SURREY SATELLITE TECHNOLOGY LTD

Changing the economics of space

Council for Space x ICT

Ministry of Internal Affairs & Communications

ICT Business with Micro/Mini-Satellites

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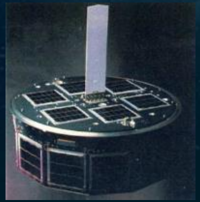
Executive Chairman SSTL

25th January Tokyo

Small satellites

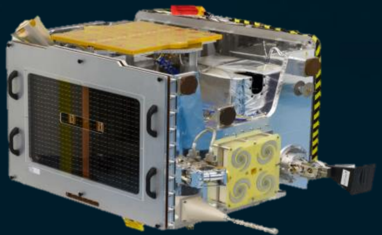
Small satellites are not new but, since the early 1980's, they have evolved steadily in their capabilities and most importantly their utility – to the point where, in the last few years, they have provided both lower cost and more responsive solutions to meet many well-trodden applications whilst also stimulating completely new business models.

This has fundamentally changed the economics of space … for both the civil and the security/defence sectors.



Key characteristics:

- Physically small
- Low cost of manufacture & launch
- Rapid development and build
- Use of up-to-date technology ('COTS')
- An 'IT' management approach – innovative & agile small teams
- Flexible orbital operations



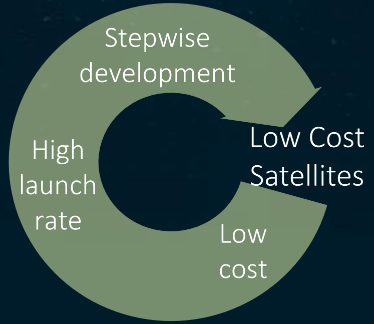
Small satellites

The underlying technologies that have enabled this 'peaceful revolution' have come from the enormous investments made by the industrial and domestic consumer sectors.

These have created mass markets for their products … reducing the unit production costs by orders of magnitude whilst at the same time achieving high yield and reliability through a parallel revolution in manufacturing & production techniques.

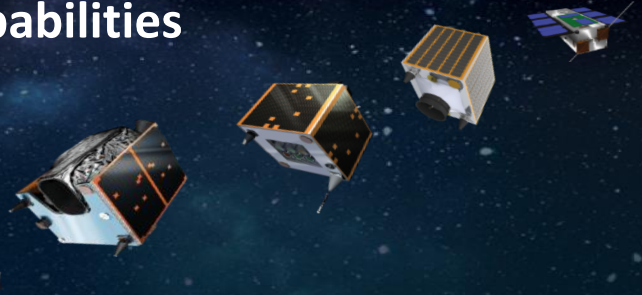
So far, the evolution of small satellites has been driven primarily by advances in microelectronics, whilst the structural designs have remained based largely on conventional techniques.

philosophies



Small satellites

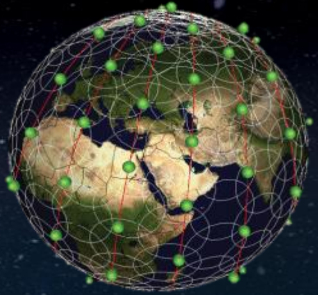
Different applications need different capabilities

Countries operating small satellites

Brought access to space within reach of every nation, smaller organisations & businesses

