Sixty years of satellites- but an older idea (1687)

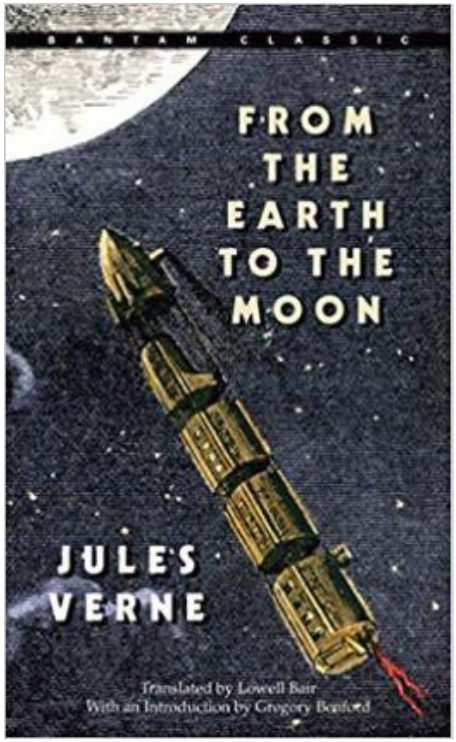
Sir Isaac Newton

Amount of Gunpowder	What Happens
2 bags of gunpowder:	Cannonball goes faster and gets farther before gravity pulls it back to Earth.
3 bags of gunpowder:	Cannonball is going so fast that it falls all the way around the world. It is in orbit!
4 bags of gunpowder:	Cannonball orbits Earth again, but goes even higher at the peak of its arc.
5 bags of gunpowder:	Cannonball is going so fast it completely escapes Earth's gravity and heads out into space, maybe to an asteroid or Mars or Jupiter!

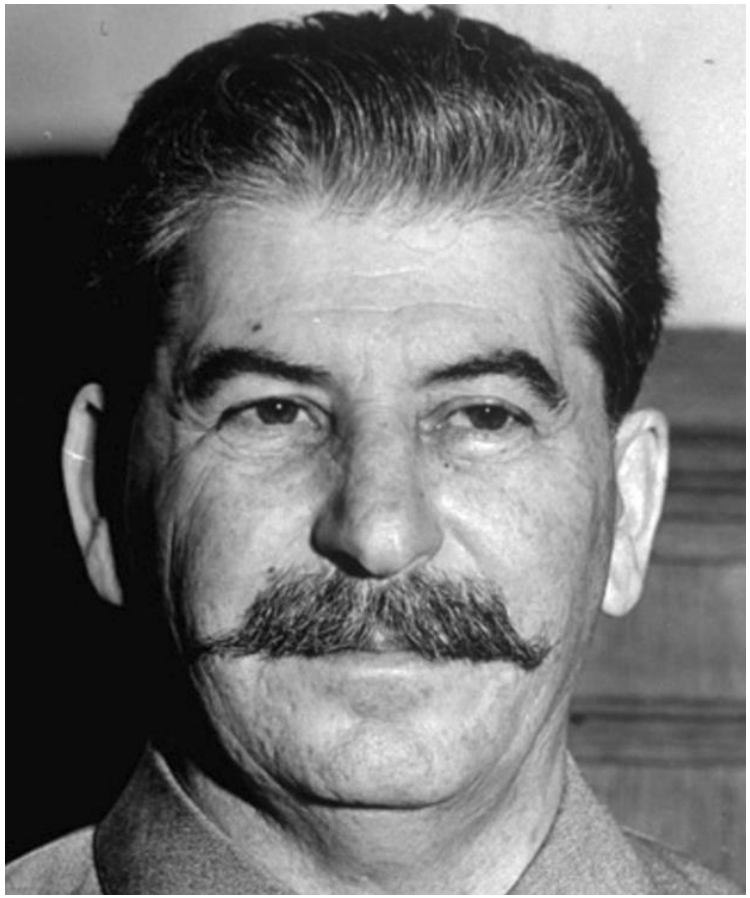
https://spaceplace.nasa.gov/how-orbits-work/en/

1865 Jules Verne

- Inspired by advances in ballistics in the American Civil War
- The Gun Club – a launch in Florida, manned mission with three crew members flying in an aluminium spacecraft
- Exactly 100 years before Apollo 8
- Inspired a 11 year old Romanian Herman Oberth- the concept of a recoil rocket



