IAC-11-B4.1.10

MEETING THE DEMANDS FOR SMALL GEOSTATIONARY COMMUNICATION SATELLITES FOR THE COUNTRIES OF THE ASIA-PACIFIC AND SOUTH AFRICAN REGIONS

Mr. Gerald Webb
Commercial Space Technologies Ltd., United Kingdom, cst@commercialspace.co.uk
Mr. Anatoly S. Karpov, Dr. Sergey F. Teselkin, Mr. Oleg A. Sokolov
Air Launch Aerospace Corporation, Russia, airlaunch@airlaunch.ru
Dr. John Paffett
Surrey Satellite Technology Ltd., United Kingdom, j.paffett@sstl.co.uk

The demand for satellite communication services that would either provide modest capacity or coverage of limited areas in certain geographic regions to address the needs of country state bodies, institutions or domestic companies is described. The demand exists, in many instances for certain national considerations, for users to desire their own systems and capacity and not be solely reliant on leased transponders or commercial service provision. This demand often translates into a requirement for a class of smaller satellite (<1600 kg), with limited capacity and coverage, which are intended to be used in conjunction with commercially provided services or to address niche services and applications. While the demand exists for the smaller class of satellite, it remains today largely unaddressed due to questions of economic viability. It is entirely feasible to develop a low cost platform to address this sector of the market. However, the availability and cost of launch provision has until now made such opportunities prohibitively expensive. This is one of the reasons why many manufactures have been focusing their efforts on the larger platforms and more quantifiable market opportunities. The true market size and potential is very difficult to gauge at this point, being stifled by the economic viability of the programs. However, as an example of the anticipated market, the demand for this class of satellite is presented. The situation is, however, expected to change and it is anticipated that the market will be stimulated. Smaller satellite platforms are being proposed, such as the direct injection and 1600 kg transfer variant of the Surrey Satellite Technology Limited (SSTL) Geostationary Minisatellite Platform (GMP). A shift is being observed in the launch market, with opportunities opening up for ride shares on large conventional launch vehicles as well a number of smaller launch vehicles intended for the cost effective delivery of <1600 kg payloads into geostationary and geostationary transfer orbit. A brief analysis of the suitability of current and expected launch vehicles and systems for the provision of this type of mission is assessed.

INTRODUCTION

Geostationary satellites are, and will continue to be, one of the most efficient means for providing communications services to the Earth population. With a growth in applications, services and the user population, capacity requirements continue to increase at a rapid pace. Increasing demand for such services is driving development in a number of key areas, enhancing the services and applications offered and in continuing to reduce the cost of capacity provision. In the case of the last point, this has led to the continued development of larger satellite platforms carrying more and more capacity, with the aim that the costs of the launch, insurance and platform can in effect be spread over a greater number of transponders and in so doing, reduce the effective in orbit cost per transponder.

Large satellite platforms, with their corresponding high payload capacity, are well suited to provide a cost effective means for the provision of communications capacity, with the expense of the platform, launch, insurance and operations amortised across a large number of transponders yielding attractive in orbit cost per transponder figures. This is particularly the case where bulk capacity is required or capacity requirements can be aggregated onto a single platform. There are instances, however, where the users or customers are looking for their own independent asset or indigenous capability, with only modest capacity or coverage requirements. In these cases the capital investment of the larger platform can be prohibitive to the business case and the customers may be more inclined toward a smaller satellite solution. This is certainly the situation that satellite manufacturer Surrey Satellite Technology Limited (SSTL) have experienced in recent years, with a number of enquiries from prospective customers looking to deploy small payloads of limited capacity into geostationary orbit.

The requirement for the smaller class of platform has been identified, with a launch mass of between 600-1600 kg, able to accommodate small payloads (1-2 kW / <250 kg), providing limited capacity or coverage. While the demand for this class of spacecraft is apparent, the market remains largely unserved and customer requirements have on the whole remained unaddressed, due to the economic and programmatic viability of deploying small payloads in geostationary orbit. The gating factor in recent years has not been the satellite platform cost, but instead the launch availability and cost, with some launch service providers charging the same for launch of a 1000 – 3000 kg satellite, making the lower end prohibitively expensive.