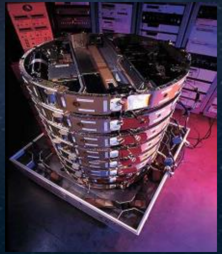
Small satellite constellations

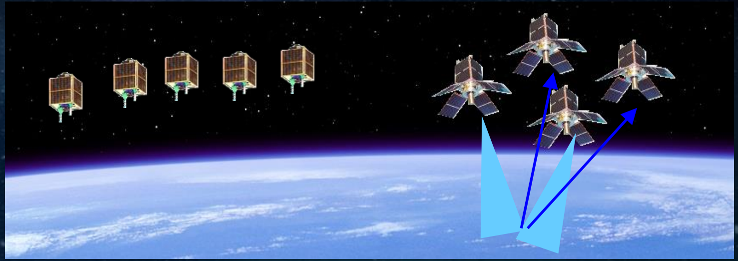


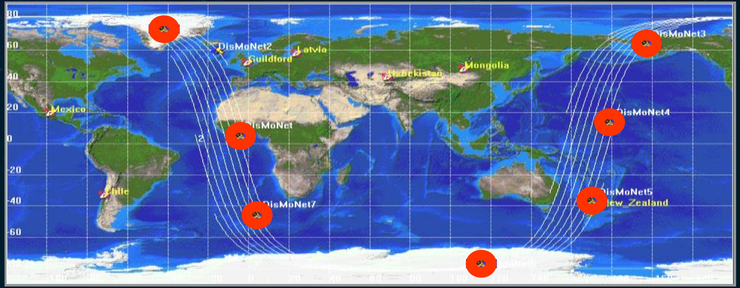
The lower unit cost of small satellites has made constellations economically practical - primarily in low Earth orbit.

The first applications were for digital store-&-forward communications in the 1990's (before www) e.g. HealthSat, Orbcomm, Iridium, Globalstar

Optical Earth Observation from smallsats took longer to become operational, from around 2005, but now provide high resolution pan, m/s & video







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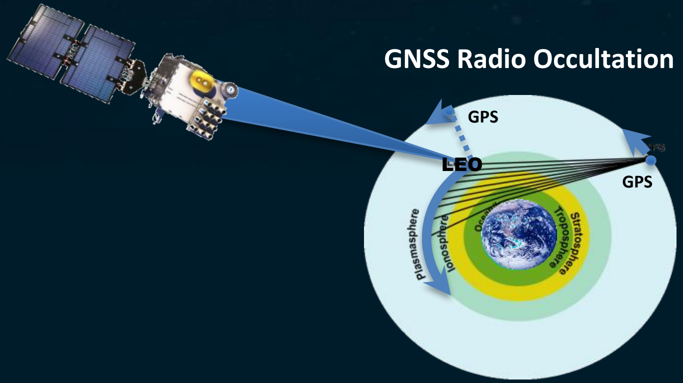
Small satellite constellations

Many new initiatives have emerged, enabled by the rapidly maturing Smallsat technologies:

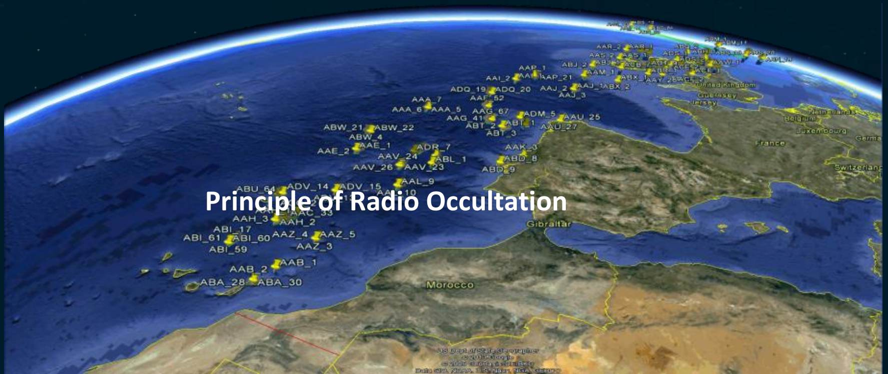
- Ship & Aircraft tracking
- Smart cities, agriculture, pollution management
- M-2-M digital communications
- Responsive disaster monitoring & management