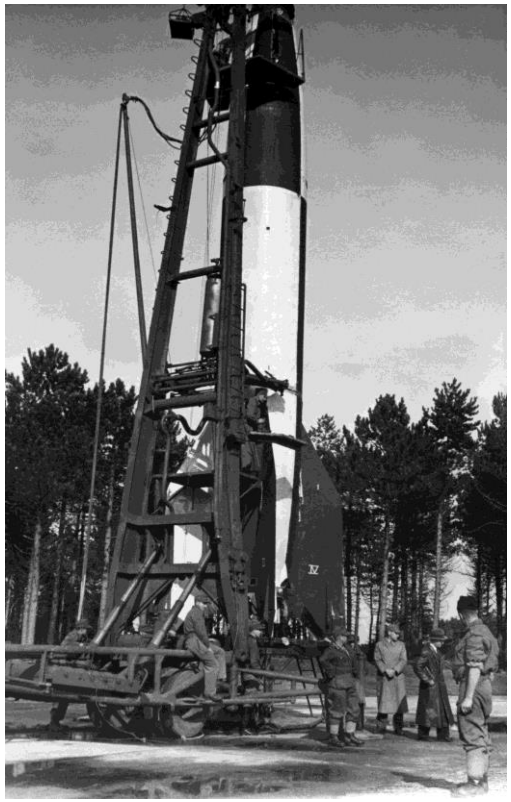
Russian Rockets

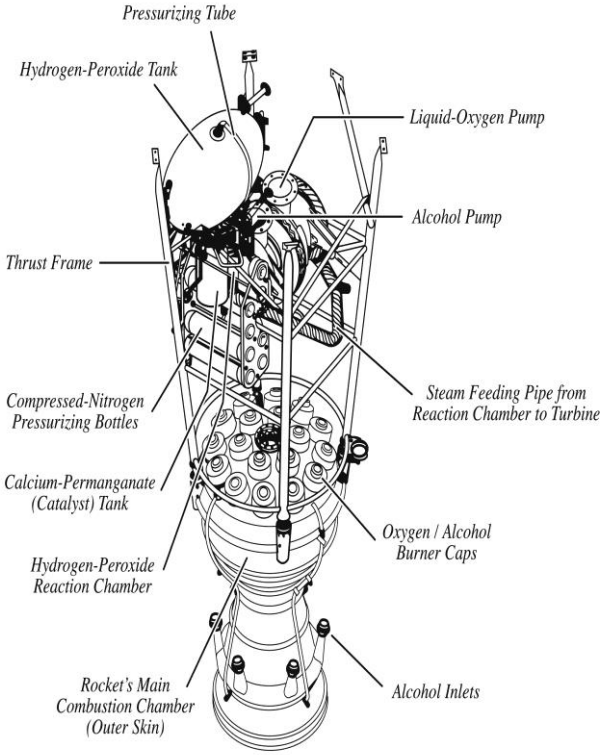


US Rockets

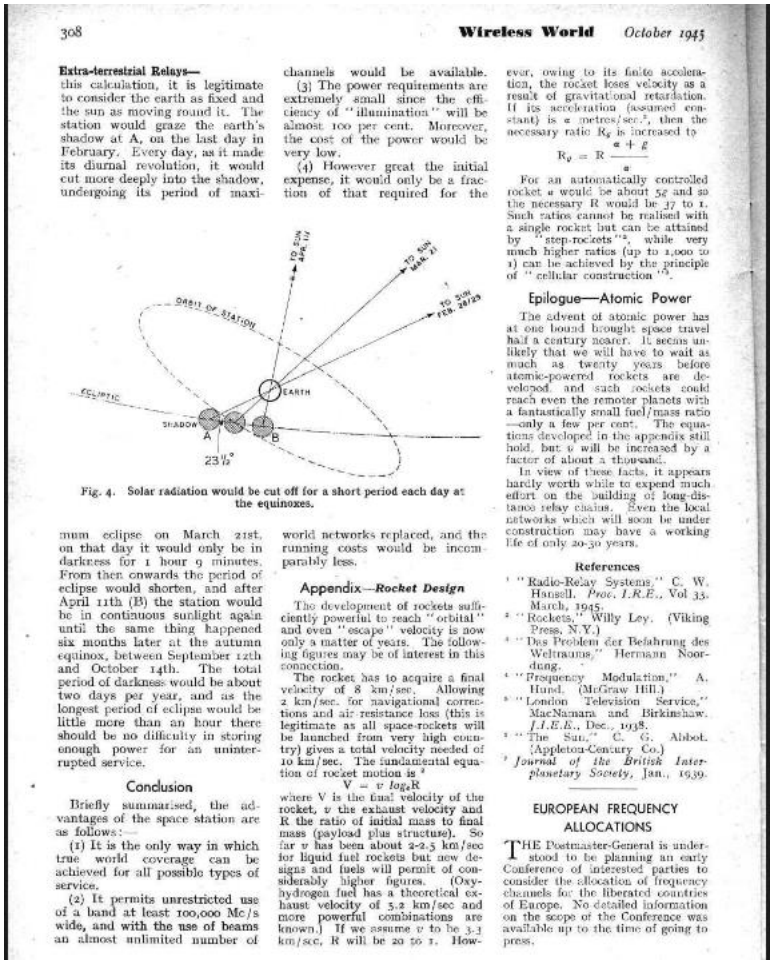
Robert (Goddard) with Rocket in Roswell
1935

German rockets





Mr Clarke



Extra-terrestrial Relays—

this calculation, it is legitimate to consider the earth as fixed and the sun as moving round it. The station would graze the earth's shadow at A, on the last day in February. Every day, as it made its diurnal revolution, it would cut more deeply into the shadow, undergoing its period of maximum eclipse on March 21st, on that day it would only be in darkness for 1 hour 9 minutes. From then onwards the period of eclipse would shorten, and after April 11th (B) the station would be in continuous sunlight again until the same thing happened six months later at the autumn equinox, between September 12th and October 14th. The total period of darkness would be about two days per year, and as the longest period of eclipse would be little more than an hour there should be no difficulty in storing enough power for an uninterrupted service.

Conclusion

Briefly summarised, the advantages of the space station are as follows:—

(1) It is the only way in which true world coverage can be achieved for all possible types of service.

(2) It permits unrestricted use of a band at least 100,000 Mc/s wide, and with the use of beams an almost unlimited number of channels would be available.

(3) The power requirements are extremely small since the efficiency of "illumination" will be almost 100 per cent. Moreover, the cost of the power would be very low.

(4) However great the initial expense, it would only be a fraction of that required for the world networks replaced, and the running costs would be incomparably less.

Fig. 4. Solar radiation would be cut off for a short period each day at the equinoxes.

Appendix—*Rocket Design*

The development of rockets sufficiently powerful to reach "orbital" and even "escape" velocity is now only a matter of years. The following figures may be of interest in this connection.

The rocket has to acquire a final velocity of 8 km/sec. Allowing 2 km/sec. for navigational corrections and air resistance loss (this is legitimate as all space-rockets will be launched from very high country) gives a total velocity needed of 10 km/sec. The fundamental equation of rocket motion is [7]

$$V = v \log_e R$$

where V is the final velocity of the rocket, v the exhaust velocity and R the ratio of initial mass to final mass (payload plus structure). So far v has been about 2-2.5 km/sec for liquid fuel rockets but new designs and fuels will permit of considerably higher figures. (Oxy-hydrogen fuel has a theoretical exhaust velocity of 5.2 km/sec and more powerful combinations are known.) If we assume v to be 3.3 km/sec, R will be 20 to 1. However, owing to its finite acceleration, the rocket loses velocity as a result of gravitational retardation. If its acceleration (assumed constant) is α metres/sec.^{2}, then the necessary ratio R_g is increased to

$$R_g = R \frac{\alpha + g}{\alpha}$$

For an automatically controlled rocket α would be about 5g and so the necessary R would be 47 to 1. Such ratios cannot be realised with a single rocket but can be attained by "step-rockets"[2], while very much higher ratios (up to 1,000 to 1) can be achieved by the principle of "cellular construction"[3].

