

## MICRO- MINI- Satellites for Affordable EO Constellations: RAPID-EYE & DMC

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**Abstract:** Operational Earth Observation from space requires daily imaging of areas of interest. Single satellites cannot achieve this but constellations are ideally suited to providing multiple looks at land-based fast changing phenomena. The first low Earth orbiting satellite constellations attempted to provide mobile and multimedia communications on a global basis, but the extremely high investment and technical risk has led to business failures. However, microsattellites can for the first time provide an affordable constellation which will give operational EO coverage. In order to be economically viable such systems need to be based on new approaches that are associated with more affordable implementation and operating costs.

SSTL's low cost micro- and mini-satellites provide an affordable solution for profitable commercial space constellations. SSTL has pioneered the field of low cost small satellite technology for the past 21 years and based on its skills, experience and resources, is now set to execute a new breed of satellite constellations. SSTL's approach calls for low initial investment but can ensure realistic revenue returns.

SSTL has recently started work on RapidEye and the Disaster Monitoring Constellation (DMC) targeted for a variety of EO applications. These are pioneering the use of Low Earth Orbit constellations for Earth Observation. The DMC has forged the concept of a Novel International Partnership that provides the synergy of a multi-satellite constellation for nations each contributing a satellite, whilst retaining individual ownership. This heralds a new way of making access to space even more affordable.

**Zusammenfassung:** *Kostengünstige Micro- und Mini-Satelliten-Konstellationen: RAPID-EYE und DMC.* Die operationelle Erderkundung aus dem Weltraum erfordert die tägliche Beobachtung der interessierenden Gebiete. Einzelne Satelliten sind hierzu nicht in der Lage, Satelliten-Konstellationen jedoch sind geeignet, vielfache Blicke auf sich schnell ändernde Phänomene auf dem Festland zu werfen. Die ersten Satellitenkonstellationen in einem niederen Erdborbit sollten erdumfassende Mobilfunk- und Multimediakommunikation ermöglichen. Die extrem hohen Investitionen und technischen Risiken führten jedoch zu Geschäftseinbrüchen. Es ist aber erstmals möglich, mit Hilfe von Mikrosatelliten eine kostengünstige Konstellation zu realisieren, die eine Abdeckung zur operationellen Erdbeobachtung bietet. Damit ein solches System ökonomisch durchführbar ist, müssen ihm neue Herangehensweisen zugrunde liegen, die mit bezahlbaren Implementierungs- und Betriebskosten einhergehen.

Mit seinen kostengünstigen Mikro- und Minisatelliten präsentiert SSTL eine preiswerte Lösung für profitträchtige kommerzielle Weltraumkonstellationen. In den vergangenen 21 Jahren war SSTL Wegbereiter auf dem Gebiet der Niedrigkosten-Kleinsatellitentechnologie und geht nun – dank seiner Erfahrungen, Fähigkeiten und Ressourcen – daran, eine neue Generation von Satellitenkonstellationen herzustellen. Das Vorgehen von SSTL erfordert niedrige Einstiegsinvestitionen, garantiert jedoch realistische Gewinneinnahmen.

SSTL hat vor kurzem die Arbeiten an RapidEye und der Disaster Monitoring Constellation (DMC) begonnen, die auf vielfältige Erderkundungszwecke ausgerichtet sind. Sie markieren den Beginn der Nutzung von Satellitenkonstellationen im niederen Erdborbit für die Erderkundung. Mit dem DMC wurde das Konzept einer neuen internationalen Partnerschaft kreiert, das auf dem Synergieeffekt einer Mehrfachsatelliten-Konstellations beruht, zu der verschiedene Länder ihren Satelliten beisteuern, ohne dass ihr Eigentümerstatus geändert würde. Hier deutet sich ein neuer Weg an, den Zugang zum Weltraum noch kostengünstiger zu gestalten.

## Introduction

Space traditionally is funded by governments. The commercialisation of space has been attempted for many years, however the majority of funding for space activities still originates from governments. The only exception is the GEO communications satellites market which has been effectively and profitably exploited by the private sector.

In the mid 1990's, it was very popular for private investors to put money into new LEO communications constellations – such as Iridium. However the subsequent bankruptcy of Iridium and ORBCOMM has seriously undermined the confidence of the space investment market, especially in LEO constellations.

Taking advantage of many years of investment by the US government in Earth observation from space, EarthWatch with Ikonos has managed to initiate a commercial business in the hitherto difficult Earth Observation data market. As this business has just commenced, the market waits with interest to see whether it will prove truly commercially viable.