AIS-B ship tracking

GNSS Radio Occultation

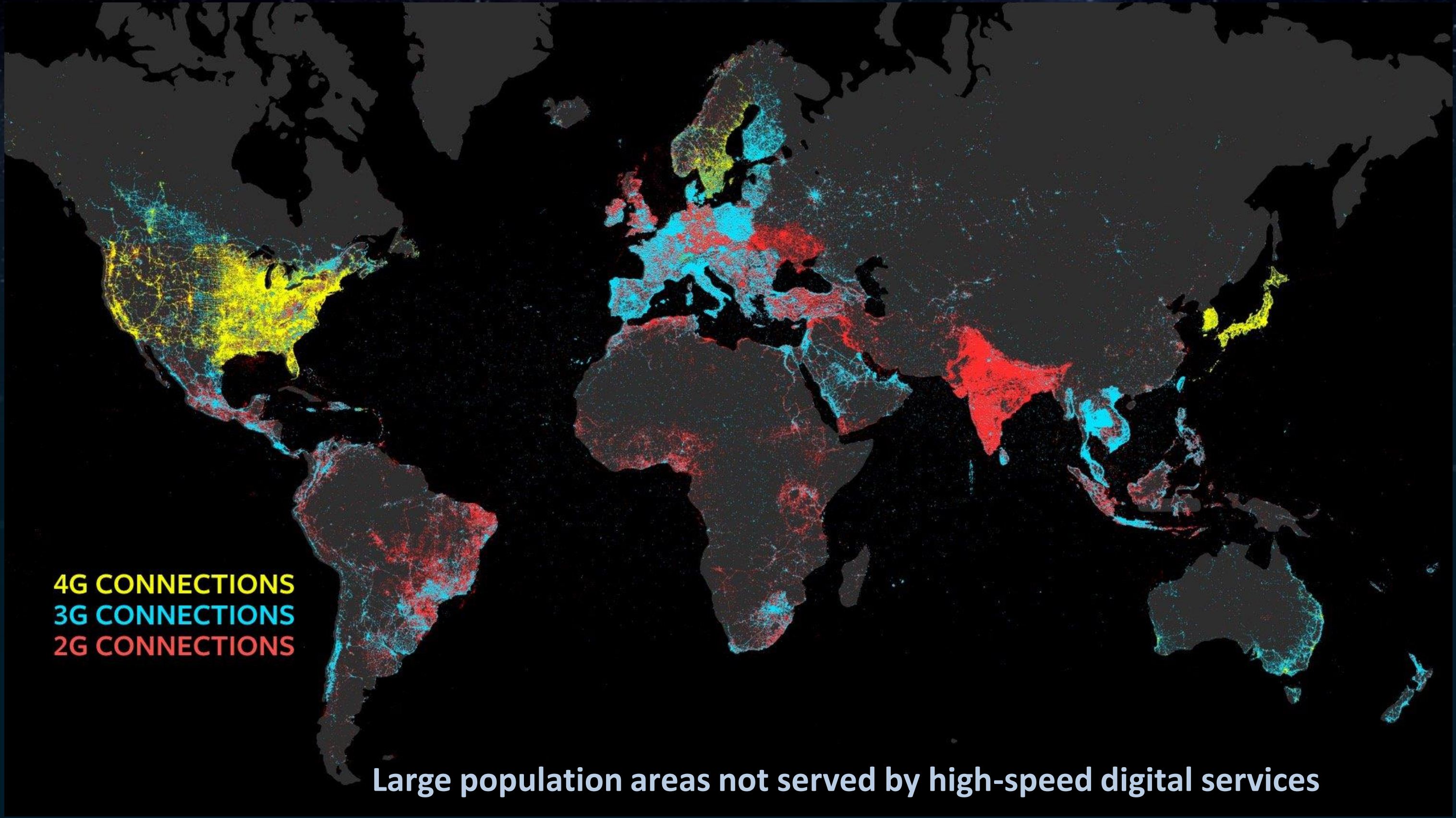


ADS-B aircraft tracking



Principle of Radio Occultation

Terrestrial digital connectivity



http://mybroadband.co.za/news/internet/172964-what-the-world-looks-like-in-2g-3g-and-4g.html

Global digital connectivity

Traditional GEO SAT communications well established

- Overlay to fibre
- Remote region service
- DTH broadcast and broadband internet connectivity

Big GEO satellites are getting BIGGER!

- Higher power – smaller ground terminals
- $/MHz/Mbps capacity efficiency

Appetite for smaller GEO satellites

- Reduce capital investment for start-up services
- Service augmentation
- Frequency filing

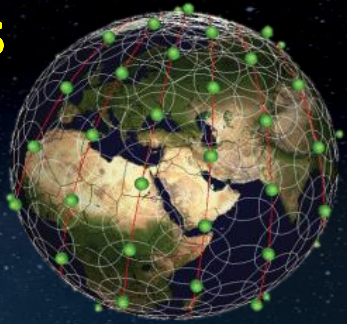
Advantages

- Wide regional coverage
- Simple ground terminals

Disadvantages

- Costly launch
- Latency – becoming critical for some digital applications
- High radiation environment

LEO communications constellations



New business models enabled by small satellite development

- Low unit cost
- Constellations (10-100-1000's)
- Multiple launch requirement stimulating launcher market
- Unique solution for financial markets
  (ΔmS advantage wrt Fibre)
- Global coverage possible (incl. high latitudes)

Questions…

- Constellation capital cost?
- Launch costs - $/kg?
- Business plan - revenues/cost (RoI)?
- Launcher capacity?