Epilogue—Atomic Power

The advent of atomic power has at one bound brought space travel half a century nearer. It seems unlikely that we will have to wait as much as twenty years before atomic-powered rockets are developed, and such rockets could reach even the remoter planets with a fantastically small fuel/mass ratio—only a few per cent. The equations developed in the appendix still hold, but v will be increased by a factor of about a thousand.

In view of these facts, it appears hardly worth while to expend much effort on the building of long-distance relay chains. Even the local networks which will soon be under construction may have a working life of only 20-30 years.

References

[1] "Radio-Relay Systems," C. W. Hansell. *Proc. I.R.E.*, Vol 33, March, 1945.

[2] "Rockets," Willy Ley. (Viking Press, N.Y.)

[3] "Das Problem der Befahrung des Weltraums," Hermann Noordung.

[4] "Frequency Modulation," A. Hund. (McGraw Hill.)

[5] "London Television Service," MacNamara and Birkinshaw. *J.I.E.E.*, Dec., 1938.

[6] "The Sun," C. G. Abbot. (Appleton-Century Co.)

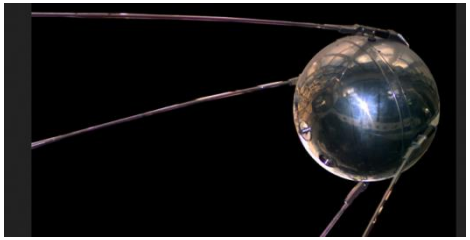
[7] *Journal of the British Interplanetary Society*, Jan., 1939.

EUROPEAN FREQUENCY ALLOCATIONS

THE Postmaster-General is understood to be planning an early Conference of interested parties to consider the allocation of frequency channels for the liberated countries of Europe. No detailed information on the scope of the Conference was available up to the time of going to press.

Sixty years of satellites- politics and power

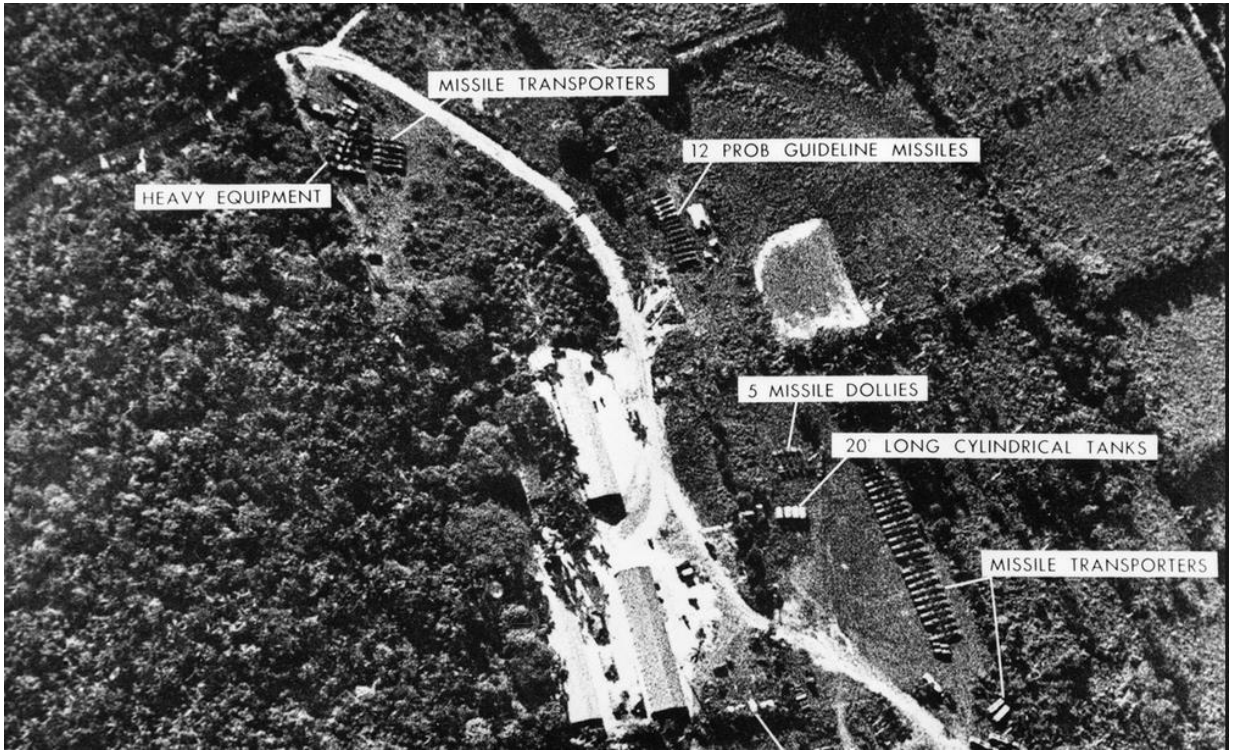
- USSR Sputnik 1 1957



- NASA October 1 1958
- April 12 1961 Yuri Gagarin - The First Man…. 108 minutes in space