Surrey Satellite Technology Ltd (SSTL) in the UK has pioneered advanced micro-minisatellites over the last 20 years. Its range of low cost, rapid-response, small satellites has catalysed new business opportunities, especially based on commercial constellations, which have only matured during the last two years. SSTL has commenced work

on the Disaster Monitoring and the RapidEye EO constellations. This paper describes how SSTL and its products meet the demands of private investors, the current projects available for investment, and future business opportunities for small satellites.

## Symbiosis of Industry & Academia Yields Innovative Small Satellites which Create the Market

SSTL's strength is founded on the key concept of symbiotic academic and commercial partnership, allowing the Company to innovate rapidly and also appeal to a hitherto almost virgin market associated with in-depth satellite know-how transfer and training working with the Surrey Space Centre. SSTL's core business now has two complementary elements – know-how transfer & training missions and manufacturing turn-key satellite missions. Importantly, each of these businesses stimulates the other.

The opportunities offered by micro-mini-satellites in realising affordable constellations for Earth observation and LEO communications were first described at the IAF'96 and have since matured to reality by IAF'2000. Surrey's increasing reputation, built upon almost annual launches and rapidly developing capabilities demonstrated in orbit, has also catalysed a substantial number of 'turn-key' satellite manufacturing missions and, more recently, subsystems and studies.

## COTS and End-to-End Capability at SSTL

In parallel, SSTL pursued a policy of 'complete in-house capability' in order to decouple itself as far as possible from the onerous management and risk of relying unduly on subcontractors; to be able to react rapidly; and to be able to offer credible and detailed satellite know-how transfer & training. This policy also had the important effect of maintaining SSTL's independence from the 'aerospace establishment', a position that has proved highly advantageous. SSTL has developed a practical COTS satellite en-

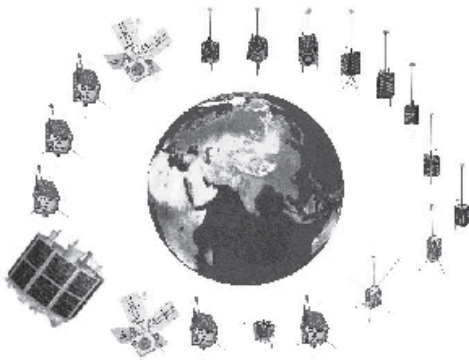


Fig. 1: 19 SSTL Satellites Launched.

gineering philosophy, backed by extensive real in-orbit experience, that has since become the benchmark for the small satellite community.

In addition to concentrating on complete satellites, SSTL has also ensured that it can offer a 'one-stop-shop' for complete mission requirements, including the supply of groundstations, launch services and insurance to those customers who need these.

### Low Cost, Regular Launches Critical to Market Development

SSTL has expended considerable marketing effort, since its formation, on promoting low cost launch facilities for micro-minisatellites as this has been a serious bottleneck in the commercial development of the low cost small satellite business – acutely illustrated within the USA. SSTL played a key catalytic role in the development of the first commercial secondary payload facility for micro-satellites on Ariane and in the commercialisation of secondary and affordable primary launches in the FSU. This has been fundamental to enabling SSTL to achieve a high mission launch rate and, consequently, a high innovation rate to meet customers' requirements.

### Low-Cost Micro-Minisatellites enable Affordable Constellations

The small satellite market sector has grown gradually during the last decade, but has recently gathered pace as the capabilities of micro-minisatellites to meet real applications has been demonstrated – particularly illustrated by SSTL through the landmark Thai-Paht & UoSAT-12 missions.

SSTL currently occupies over 80% of the accessible micro-mini satellite market sector – and the value of this sector is growing to become in excess of £ 100M p.a. in 2001.

SSTL's marketing activities have contributed substantially to the international impetus for the development of small satellites by repeatedly illustrating to both established and emerging space organisations the practicality and benefits of 'affordable access to

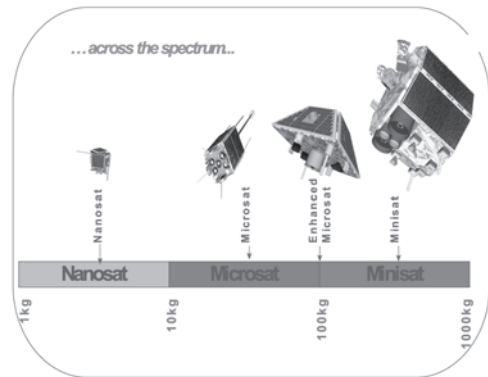


Fig. 2: Across the spectrum.

space'. Small satellites are now widely perceived as the most commercially practical means of implementing satellite constellations – and constellations are seen as the key to commercialisation of space.