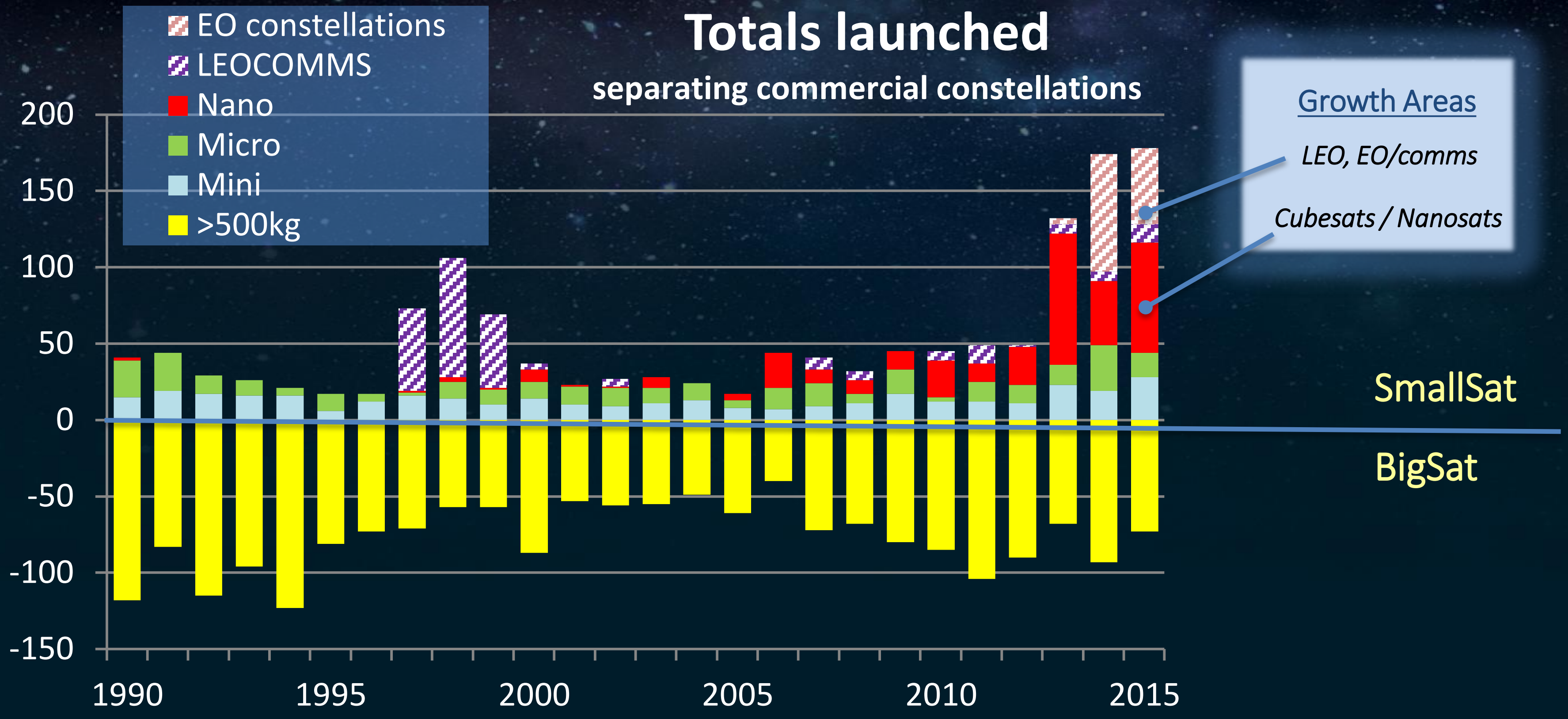
Advantages

- Link budget – smaller terminals
- Low latency
- Resilience to failures
- More launch options
- Frequency reuse
- High latitude coverage