Sixty years of satellites- politics and power

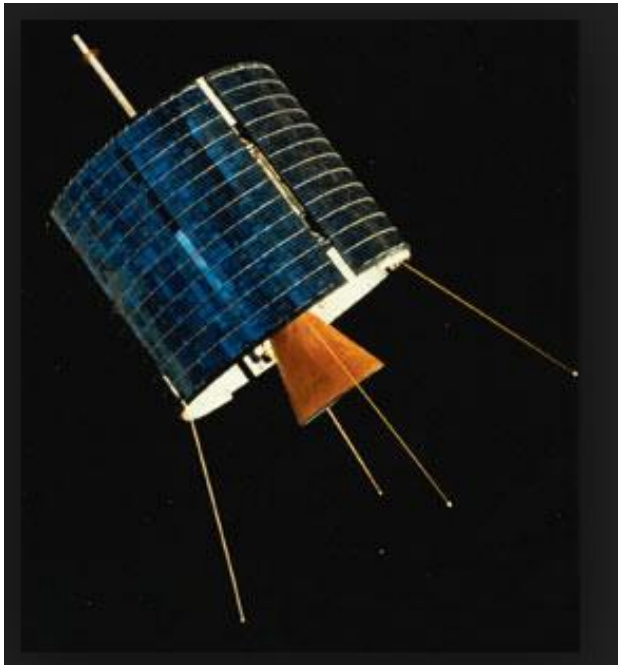
- Cuban missile crisis October 1962



- 1962 Satellite Communications Act to allow the US Government to supervise fair access for commercial satellites

Satellite communications

- July 10 1962- AT& T and Bell Labs, The Post Office and French PTT launch of Telstar 1- world's first communications satellite
- 170 kilograms,14 watts,3600 solar panels, 600 phone calls and one Black and White TV channel- low earth orbit (two and a half hours)
- Transmissions between Europe and the US for twenty minutes each orbit



Satellite communications

- 1963 First geosynchronous satellite launched
- April 1965 Intelsat's first satellite Intelsat1 'Early Bird' placed in Geostationary orbit by a Delta D rocket
- 'TV and telephone and telegraph and high speed data'. (Quad play!)
- Satellite Communications Act created Comsat which became **Intelsat** in 1964 – 17 nations
- Country signatories could be government or private operators or a mix usually termed Public Telecommunication Operators (PTO) – known as the 'closed skies' era
-

Satellite industry – Intelsat

- 1965 Intelsat 1
- TV moments
- 1969 Moon Landing

- 1985 Live Aid Concert
- 1989 HD TV US and Japan
- 2000 Sydney Olympics

Satellite industry – Inmarsat- closed skies to open skies

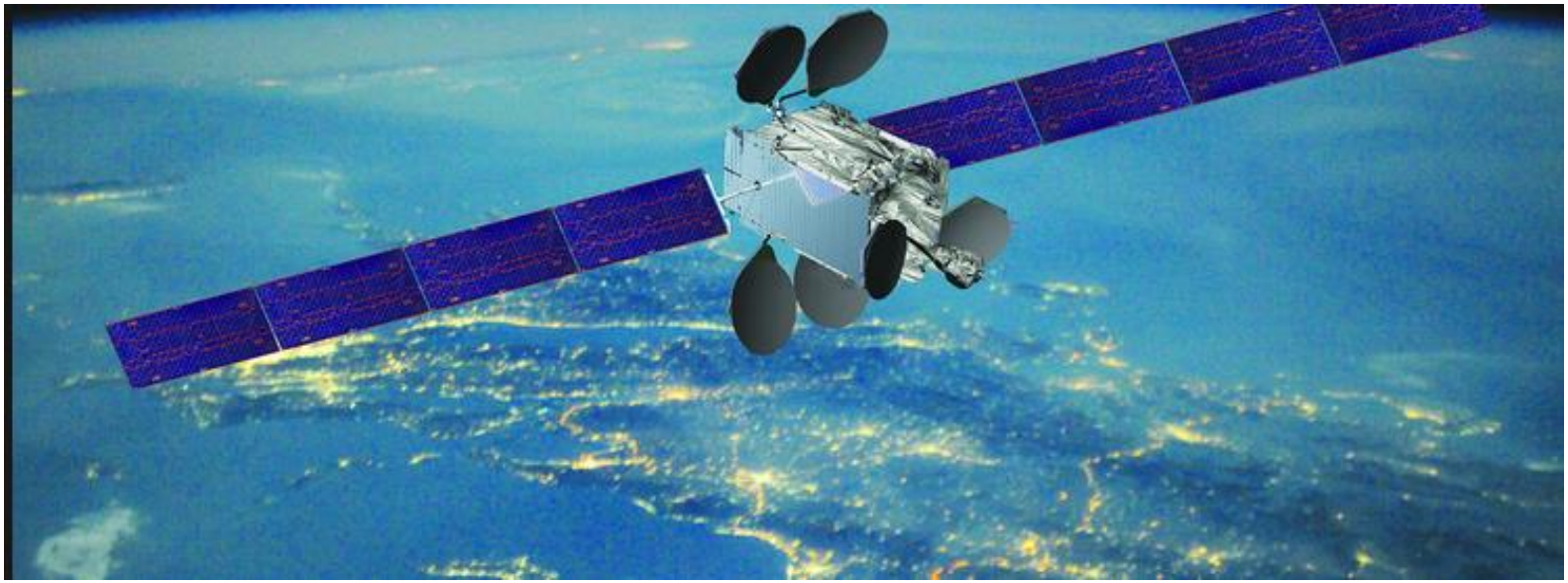
- 1990's ITU starts discussing 'Open Sky' Policy
- Inmarsat SOLAS - safety of life at sea
- **In**ternational **Mar**itime **Sat**ellite Organisation formed in 1976 – acted as an ISO (International Service Operator)
- 1982 Inmarsat provision of mobile satellite communication services
- 1989 Land Mobile Service
- 1990 Aeronautical Service (for aircraft).
- 1999 First company to deregulate (1999)
- 1999 to present – Inmarsat 4 and 5

