentalists and other users for several decades. This project is backed by CLS, CNES, Thales Alenia, Nexeya, and others in France. There are currently two preliminary satellites in orbit to provide experimental tests with ground equipment and refine the design of the satellites and ground terminals. While Argos was a
project of the French government and CNES, Kineis is seen more of a commercial venture (Kineis constellation n.d.).

10 Other Messaging Satellite Systems

The above discussion and summary discussion of planned small satellite messaging systems that also includes the second generation of Orbcomm still do not represent a completely exhaustive list of all the various types of small satellite constellations that have been announced as possible new initiatives in the field of AIS and messaging services. There are some that have indicated plans for a sort of satellite communications service that would be sold on a public subscription basis and other types for safety, development, and scientific services. The above listing is representative of the systems that seem likely to be deployed. The listing of constellations in Part 13.1 is provided as a more complete listing of various systems that might be deployed within the next 5 years.

11 Cost of System Versus Size of Markets

Most of the systems that are now envisioned or are in actual deployment at this time are quite cost-effective. Many of these systems can be deployed for a cost that is equivalent to the cost of the launch of a single high-powered and high-throughput geosynchronous satellite system that might be deployed by Intelsat, Eutelsat, Telesat, SES, or Viasat, but there is still doubt as to whether the market for such AIS and messaging services is sufficient to cover the total cost of operations of so many new LEO constellations planned for operation in the L-band with such limited data throughput capability. The messaging smallsat constellations, even with advanced new coding systems, are limited in their throughput. Planned expansion of VHF data exchange services (VDES) will be limited by L-band allocations for this service to ships.

For decades, the Argos system has been subsidized in its global messaging service by CNES. Now at least six LEO constellations, i.e., Orbcomm, Spire, Kepler, Else, ELO, and Kineis, are planning to provide these various types of messaging services. Clearly the new IoT market with perhaps many billions of interactive units seeking to be interconnected creates new market opportunities. Nevertheless some of the market analysis has now undertaken a question that the planned investment costs for these various systems that will likely top a billion dollar (US) can all be recouped.

12 Conclusions

The world of “NewSpace” and particularly the ongoing effort to create new types of small satellite services seem to continue apace. There is clear appeal to create new small satellite constellations, especially low-cost nanosat systems that can typically
be deployed for under $300 million dollars. This is a business that start-up companies, especially if helped by larger satellite companies, can contemplate entering.

New space investment strategies that can be started with kick-starters and crowdsourcing and then financed by angel investors with rounds of funding have allowed companies such as Planet and Spire to soar into prominence. These two start-ups currently operate two of the largest satellite networks in the world.

The success of some of the smallsat constellations and new launch vehicle firms like SpaceX, Blue Origin, and Rocket Labs can create false expectations in some of the small satellite initiatives now seeking to create new LEO constellations to serve new markets that have yet to be entirely proven. The arena of data analytics is perhaps the new space market with the greatest potential for new vibrant space applications, but it is also the area where the greatest commercial risks might also lie. The large number of these new systems, existing and proposed, represent a risk that is now heightened by the economic downturn associated with the Covid-19 virus.

13 Cross-References

- Ground Systems to Connect Small-Satellite Constellations to Underserved Areas
- Messaging, Internet of Things, and Positioning Determination Services via Small Satellite Constellations
- Mobile Satellite Communications and Small Satellites
- Radio-Frequency Geo-location and Small Satellite Constellations
- Remote Sensing Applications and Innovations via Small Satellite Constellations
- Small Satellite Constellations Versus Geosynchronous Satellites for Fixed Satellite Services and Network Services
- Smallsats, Hosted Payload, Aircraft Safety, and ADS-B Navigation Services

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