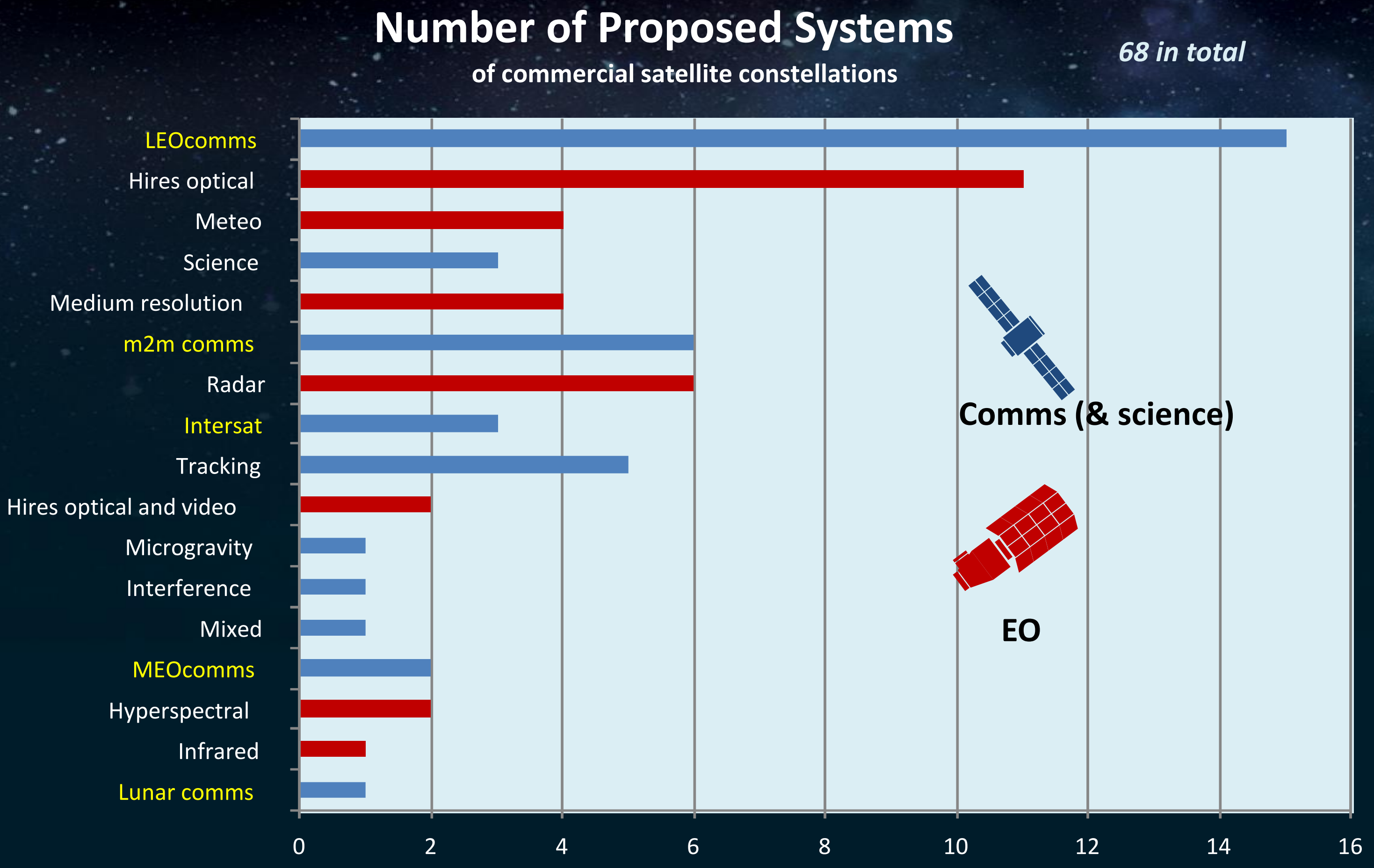
Disadvantages

- Many satellites needed
- Agile beams – hand-over
- Inter-satellite links
- Battery cycles / doppler