Satellite industry – Inmarsat Ka Band

- **I-5 body** –6.98 metres (22.9ft), the height of a double decker bus
- **User beams** – 89 Ka-band beams generated by two transmit and two receive apertures
- **Spot beams** – six steerable on demand spot beams
- **Solar arrays** – a wingspan of 33.8 metres (111ft)
- **Solar panels** – five panels of ultra triple-junction gallium arsenide solar cells generate 15 kW of power at start of service and 13.8 kW by end of life
- **Station-keeping thrusters** –xenon ion propulsion system (XIPS)
  Launch mass – 6,100kg
- **Mission lifespan** – 15 years

Satellite industry – Intelsat –

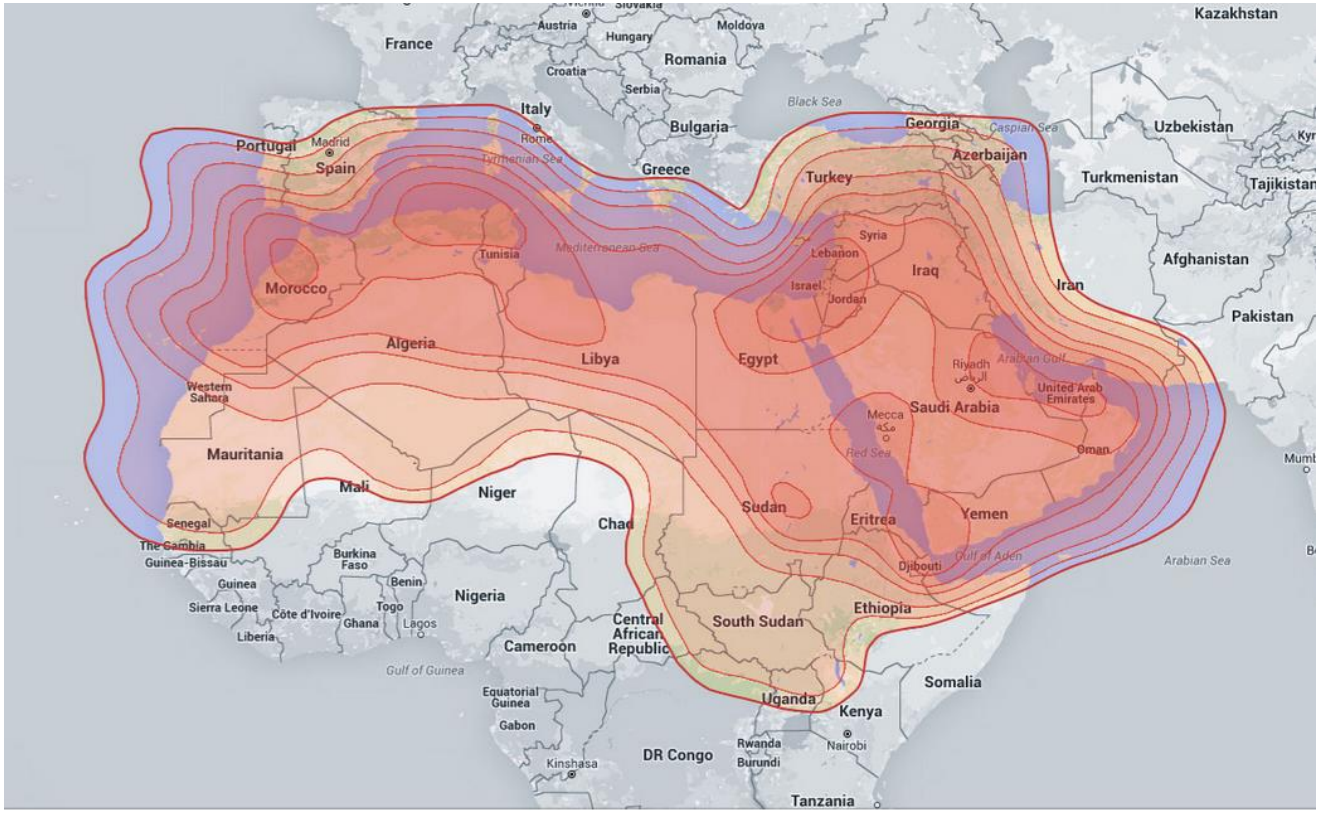
- Commercial and technical evolution
- 2001 Privatisation (two years after Inmarsat)
- Coincides with dot com bust, telecoms meltdown and fibre glut (dark fibre impact on revenue)
- 2006 Acquires Pan Am Sat – becomes world's largest fixed service satellite service provider
- 2009 $3.5 billion fleet investment and hosted payload agreement with the Australian defence force
- 2012 Intelsat EPIC announced C Band, KU and Ka Band high throughput satellite (HTS) with spot beams
- Ku-band user spot beams on first two satellites



Eutelsat

- Formed 1977 to operate first European satellites (launched 1983)
- 1990-2000 post Berlin Wall (November 1989)
- Eutelsat extended to cover Eastern Europe- Hot Bird satellites
- Privatised in July 2001. IPO in 2005
- HOT BIRD broadcast satellite service to Russia, the Middle East, Turkey and Africa
- Acquisition of Satmex (Mexico) in January 2014, commercialised capacity on 40 satellites providing coverage of Europe, Africa, the Middle East, Asia and the Americas.
-

Arabsat



Founded in 1976 by the 21 member-states of the Arab League
Six satellites, at 3 orbital positions, 20°, 26°, 30.5° East: Arabsat-5C (20°E), BADR-4, BADR-5, BADR-6 and BADR-7 (26°E), Arabsat-5A (30.5°E) including Ka Band.
Market-Specific Spot beams.(North W.Africa, W Africa, S.Africa, East MENA and C.Asia)

Hispasat

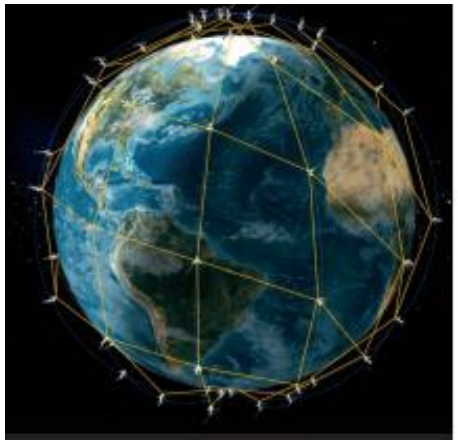
- Small GEO
- TV broadcasting, multimedia applications, Internet access and mobile or fixed services
- Ku and Ka band
- Europe, the Canary Islands and South America