It is in part due to the economic viability of the smaller class of satellite that manufacturers have focused their efforts on the provision of satellite platforms of 3000 kg and above, with power handling capabilities from 4 to 20 kW. Even the SSTL Geostationary Minisatellite Platform (GMP) is today focussed on the 3000 kg end of the market, where launch availability and costs are more viable and opportunities can be more easily addressed. Plans exist, however, to provide smaller platforms in the future, but those are currently awaiting changes in the launch market.

While the availability and cost effectiveness of launch services for small satellites into geostationary and geostationary transfer orbit has been limited in the past, there are now clear indications that this situation is changing. Supported by Commercial Space Technologies Limited (CST), an independent launch brokerage company, the current status of existing launch activities and the plans for new and upcoming launch systems are monitored. Movements are being observed in both the willingness of the larger launch vehicles to consider multi passenger or ride share launch scenarios and the development of a class of smaller launch vehicles targeted at providing cost effective delivery of small satellite platforms.

One of the potential small satellite launch systems is the "Air Launch" Space Transportation System (STS), currently under development by the Russian Air Launch Aerospace Corporation (ALAC). The planned launch system, described further within this paper, will provide not only competitive launch costs, but also localised satellite integration, minimizing logistical and shipping costs.

With the greater availability of cost-effective launch solutions for smaller geostationary communications satellites the existing unserved user and customer base can be addressed and the market stimulated.

ANALYSING THE DEMAND

The use of small satellites to address opportunities only requiring limited capacity or coverage is not new, and there are previous examples of such systems. The "Sirius 1" satellite with an in-orbit mass of 660 kg was launched in 1989 for Sweden and the "Thor 1" satellite with the same in-orbit mass was launched in 1990 for Norway. A number of other countries followed this trend: the "Thaicom 1" and "Thaicom 2" satellites, both with an in-orbit mass of 629 kg were launched in 1993 and in 1996 for Thailand while the "Koreasat 1" and "Koreasat 2", both with an in-orbit mass of 833 kg were launched in 1995 and in 1996 for Korea [1]. All these satellites had 12-15 transponders, sufficient for the servicing of these countries' territories in accordance with the level of the demand at that time for satellite communication services. A more recent example is "Amos-3", launched in 2008 for Israel, with a launch mass of 1360kg

In more recent years the number of small geostationary satellites has reduced, due to growth in capacity demand and the corresponding trend toward larger platforms, and also the decreased viability of smaller satellites due to launch availability and cost. The vast majority of geostationary communications satellites are now large platforms, with launch mass of 3000kg and above, power provision of between 4-20 kW and the ability to support large, complex payloads, with many providing coverage over multiple regions and across multiple frequency bands. Where a customer or user has a requirement for limited capacity or coverage, their demand is either met through the procurement of commercial services, lease of transponders, aggregation of requirements onto a larger platform, or the demand has remained unmet.

In the last couple of years SSTL has had a number of enquires for the provision of a 600-1600kg class of geostationary satellite, able to accommodate small payloads (1-2 kW / <250kg). These have been from prospective customers who do not need the capacity offered by a large platform nor the corresponding level of capital investment, and do not wish to use, or be reliant on, existing commercial capacity and desire for one reason or another their own system and capacity. These enquiries have come from a broad spectrum of customers, targeting a wide range of services and applications. The types of customer and applications include

- Existing commercial operators – Augmentation, early service or filing protection.
- New entrant operators – Early service and service ramp up.
- Commercial entities – Independent capacity, backhaul and backup
- Countries / Governments – Territorial coverage, national infrastructure, internal services
- Military – Independent secure capacity
- Various – Training, research and development

In many, if not all of the cases, the customers requirements have not been able to be satisfactorily addressed and the need has remained unmet.

While the market for this type of product is apparent, the true size and potential are difficult to gauge, as the number of actual programmes is suppressed by the economic viability. Based on the level of enquires, the number that have been addressed and the number remaining unmet, it is believed that, conservatively, a market of 4-10 satellite per year could be achieved if the right in orbit delivery price could be achieved.