Small satellite market



Small satellite constellations

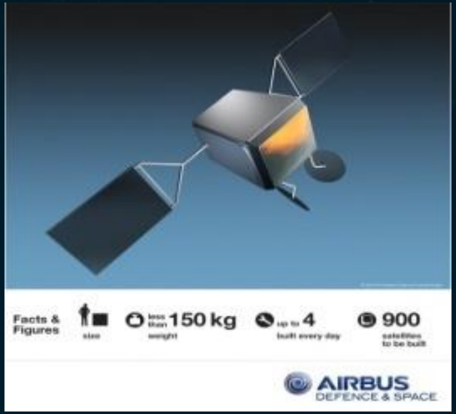


Small satellite communications constellations

System	#satellites	Mass class
Iridium (voice+data)	Gen 1: 93 (late 1990's) Gen 2: 66	700→ 860kg
GlobalStar (voice+data)	Gen 1: 72 (late 1990's) Gen 2: being deployed now	480→ 700kg
Orbcomm (M2M)	Gen 1: 32 (+6) current Gen 2: 19	50 → 150kg

New generation, "5G", Ka-band & V-band comms

System	#satellites	Mass class
OneWeb	648	<200kg
Boeing	3000	"small"
Samsung	4600	"small"
SpaceX STEAM	4000	200-300kg
LEOSAT	80-140	"small"



Small satellite constellations

~19 systems proposed comprising over 10,000 satellites

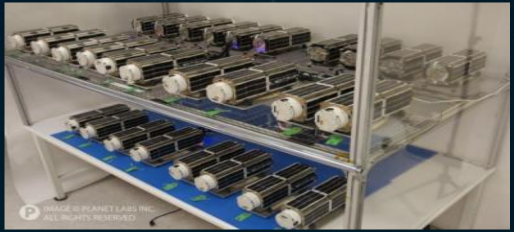
	#satellites	Mass class
SkyFi	60	<10kg
Outernet	100	<10kg
Yaliniy	135	
Sky Space and Global	200	<10kg
Blink Astro	12	
80LEO	288	~150kg
Commstellation	Up to 800	~150kg
Kepler communications	?	<10kg
Audacy	200	<10kg
…		

Addressing a range of applications including IOT, M2M, etc.