Hispasat 36W-1 with SmallGEO platform

First flight	Hispasat 36W-1 (Hispasat)
Second flight	EDRS-C (Airbus D&S/Avanti)
Orbital position	Geostationary orbit
Lifetime	15 years
Payload mass	up to 300 kg
Payload power	up to 3 kW
Propulsion	▪ Transfer to GEO: chemical ▪ Orbital stationkeeping: electric
Launcher compatibility	Ariane 5, Proton, Falcon 9, Soyuz
Prime contractor	OHB System AG (DE)

Iridium Next (L band) Second Generation

- First Generation bankruptcies- Iridium+ Teledesic (ceased trading)+ Skybridge
- January 14, 2017– the first payload of ten Iridium Next satellites launched and deployed into Low Earth orbit by Space X- Largest and fastest ever slot swop
- First of seven launches over the next 15 months - 10 per launch - Includes real time global aircraft tracking (polar orbits)

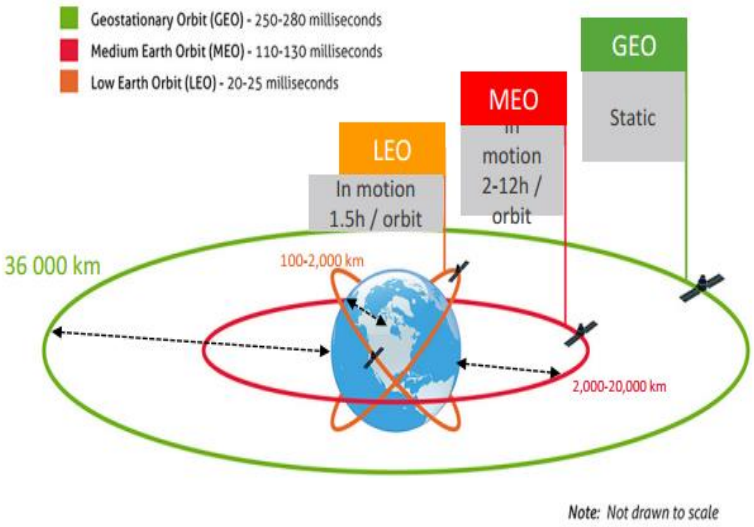


The World Radio Congress November 2019

3GPP New Radio Specs

June 2018 in La Jolla

GSO MEO and LEO coexistence and 5G?



New rockets BIG SATS and NEW SATS

Space price list

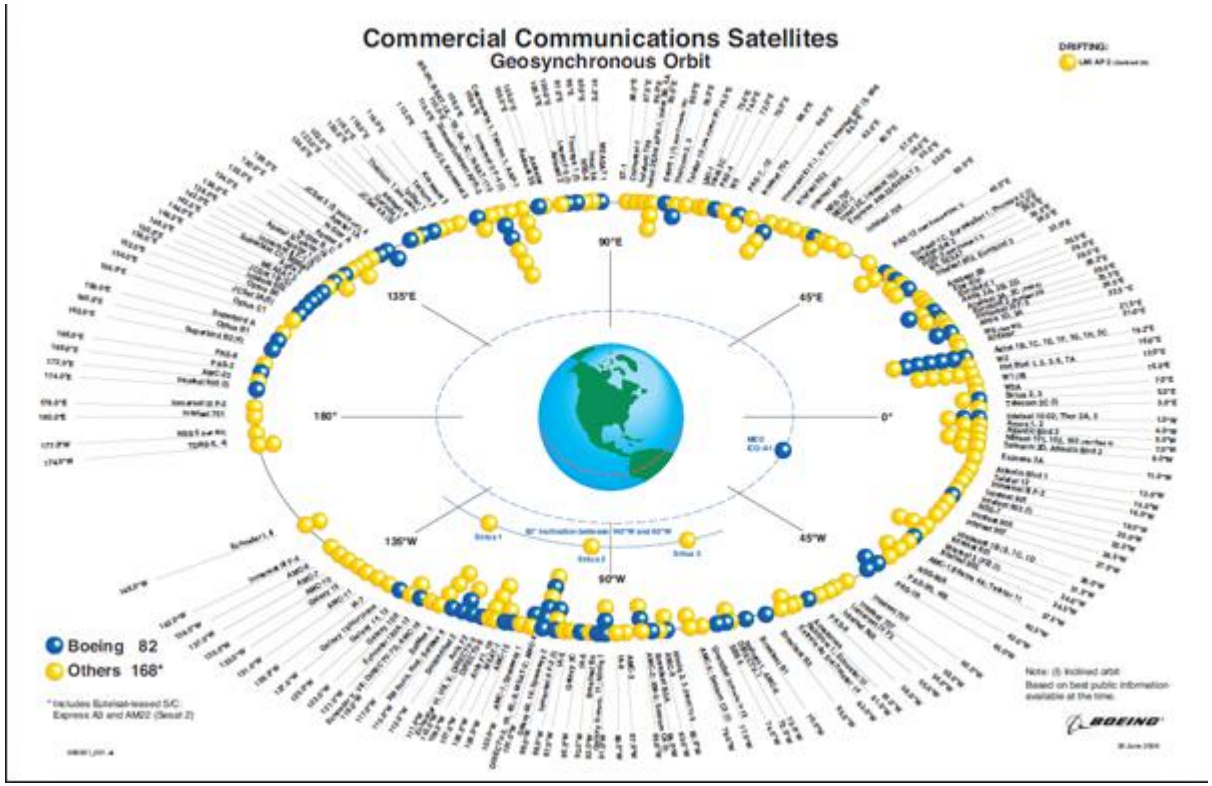
Pluto with baggage allowance

TECHNICAL OVERVIEW

HEIGHT	STAGES	BOOSTERS	PAYLOAD TO LEO	PAYLOAD TO MARS
70 m 229.6 ft	2	2	63,800 kg 140,660 lb	16,800 kg 37,040 lb

TOTAL WIDTH	MASS	PAYLOAD TO GTO	PAYLOAD TO PLUTO
12.2 m 39.9 ft	1,420,788 kg 3,125,735 lb	26,700 kg 58,860 lb	3,500 kg 7,720 lb

A new generation of BIG SATS?