ASIA PACIFIC AND SOUTH AFRICAN REGION DEMAND

Within the Asia Pacific and South African regions, demands for communications infrastructure and capacity continue to rise at a significant rate, with satellite communications providing the most effective means of providing coverage and facilitating a rapid roll out of services and applications. The full spectrum of customer types, applications and services are seen, with a greater demand for systems with lower capacity and limited coverage than in other regions of the world, with the highest foreseen demand for national or government services.

From the commercial service perspective many anticipate a continued growth in the demand for capacity throughout the regions, attracting the attention not only of the existing service providers but also new entrant operators looking to establish themselves. Some multinational corporations have also been assessing the viability of implementing their own systems in this region to improve the robustness of their communications infrastructure and also reduce the costs of communications capacity provision. Individual countries and governments have also expressed interest in implementing their own systems for provision of commercial, governmental and military services or a combination thereof, to establish independence and remove dependency from foreign owned systems. In many cases the national capability is foreseen in addition to leased commercial capacity and services.

COST EFFECTIVE SATELLITE PLATFORM PROVISION

In response to the growing demand for small geostationary satellite platforms, SSTL has embarked on the development of its Geostationary Minisatellite Platform (GMP) intended to address the market requirements for platforms within the 500-3250 kg range. The development encompassed two variants, the first targeted at direct geostationary orbit injection and the second at more traditional launch vehicle delivery into geostationary transfer orbit.

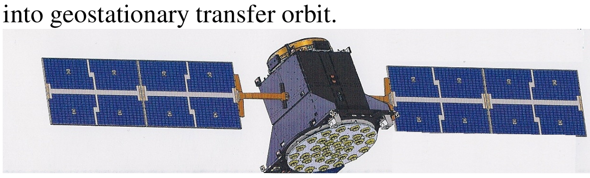

Fig. 1. GIOVE-A – First flight of the SSTL GMP

The first flight of the platform was for a Navigation application, and formed the basis of the European Space Agency GIOVE-A mission, the first satellite of the European navigation system Galileo. GIOVE-A is shown in figure 1. The satellite, launched in December 2005, was a <1000 kg direct injection variant of the platform, launched on a Soyuz-2 launch vehicle. Unfortunately, the launch costs for direct injection launch opportunities escalated significantly at that time and following the launch of the GIOVE-A satellite SSTL deferred further development of the lower end product, and along with many other manufacturers focussed their attention on the larger platforms. Today SSTL's core geostationary platform is targeted towards customers requiring a cost-effective 3000 kg class satellite able to accommodate payloads with requirements up to 450 kg, 4.5 kW.

It is SSTL's full intention to be able to offer smaller platforms in the future once cost effective launch opportunities for such satellites become available, and the GMP has been specifically designed around a modular design and architecture to facilitate the necessary changes. With an adaption of the structure and the propulsion system, the GMP lends itself to provide a cost-effective solution for smaller direct injection and transfer variant platforms.

One such configuration that SSTL will offer is a 1600 kg transfer variant platform, Figure 2. This is a specific configuration that has been optimised to take advantage of the dedicated geostationary transfer orbit delivery capability of a couple of launch systems currently under development, such as ATS and Cyclone-4, as well as secondary payload accommodation on some existing launch systems.

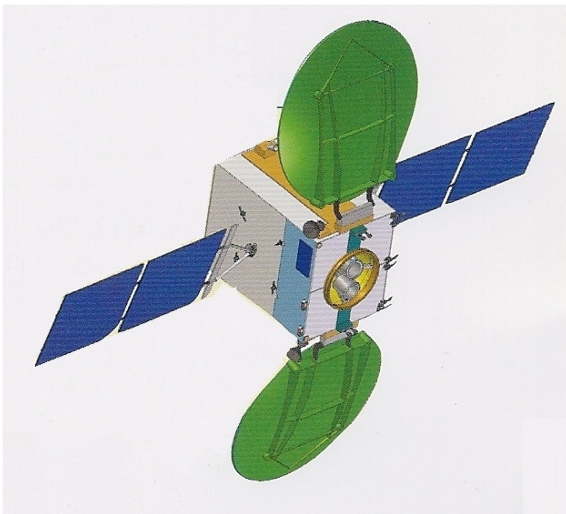

Fig. 2. SSTL 1600 kg variant GMP

The 1600 kg variant SSTL GMP provides accommodation for payloads up to 250 kg and 2.5 kW and utilises an electric propulsion system in order to maximise the payload carry capability, while still providing enough propellant for the transfer manoeuvre and 15 year mission lifetime. With such a payload capacity, the platform is able to accommodate a range of different payloads, with accommodation of 20-24 transponders feasible.