Small satellite business models

Galassia (2015)
NUS, Singapore

QEYSAT (planned) Canada



Non-traditional (space) business models

Venture capital, Public Private Partnerships

IT business models

High development pace – technology freshhness

Focus on applications and end-users

CLOUD storage and computing

Web-based services

Crowd-funding

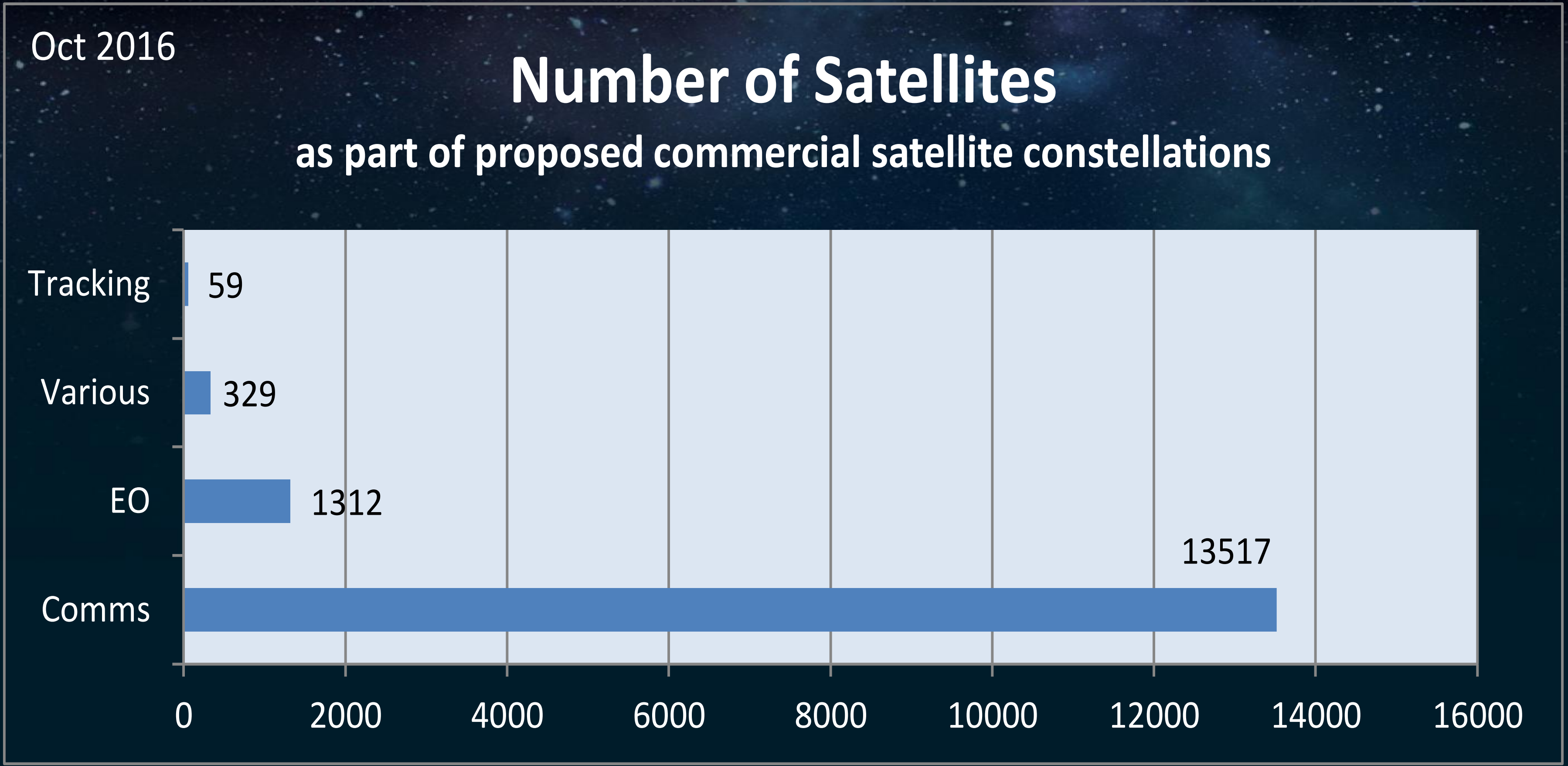
Ardusat / Nanosatisfy and Skycube satellites launched

Coming soon…

- Optical inter-sat and sat-gnd data links
- Quantum key distribution

System	#satellites	Mass class
Laserlight	12	?
BridgeSat	50	150kg
SpaceBelt	16	?
…		

Small satellite business



Future developments

In the last 5 years the pace of microelectronics development has continued to accelerate – much in line still with the observation in the 1960's by Gordon Moore.

But… there has been a parallel development in new materials combined with robotics that have given rise to new satellite/spacecraft manufacturing techniques that enhance small satellite capabilities but also further reduce cost and timescale.

Robotic additive (and subtractive) manufacturing techniques now make possible product geometries that were previously physically impossible by human hands.

Digital manufacturing provides freedom of location and dramatically increased speed of the design evolution and the product innovation cycle.

Digital factory (e.g. OneWeb)

↓

Software-defined satellites

↓

In-orbit assembly

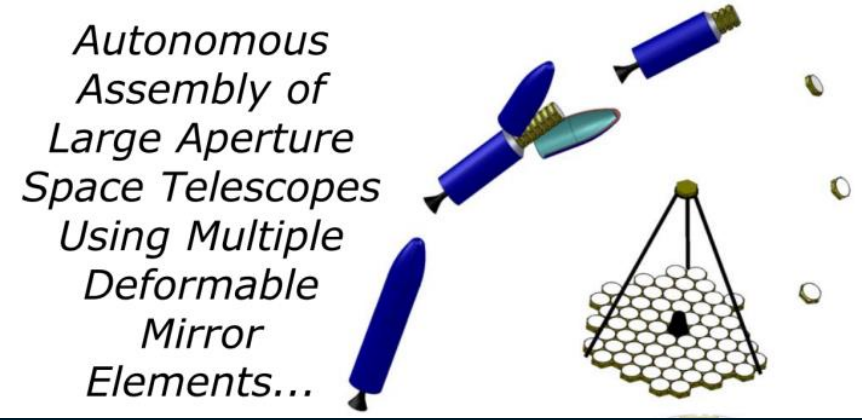
↓

In-orbit manufacture

In-orbit assembly / reconfiguration

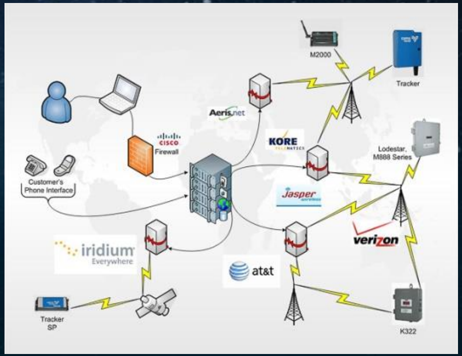
Increasingly large apertures are needed in space for astronomical, EO and Comms applications. These can only be achieved through in-orbit robotic assembly