ITU now allow 2 degree orbit separation=180 satellites
But satellites could potentially be ten times larger and heavier and more powerful than existing satellites
50,000 kilograms not 5000 kilograms
150 kilowatt rather than 15 kilowatt

THE NEW SATS

Iridium	Globalstar	Sky Space Global	OneWeb	Space X	Leo SAT	Boeing
L Band	L and S band	UHF, L and S band	Ku and Ka Band	Ku and Ka Band	Ka Band	V Band and C Band
78 LEOS	24 LEOS	200 LEOS	650 LEOS	4000 LEOS	78 LEOS	2956 LEOS
780 km	1414 km	500-800 km	1200 km	1200 km	700 km	1200 km
860 kg	700 kg	10 kg (Cube SAT)	200 kg	100-500 kg	860 kg	?

Potentially six thousand cube SATS to LEO on one Falcon Heavy

Satellite and space politics

- 13 April 2016
- American Space Renaissance Act
- http://spacerenaissanceact.com/
- Congressman Jim Bridenstine, Oklahoma
- Military – Civil – Commercial
- American Space Force – The Fourth Fighting Force

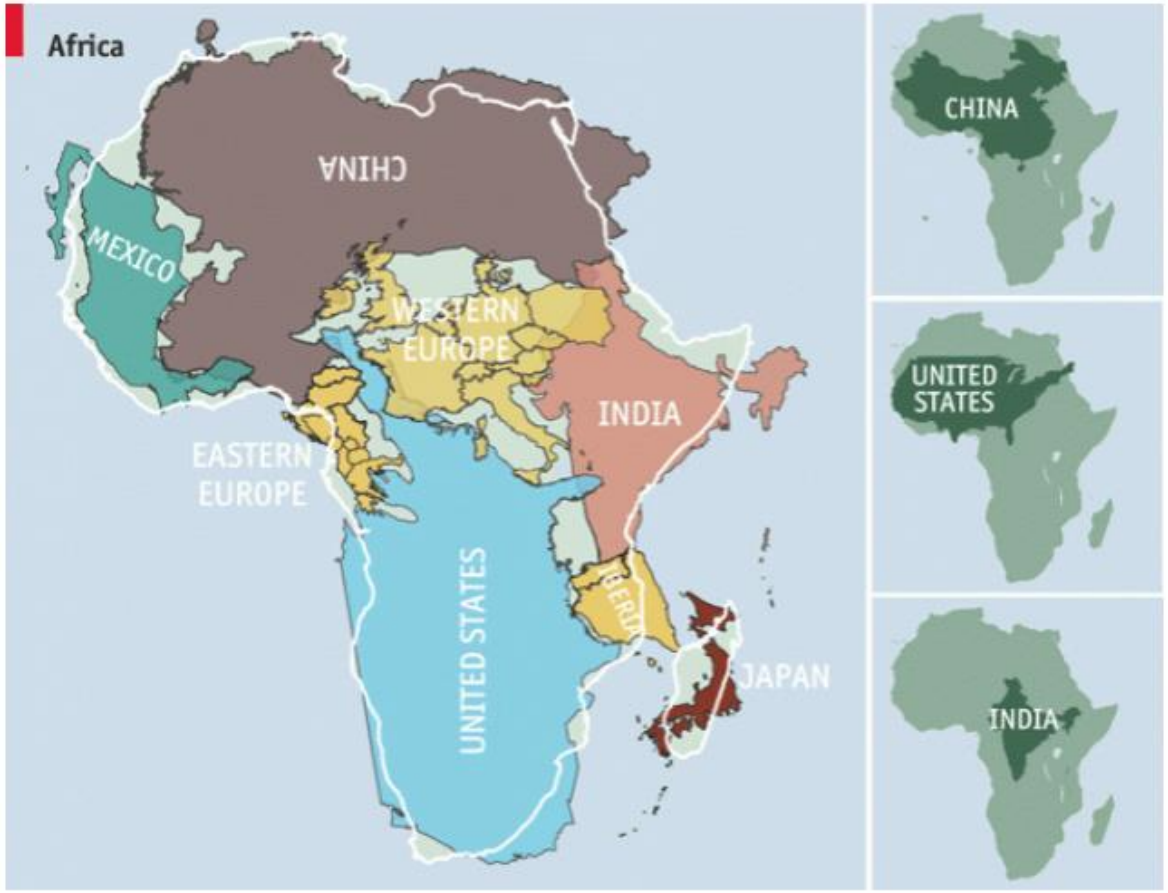
Developing economy markets

- More than four billion people remain offline.
- Fixed broadband penetration in Africa is less than one per cent.
- Mobile broadband penetration in Africa is below 20 per cent compared to more than 80 per cent in Europe
- More than one billion people living in Africa, a population that has doubled in size in less than thirty years
- Africa is geographically huge, more than 30 million square kilometres, larger than the combined geographic area of the US, Argentina, India, Western Europe and China. The rural delivery economics in Africa are therefore uniquely challenging.
- Australia is 7.6 million square miles with a small (33 million) but rich ($67,000 GDP per capita) population.
- Australia and most developing economies have relatively high energy costs

The size of Africa

The true true size of Africa

Africa is bigger than it looks on most maps of the world



LEO latency

Time	distance	
One second	300,000 kilometres	186,000 miles
One Millisecond	300 kilometres	186 miles
One Microsecond	300 metres	1000 feet
One Nanosecond	30 centimetres	One Foot

To put this in to a geographic perspective, Singapore is 50 kilometres from east to west and a radio or optical signal will take 166 microseconds to go from one end of this high tech island to the other. Malaysia coast to coast will take one millisecond.