LAUNCHING SMALL SATELLITES

While there are a number of launch systems that will deliver small dedicated or secondary payloads into low earth orbit at a commercially viable price, for programmes requiring the delivery of small <2000 kg satellites into geostationary or geostationary transfer orbit this is not the case. The availability of cost-effective launch opportunities for this size of spacecraft is limited, and in recent years has become worse due to continual increases in the overall launch market costs.

There are a number of factors that drive this situation. Firstly there are a limited number of launch systems designed to deliver this class of spacecraft into the necessary orbit. Much of the focus is in addressing the larger market for the launch of the bigger satellites. Where they do exist, such as in the case of the Indian GSLV and Chinese CZ-3 systems, there are political or legislative issues that make them unsuitable for the majority of mission opportunities. In the case of the larger launch systems, the number offering secondary or co-passenger opportunities for this size of satellite has until now been limited, therefore little competition exists in this region of the market, and as a consequence there are launch providers that will charge as much to deliver a 1000 kg payload into orbit as they would charge for a larger 3000 kg spacecraft.

The preference, cost aside, is always toward a dedicated launch, where the satellite being delivered is the one and only payload on board [3], for obvious reasons of programmatic control, logistics and planning and risk management. Unfortunately the World's launch vehicle inventory currently has few launch systems designed to deliver payloads up to 1600 kg into geostationary transfer orbit or 1000 kg direct into geostationary orbit. Actually, the launch systems in existence today have significantly more payload capabilities, and therefore can only really be considered for piggy back or ride share opportunities.

CST and SSTL continually monitor the global launch market looking for short term launch opportunities for individual missions and also medium to long term trends in launcher availability, such as increased availability of ride share opportunities as well as changes in capability and availability of modified or newly developed launch systems. Through this work, it is apparent that there may be changes which could, in the near future, make the market for smaller <1600 kg class geostationary missions more commercially viable.

It is understood that the most favourable conditions for the launch of geostationary satellites are from launch sites located near the equator. This requirement is especially important if the launch vehicle to be used has a limited payload capability that would be only just sufficient for the launching of the small geostationary satellite. At the same time, this launch vehicle should provide this dedicated launch at a price that is economically viable, and results in a competitive in orbit delivery cost for the entire system. Given that current launch systems are unable to offer cost-effective launch services for this class of satellite, it is anticipated that the development of new systems will bring competition to this segment of the market.

Today there are examples of existing launch vehicles suited to this class of satellite. The Chinese CZ-3 (Figure 3) for example, can launch payloads of 1400 kg into geostationary transfer orbit with inclinations of 28-31° from the Xichang spaceport. Its current launch price is about US$ 40 mln. However, the use of this launcher is legislatively difficult.

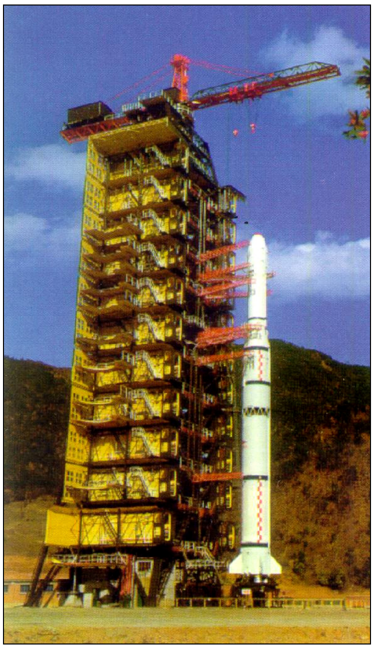

Fig. 3. The Chinese CZ-3 launch vehicle which can deliver a satellite with a mass of 1400 kg into a GTO