By 2000, SSTL has diversified its product range to extend from 6 kg nanosatellites through 100 kg enhanced microsatellites to 400 kg minisatellites. These products have demonstrated in orbit a dramatic increase in technical capability – particularly associated with attitude and orbit control – which has successfully separated the Company from its nearest potential competitors in the market sector.

SSTL's ability to be selected for satellite contracts by space 'superpowers' NASA, USAF, French government/MoD, and by China to form the first satellite Collaborative Joint Venture manufacturing company in PRC, and the establishment of the Surrey Space Club with 11 international members, have contributed very substantially to the Company's strong market standing.

The recent decision by the UK government, through BNSC, to support small satellites and the subsequent award of £ 11M to SSTL to support three advanced product missions has further reinforced SSTL's reputation and position as a foremost commercial space company.

### Small Satellite Business

In order to win satellite contracts from established space countries, SSTL has, over 20 years:

- developed low cost small micro – mini-satellites
- developed “Low Cost Small Satellite System Engineering” techniques & practices
- accumulated extensive experience and expertise for low cost small satellite manufacture and orbital operations
- lived on the low cost small satellite market

Traditional satellite companies have been set up primarily to execute expensive government funded space missions therefore they are not tailored to take on low cost satellites contracts, which are rather unattractive compared to the business maintained by national government funding.

Stimulated by SSTL’s success, many small companies and universities are becoming active in the low cost small satellite market during the last few years, however most of them are not run on a fully commercial basis and also mainly rely on national government funding for missions or projects.

SSTL is probably the only truly commercial satellite manufacturing company which operates solely on the low cost small satellite market.

### Strengths of SSTL and SSTL’s Products

In order to create a commercially-sustainable market, SSTL has developed micro-minisatellite products and services that are:

- low cost
- rapid response
- utilise advanced technologies and has demonstrated these through extensive heritage based on:
- 19 micro-mini-nanosatellites built and launched and
- 9 microsatellite know-how transfer & training programs completed with international customers.

*Turn-key Satellites:* To date, SSTL has sold 16 turn-key satellites (i. e. satellites without

know-how transfer) to public and private organisations in the USA, France, and Germany.

*Satellite Know-how Transfer Programmes:* SSTL has sold know-how transfer and training programmes (including satellite and ground station unless noted) to:

- SUPARCO, Space and Upper Atmosphere Research Organisation, Pakistan
- KAIST, Advanced Institute of Science and Technology, South Korea
- ConsortioSat, Portugal
- Mahanakorn University, Thailand
- ATSB: a public-private partnership in Malaysia,
- Nanyang University, Singapore
- Tsinghua University, China
- TUBITAK-BILTEN research institute, Turkey
- CNTS: the national remote sensing centre, Algeria
- National Space Research and Development Agency, Nigeria

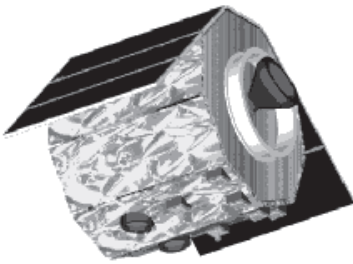
In the 15 years since the formation of SSTL, the Company has achieved a total sales worth £ 70M from the small satellite marketplace.

Over 20 years, Surrey has developed ‘Low Cost Small Satellite System Engineering’ concepts to manage this type of satellite manufacture which is very different from the traditional satellite manufacturing process – being nearer to a combination of concepts and techniques resulting in best practice from modern ‘Computer System Engineering & IT’ and ‘Traditional Satellite System Engineering industries.

### EO Constellations for Small Satellites

The rapid development of micro-minisatellite capabilities demonstrated in orbit during the last 2 years by SSTL has catalysed commercial constellations of small satellites such as the RapidEye, GANDER and DMC constellations targeted for a variety of applications.

*RapidEye Constellation:* SSTL has been selected for the German RapidEye constellation of four 380 kg Earth Observation mini-



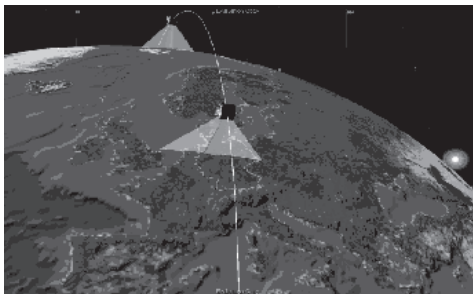
**Fig. 3:** RapidEye Minisatellite.

satellites designed for mapping and agricultural applications.

