RTT TECHNOLOGY TOPIC
November 2017

Red Rockets Yellow Rockets

It has probably not escaped your attention that October marked the 100th anniversary of the Russian revolution.

It might seem far-fetched to credit Lenin and Uncle Jo as the godfathers of the space revolution but they certainly helped get things started and it could be argued that without Stalin's remodelling of the Russian nation we might still be thinking of going to the moon.

In this month's technology topic we review 100 years of rocket technology innovation and the impact this innovation is presently having on space and terrestrial mobile broadband delivery economics.

The Russian Rocket Revolution

In the early 1920's Lenin decided to equip the Red Army with new weapons including solid fuel rockets that could compete with conventional artillery. Stalin from 1924 onwards up to his death in 1953 was equally keen on keeping up or ahead of US and German rocket research sponsoring the grandly titled Society for the Advancement of Defence, Aviation and Chemical Technology in the early 1930's.

The Russian winter proved to be a more effective weapon against Germany in the Second World War but the post war period, as some of us remember, became the Golden Age or Dark Age of Russian ballistic missile development depending on your point of view.

The Cold War spurred on a remarkable development effort on both sides of the Atlantic. In Russia the Soviet rocket designer Sergei Korolev spent from 1954 to 1957 developing the world's first inter-continental ballistic missile, the R7, powerful enough to deliver a nuclear warhead to the United States or launch a spacecraft into orbit, with Sputnik (see Chapter 1, Beginning with the Beach Ball) being its first big success. In 1961 a modified R7 launched Yuri Gagarin into space.

Early US Rockets

On the other side of the Atlantic, Robert H Goddard (1882-1945) inspired by HG Wells' book, War of the Worlds (1897) had by 1914 filed two US patents, one for a rocket using liquid fuel and the second for a two or three stage rocket using solid fuel. In 1920 the Smithsonian published his paper 'A Method for Reaching Extreme Altitudes which included a study of the practicality of sending payloads to the moon. He developed and launched what was probably the world's first liquid fuelled rocket in 1926 in Auburn, Massachusetts. Goddard proved that a rocket would work in a vacuum, put the world's first scientific payload on a rocket in 1929, used vanes in a rocket motor for guidance in 1932, developed pumps suitable for rocket fuels and in 1937 launched a rocket with a motor pivoted on gimbals controlled by a gyro mechanism.

Meanwhile Herr Braun had expeditiously moved from a stricken post war Germany to the USA to work for the US army developing the first generation of Jupiter C, Juno 11 and Saturn 1 launch vehicles with Jupiter C used to put the first US satellite, Explorer 1, into orbit in 1958.

In 1932 Von Braun had gone to work for the German army to develop liquid fuel rockets and over the next ten years developed the V2 rocket, a liquid propelled (alcohol and liquid oxygen) missile

14 meters long weighing 12000 kilogrammes capable of flying at 5600 kilometres per hour delivering a 700 kilogramme warhead to a target (Paris then London) up to 300 kilometres away. The motor typically burned for 60 seconds, pushing the rocket to around two kilometres per second rising to an altitude of about 90 kilometres.

In 1960 President Eisenhower moved rocket development away from the control of the army to the newly established National and Aeronautics and Space Administration (NASA) with a mission to produce a new generation of giant rockets to be known as the Saturn rockets. Herr Braun became Director of the Marshall Space Flight Centre and Chief Architect of the Saturn V launch vehicle.

Sixty years on this research and development behemoth is producing inspiring research on materials and manufacturing innovation which is literally fueling the 'new space' revolution. Wernher Von Braun died in Alexandria, Virginia, on June 16, 1977. His involvement in the Nazi party always remained controversial but his contribution to the US space industry is unparalleled.

European Rockets

This is not of course purely a story of competing super powers.

In 1958, Charles De Gaulle, for some the hero of the anti-Nazi resistance movement during World War 11, returned to power in France and convinced himself that it would be naïve to depend on the US for military protection in the era of nuclear tipped intercontinental ballistic missiles at which point he committed France to full technological independence from the USA including complex and expensive research programmes on nuclear technology and rocketry.

You could debate the longer term wisdom of this decision though a probably unexpected outcome is that 60 years later France has an electricity grid fed by a higher percentage of nuclear power than any other country in the world. The guilty secret here is that you can only get a decent supply of weapons grade plutonium if you have a scale efficient uranium processing capability.

Britain was similarly disinclined to accept that it was a declining colonial power out paced by larger scale sovereign competition and managed to embark on some spectacular and in hindsight misjudged rocket based defence projects of which Blue Streak, started in 1965 and scrapped in 1970 was probably the most notable example.

On a positive note, spending arguably disproportionate sums of money on missile development has had produced a long term legacy of rocket technology capability both in France and the UK France is a major contributor and economic partner in the European Ariane expendable launch system used to launch GSO and LEO satellites from Kourou in French Guiana with the rockets manufactured under the authority of the European Space Agency and Centre National D'Etudes Spatiale with Airbus as the prime contractor. The UK has a robust and relatively competitive near and deep space systems industry, BAE Systems being an example

Rest of the World Rockets

In practice a large part of present day rocket launch technology is the product of intercontinental ballistic missile development work initially in Russia and the US in the 1950's, China from the early 1960's, India from 1969, Brazil from the 1970's and more recently Israel, Iran and of course from 2012, North Korea. More than 70 countries claim to have space programmes including Malaysia, Indonesia, Egypt, Pakistan, and Egypt

On February 15th 2017, the Indian Space Research Organisation launched 104 satellites into orbit on a single rocket setting a new world record. The rocket's main cargo was a 714 kg satellite for earth observation but packaged with 103 Nano satellites weighing a combined 664 kg with the smallest weighing 1.1 kg. 90 of the Nano satellites are from a San Francisco company, Planet Inc. each weighing 4.5 kg that will send earth images back from space.