New developments are promising to add two more launchers to this inventory. The first of them would be the "Cyclone-4" (Figure 4), the newest improved option of the Ukrainian "Cyclone" launch vehicle family which has been just developed (currently, the on-ground testing process is being completed) for launches from the Brazilian Alcantara test range. This launcher will insert a payload of up to 1600 kg into GTO with a low inclination at approximately the same launch price as for the CZ-3. The launch site for its operation has to be built by the Brazilian Party at the near-equatorial Alcantara test range. In accordance with the most recent announcements, this construction should be completed in 2012-2013. This project and the current process of its realization were described in details in [4]. The other is the "Air Launch" Space Transportation System (STS), a launch systems being developed by the Russian Air Launch Aerospace Corporation (ALAC). This project is described in details in [5] while its most recent overview is outlined in [6]. The Air Launch system is also detailed further in the following section.

Fig. 4. The "Cyclone-4" Ukrainian/Brazilian launch vehicle would launch up to 1600 kg of payload into a GTO from its launch site in the near-equatorial Alcantara test range

AIR LAUNCH

The 'Air Launch' project has been developed by a group of Russian space and aviation companies at their own expense. The ALAC was and is managing the development of the launch.

The "Air Launch" STS is featured, according to the project, by the dropping of the relatively large liquid-propellant "Polet" launch vehicle (102 tons of launch mass) from a super-heavy cargo airplane.

The "Polet" launch vehicle has a two-stage design that would be additionally equipped with a specially developed upper stage. The Antonov "Ruslan" An-124 super-heavy cargo airplane, which is being operated currently in Russia and Ukraine in a significant number, should be used as the carrier aircraft after a certain upgrading. (An accommodation of the "Polet" launcher in this carrier airplane is shown in Figure 5).

The high lift capability of the chosen carrier airplane allows it to carry the launcher of relatively large mass. In order to provide this launcher with as much as possible payload capability, the choice of its propellant was made in favour of a liquid-propellant design and, proceeding from considerations of ecological safety, the liquid oxygen + kerosene propellant combination was chosen.

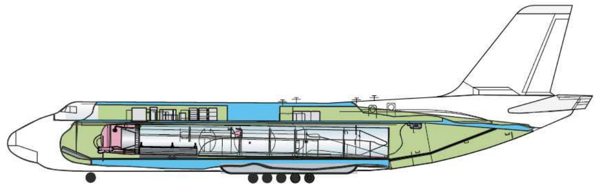

Fig. 5. The accommodation of the TLC with the "Polet" launch vehicle in its transportation/launching container inside the "Ruslan" carrier airplane

This solution allowed the adoption of certain ready technologies, for example, the main rocket engines and even the whole second stage from the Russian improved "Sojuz-2.1V" launch vehicle. The task of ejecting a large launcher fuelled with a great quantity of liquid from a flying airplane's cargo bay was solved by using the innovative technology of pushing the launcher out by a special gas-generator from a transportation/launching container installed inside the carrier airplane. After this ejection, the launcher has to be ignited in the air in conditions of free fall with the provision of a trajectory turn. (The profile of the "Air Launch" STS's mission from the launch of the "Polet" launch vehicle is shown in Figure 6.)

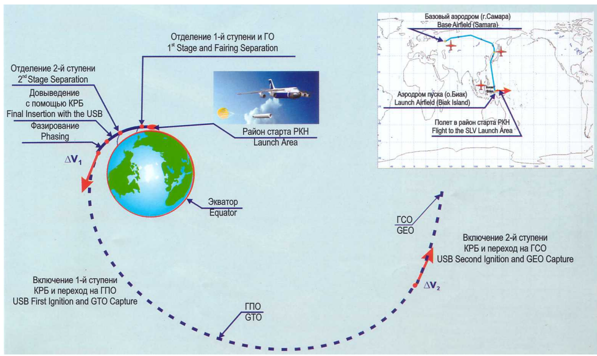

Fig. 6. A profile of space payload direct insertion into the GEO by the "Air Launch" STS from a near-equatorial point of launch (the route of the STS flight from a basic airfield in Russia to the Biak Island with a following launch is shown in top right corner)

Thanks to using the air launch concept, the STS's carrier airplane should play the role of a first reusable stage which will allow the carried launch vehicle to have a higher payload capability than other launchers of comparable launch mass. This feature, in combination with the distinctive feature of air-launched systems, the capability to provide a launch at any azimuth and, therefore, to inject payloads into orbits with any inclination without a turn of the orbit's plane, enables the "Air Launch" STS to launch small geostationary satellites with launch masses of up to 1600 kg into geostationary transfer orbit and even to insert certain small satellites of less mass (up to 800 kg) directly into the geostationary orbit. In order to provide these missions, an especially developed upper stage should be added to the prime two-stage launch vehicle and the take-offs for these sort of missions should be provided from a near-equatorial airfield.