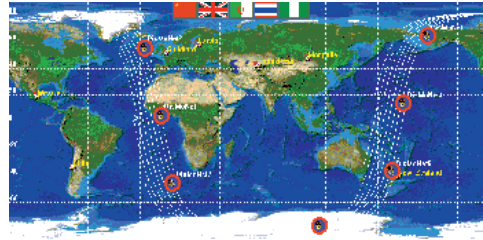
RapidEye will provide 6.4 m GSD, wide swath 6-band multispectral imaging with daily revisits in the European region for precision farming and improved crop harvest prediction.

RapidEye will generate a significant impact upon the agriculture and food trading sectors. The total budget of the constellation is approximately \$100M including satellites, launches and groundstations.

*Disaster Monitoring Constellation (DMC):* Lastly, the Disaster Monitoring Constellation (DMC) of at least 5–7 satellites led by Surrey, is being built with the humanitarian objective of disaster assessment, monitoring and mitigation and the commercial objective of dynamic remote sensing services. The DMC consists of an international consortium of partners. Each partner owns one satellite and the whole constellation will be managed by a DMC consortium to share satellite resources in the constellation. The



**Fig. 4:** RapidEye constellation of 4 minisatellites.

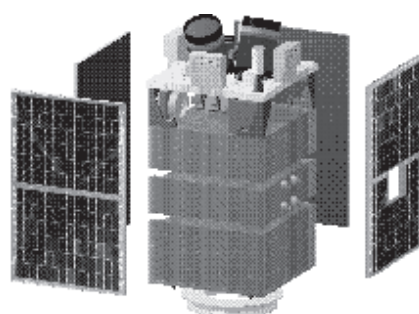


**Fig. 5:** Disaster Monitoring Constellation of 5–7 MicroSatellites.

British government supports one satellite, through the British National Space Centre Small Satellite Initiative, and the other partners include Algeria, Nigeria, China, and Thailand.

The constellation will comprise five 70 kg enhanced microsatellites – each satellite being contributed by a consortium of international partners. The DMC will provide 36m GSD multispectral (Green, Red and Near-Infrared) with an extreme swath width of 600 km. Two cameras consisting of 10,000 pixels linear CCD arrays will be mounted side by side, at fixed offset, to provide the 600 km swath (with a 120 km overlap).

The DMC is the first example of a Novel International Partnership whereby 5 different organisations each contribute a microsatellite into the constellation – to be operated in concert whilst maintaining individual ownership. Each partner thus derives significant synergy benefits. The constellation is scheduled to be launched in 2002 into a 686 km sun synchronous orbit.



**Fig. 6:** DMC Microsatellite.

### **International Collaboration through-Surrey Space Club**

In order to promote and provide a means of developing international co-operation, as exemplified by the DMC, the Surrey Space Club was formed in 1998.

The Surrey Space Club provides ongoing after-sales-services for KHTT customers, help on maintaining sustainable national space programmes and promotion of international long-term co-operation.

The members of Surrey Space Club are able to participate the following activities co-ordinated through an annual conference of members:

- share satellite resources in orbit
- share global groundstation network
- exchange new ideas on research and development
- build small satellite constellations together
- co-ordinate low cost launch opportunities
- assist in long-term national space program planning

### **Future business opportunities for small satellites**

On completion of the DMC, SSTL is planning to call for participation every two or three years for the following low cost small satellite constellations:

- Ionospheric measurement for Earthquake prediction
- Microwave measurement of temperature for Earthquake prediction
- Higher Resolution Optical Enhanced Micro-satellites (~ 2 metre GSD)
- Higher Resolution Optical Mini-Satellites (~ 1 metre GSD)

- IR Imaging Minisatellites
- SAR Minisatellites
- LEqO or NEqO remote sensing micro-mini-satellites
- LEqO or NEqO microsatellites and minisatellites for communications
- Swarms of Nano-satellites
- Navigation minisatellite constellations

### **Conclusions**

The demonstrated capability of the latest SSTL microsatellites and minisatellites has catalysed new business opportunities, particularly associated with affordable constellations for optical Earth observation and radar remote sensing.

Compared with conventional satellites, these modern small satellites now enable any country, company or university to have direct access to and benefit from space at low cost, low risk and on a short timescale.

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