Brazil claims to be developing the technology to send domestically made satellites into space with locally made rockets by 2020. Visiona, a private sector joint venture with state run telecom operator Telebras and Embraer SA, the world's third largest commercial plane maker are all part of an emerging rocket manufacturing and supply chain. The 2017 launch of the nation's first defence and communications satellite was a step towards this target of self-sufficiency with Thales SA and Ariana Space contracted to deliver the satellite into space supported by a large team of Brazilian engineers. The 5.8 tonne geostationary satellite will provide broadband internet to Brazil and secure communications for military and government employees.

In case you didn't know, Brazil is the fifth largest country in the world with a total area of 8 million square kilometres, similar to Australia but including 55,455 km of water. Indonesia is two million square kilometres. Africa is 30 million square kilometres. Continents trump countries in the bigness states. Although the present satellite build programme has a limited amount of home grown technology, the intention is to produce a micro satellite of 100 kilograms for launch into low earth orbit at 1000 kilometres for missions such as deforestation monitoring, tracking hydraulic reservoirs and monitoring 17000 kilometres of Brazilian border though this is dependent on the state of the Brazilian economy.

Chinese Rockets

Rockets were invented by the Chinese in the 13th Century so they had a head start on the rest of the world. The latest big rocket from China is the Long March 5, the first of this big rocket series not to use solid fuel boosters. The liquid oxygen and kerosene powered Long March 5 has a payload of 14000 kilograms to GSO transfer orbit or 25,000 kilograms to low earth orbit, close to the capability of the US Delta 4 Heavy rockets. China placed a lander and rover on the moon in 2013 and in 2016 sent two taikonauts, Chinese astronauts, into space to stay for 30 days on the Tiangong-2 space station. The next Long March 5 mission is scheduled to return to the moon and the rocket, and the two planned successors (Long March 6 and Long March7) are being designed to deliver an orbiter, lander and rover to Mars by 2020.

The rise of the new rocket men

Sovereign investment in rocket technology is not the only option. In particular it can be observed that a new generation of aspiring space entrepreneurs are emerging with access to sufficient cash and borrowing facilities to develop private sector based rocket and launch technologies, including specifically reusable rockets.

These technologies are technically and commercially competitive with legacy rocket systems with the potential to deliver a major reduction in delivery cost .Space X in particular supports a mix of military and commercial payloads and is the first private sector space ship to have serviced the International Space Station having won the NASA International Space Station Cargo Resupply Services contract which it shares with Orbital ATK, now a division of Northrop Grumman. Last month, Space X delivered other ten Iridium Next satellites into space on one rocket and recovered all stages for reuse. Few days pass without another announcement from Mr Musk on his proposed Mars Mission. In parallel Jeff Bezos is putting one $billion dollars per year into Blue Origin and Mr Branson is just about to send Mr and Mrs Clooney into space (Sandra Bullock is already there of course).

What does this mean for 5G?

Well many of you are getting a bit bored with this ongoing narrative but reducing launch costs and improving reliability (reduced insurance costs) are critical to delivering space based communications at a price per bit which makes sense for 5G terrestrial backhaul and urban and

rural mobile and fixed broadband infill.

Over the next few months we will work our way through the other innovations that are taking place in the space sector and their composite impact on this cost economic equation.

But don't forget that it was Stalin that got us started.

5G BOOK – 5G Spectrum and Standards – Geoff Varrall
Published by Artech House

The spectrum, band plan and standards choices for 5G and satellite mobile and fixed broadband, the technology and the economic impact of these choices on the mobile broadband and satellite industry supply chain, operator community and target vertical markets.

£119.00
Order a copy here

Making Telecoms Work - Geoff Varrall
Published by John Wiley

The technology economics of wireless versus fibre, cable, copper and satellite connectivity and the changing business dynamics of the telecommunications industry.

£66.50
Order a copy here

RTT, The Mobile World and Policy Tracker are working on a new book project on 5G and Satellite Spectrum, Standards and Scale and related regulatory and competition policy issues prior to WRC 2019. The book will be published by Artech House next year.

If you are interested in knowing more about this project or are developing products and services that you feel should be included or a regulatory and advocacy position that you feel should be reflected then please e-mail us for more information.

geoff@rttonline.com

About RTT Technology Topics

RTT Technology Topics reflect areas of research that we are presently working on. We aim to introduce new terminology and new ideas to help inform present and future technology, engineering, market and business decisions. The first technology topic (on GPRS design) was produced in August 1998. 19 years on there are over 220 technology topics **archived on the RTT web site.**

Do pass these Technology Topics and related links on to your colleagues, encourage them to join our **Subscriber List** and respond with comments.

Contact RTT
RTT, **Policy Tracker** and **The Mobile World** are presently working on research and forecasting projects in the mobile broadband, public safety radio, satellite and broadcasting industry and related copper, cable and fibre delivery options.

If you would like more information on this work then please contact **geoff@rttonline.com**
00 44 7710 020 040