The "Frans Kaisiepo" airfield on the Biak Island (Indonesia) was chosed for this role. The corresponding agreement with the Indonesian Government was signed in late 2005. By that time, two of the "Ruslan" airplanes had been transferred from the Russian Air Force to the ALAC especially for their use as carrier aircraft for the "Air Launch" STS. Simultaneously, a necessary state support was arranged through the Russian Federal Space Agency (Roscosmos) with the inclusion of the project into the Russia's Federal Space Programme for 2006-2015, Currently, full-scale demonstrator flight tests are being prepared with state support in order to verify the main innovative technology, the ejection of a 100-ton launch vehicle from the carrier airplane. These tests are planned for 2012-2013, while the maiden mission of the STS would take place in 2014. It is supposed that the price for a GTO or GEO launch would not exceed US$ 40 mln. while the available rate of launches would be 6-8 per year.

Meanwhile, the project has found support in Germany. The German potential partners have proposed to establish in Germany (Munich, Bavaria) a special facility (centre) for the pre-launch preparation of payloads (mostly, Europe-built ones) for the "Air Launch" STS and for mating them with the "Polet" launchers there. According to this proposal, the "Ruslan" carrier airplanes with the unfuelled launchers on board should fly from Russia to this centre from where, after mating these launchers with the prepared payloads, they should fly to the launching airfield on the Biak Island. The launcher should then be fuelled on this airfield while the STS as a whole, including the carrier airplane, should be finally prepared for flight with a launch that should be carried out in the air over the open sea. The project for this centre, which has received an appellation of "European Payload Pre-Integration Centre" (EPPIC), is currently at the stage of a feasibility study.

A use of the EPPIC services promises significant benefits for the STS launch customers, especially for those who will intend to launch European-built satellites. Indeed, the satellite to be launched should be delivered not to a remote spaceport but to the near-located EPPIC where it should be accepted for testing, processing and preparation including its transportation to the launch site and final preparation there. By this way, the launch customer could participate in this process as a supervisor, if he would like, or could simply wait for when the satellite will be handed in to him after an in-orbit final check-up (the so-called "single window" or "turnkey" concept). These potential benefits in combination with other potential advantages of the STS, which include the opportunity to launch satellites directly into geostationary orbit and the acceptable launch price, drew the attention of SSTL which can provide the turnkey service provision for satellite customers.

CONCLUSIONS

1. There is an expanding demand for the provision of satellite communications to developing countries within the frames of their national needs. This demand, especially for the countries of the Asia-Pacific and South African Regions, can be met by using their own small geostationary communication satellites.
2. The small geostationary communication satellites, which are already being developed and built by certain satellite developers, in particular, by SSTL, could be used not only for servicing developed countries with relatively small territories but also for countries that have much larger national territories. The use of these satellites for servicing the latter would be realized by deploying a satellite constellation with a progressive development for following the growing demand for capacity in these countries. This way will avoid the unused capacity which would result if a single larger geostationary communication satellite would be launched for the same purpose.
3. The best method for launching the small geostationary communication satellites for developing countries would be by dedicated launches with small launch vehicles and systems which have the capability to insert small payloads into GTOs and, if possible, directly into the GEO, from near-equatorial launch sites. With that, the launch prices for these missions should be comparable with the prices for the piggy-back launches of the same size of satellites by heavier launchers.
4. Certain small launch vehicles, especially the new ones that are planned to be put into operation by 2015, can provide this opportunity. Among them, the Russian "Air Launch" STS would be most suitable for this purpose thanks to a combination of various features that would provide additional advantages for the required missions.

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