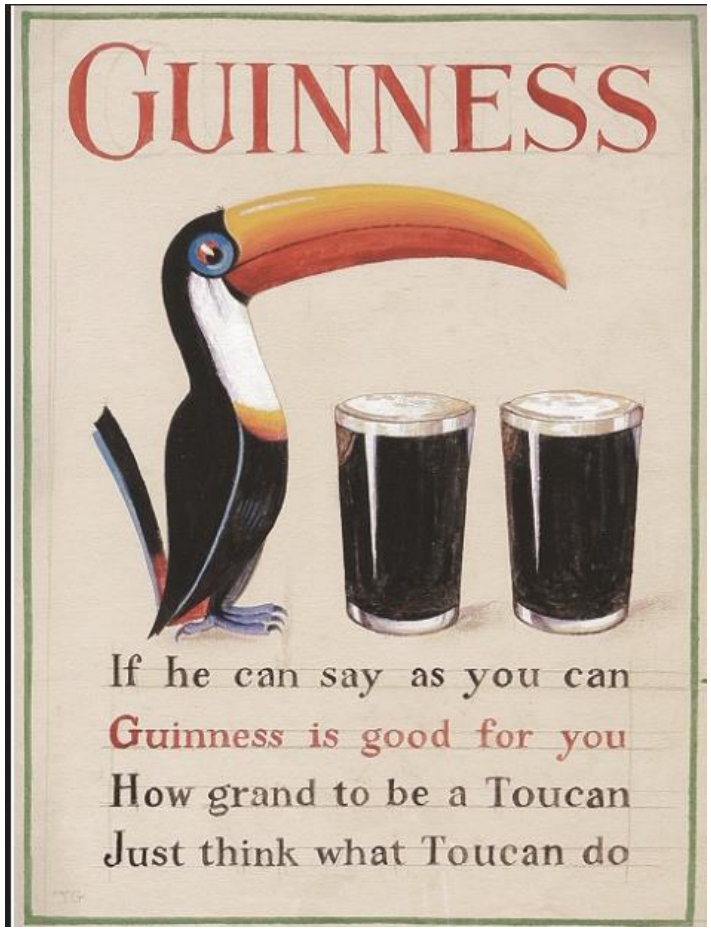
Australia from the east coast to west coast is 4000 kilometres - a coast to coast travel time of 13 milliseconds. Africa North to South is 8000 kilometres=26 milliseconds

Coca Cola and OneWeb

Here's Why Coca-Cola is Investing in OneWeb

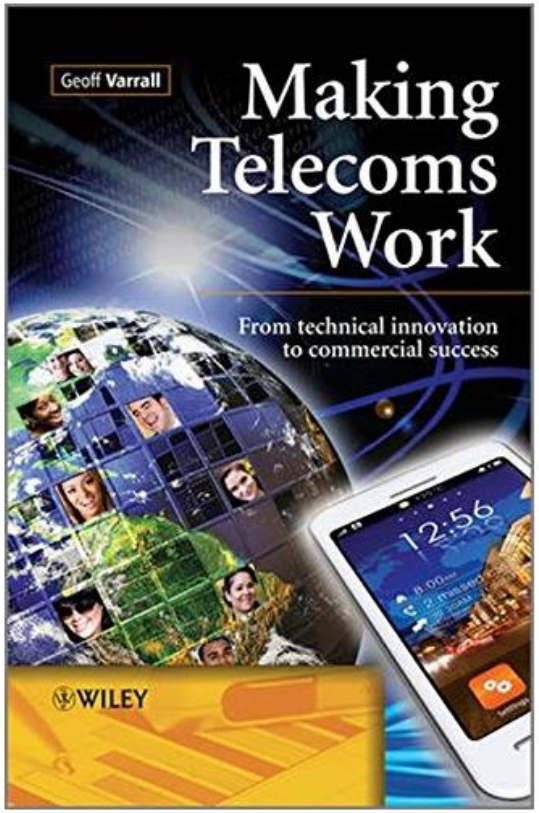
by **Peter B. de Selding** — June 26, 2015

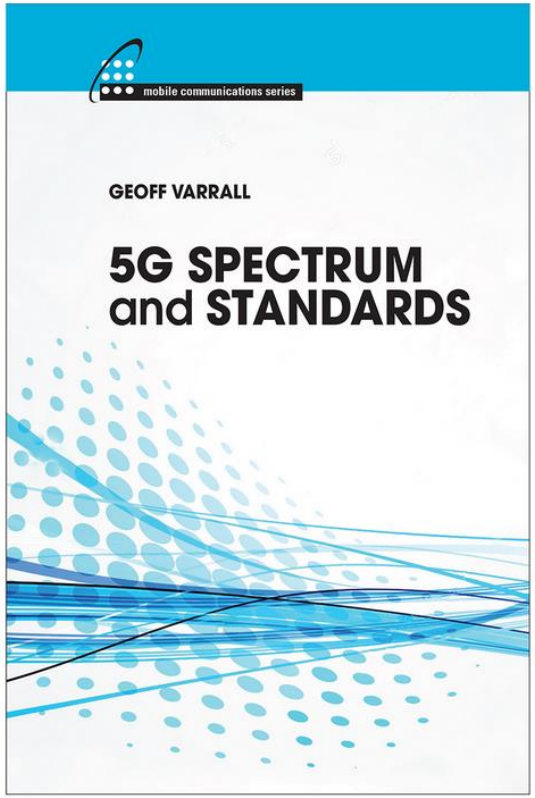
Guinness



40% of Guinness production worldwide is drunk in Africa
In the late 2000s, Nigeria surpassed Ireland to become the second largest market for Guinness consumption.

5G and Satellite Resources





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