UK-US ARReST demonstration project



Small satellite constellations

These factors have come together to stimulate new innovative space system proposals – taking advantage of the design agility, low unit cost and rapid manufacturing delivery to make constellations of 100’s, even 1000’s, of small satellites practical that could enable new infrastructures providing ubiquitous access to high speed digital communications and unparalleled persistence of global Earth observation.



At the same time, the growth of the various terrestrial communications infrastructures and advances in data handling, management and knowledge extraction – often referred to as ‘Big Data’ – have blurred the boundaries between space and terrestrial systems.

Synergy of space & terrestrial systems leading to ad-hoc communications networks

Small satellite constellations

These new ‘mega’ constellations also pose additional challenges

- regular, affordable launch on a tempo hitherto not achieved
- space traffic management and debris control
- the efficient handling communication of vast amounts of data
- safe autonomous orbital operations
- communications spectrum and legal or policy issues.

However, like the extraordinary number and diversity of ‘SmartPhone Apps’ that have been created by a completely new business community, most of which we would not have dreamed of a decade ago, it is probable that the new smallsats and constellations will stimulate applications that we currently do not envisage

Orbital debris and small satellites

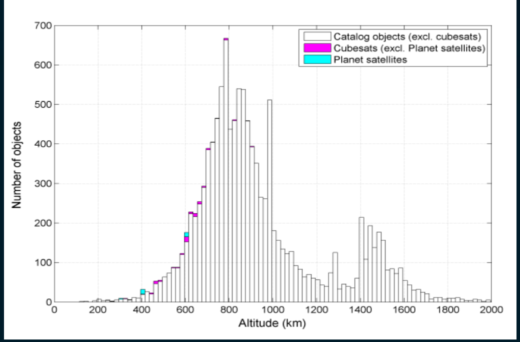
Space debris is a issue for all of the space community.

Widespread misconception that only satellites are major contributors

- Key contributors to the debris problem are defunct upper stages & large satellites
- Small satellites rarely carry pressure tanks, pyro devices or other energetic systems
- Cubesats are predominantly launched in orbits with lifetimes much less than the recommended 25 years
- 100 Cubesats have the same cross sectional area as a typical 500kg satellite
- The key issue is actually tracking and manoeuvrability
- Mega-constellations also introduce space systems not previously considered in debris population modelling.

We expect the small satellite community to come up with technologies and solutions

- Clean-up missions with capture technologies.
- De-orbit technologies, including tethers, sails, electric propulsion
- Operator assisted tracking, beacons and retroreflectors?



http://www.spacenews.com/article/opinion/42329another-view-on-cubesats-and-debris
https://www.planet.com/pulse/keeping-space-clean-responsible-satellite-fleet-operations/?utm_content=buffera312c

What does this mean for exploration?

Small satellite techniques

- Will not replace the ‘hi-fi’ science observatories and missions
- Can provide complimentary science – increased temporal/spatial measurements
- Support the exploration infrastructure – communications & navigation/timing
- Increase tempo of focussed exploration
- Encourage a reduction in overall cost
- Provide opportunities for wider global participation in exploration – public/private
- Introduce a ‘commercial’ element into exploration - exploitation

Conclusions

We have seen an unprecedented investment in the industry in the last few years

We have never built or planned to build so many “small” satellites

Commercial ventures are redefining what space can offer the users

New applications, new business models, new challenges

Small satellites tending to optimise for size & capability

BUT…

- Remember IRIDIUM & GLOBALSTAR
- Huge investments
- Return on investment expected by investors
- Expect consolidation

http://www.bloomberg.com/news/features/2015-01-22/the-new-space-race-one-man-s-mission-to-build-a-galactic-internet-i58i2dp6