Special Project

FROM RUSSIA WITH LOVE ?

By Barry Fox

Russian rockets now launch American made communications satellites.

It is an eerie experience to fly by special charter, with military papers, into an area of the old Soviet Union that was never marked on a map, and when finally marked was deliberately shown in the wrong place. It is even eerier to land on a deserted airstrip, the largest in the world, and drive by old bus over bumpy roads, past decaying buildings and deep into the desert wasteland to look at a rocket launch site that was built, not just to put men in space, but to rain destruction on the Western world.

But the spookiest thing of all, is to walk through the rain into a giant, decaying brick building on the outskirts of Moscow and see at least a dozen giant Proton rockets being assembled – not now as Inter-Continental Ballistic Missiles, designed to carry nuclear war-heads, but to earn hard currency for the crippled Russian economy.

But first the background, and some hard facts.

ASTRA

Luxembourg now owns more territory in space than it does on the ground. Astra, the Societe Europeenne des Satellites, launched 1A in December 1988 and made Rupert Murdoch's Sky what it is today. SES has launched eight satellites in the ten years since then; seven at 19 degrees East, broadcasting a mix of analog and digital signals, with Astra 2A now safely in place at the company's new all-digital slot at 28 East.

Currently Astra transmits direct to 27 million analog dish households in Europe (four million of them in the UK) and four million digital homes. By 2004, Astra expects the ratio to be 24 million digital: 20 million analog.

2A is the sixth satellite which SES has bought from Hughes Aerospace in California.

Astra 2A launch using a Proton rocket

It is the first launch into the new slot at 28 East. Hughes started to manufacture satellites for the US Government in the early 1960s. 2A is a high power version of the 601 design, with seven kilowatt power consumption and 15 years expected lifetime. Each channel is powered by a 98·5 watt travelling wave tube amplifier.

DELAY

2A was originally scheduled for launch in August 1997, but was delayed by late delivery from maker Hughes Aerospace and problems with the Russian rocket program after one failed when launching Asiasat 3 over Christmas 1997. So earlier this year Astra temporarily moved 1D from 19 East to 28 degrees East so that BSkyB could start a digital service even if Astra 2A could not be launched in time. Astra has also leased the Nordic satellite Sirius 3 for a year to provide backup for 2A until Astra 2B is launched in the third quarter of 1999.

After a successful launch from Russia's Baikonur Cosmodrome at the end of August, 2A was tested in orbit at the end of September, just ahead of Sky's official launch on October 1st. All worked well and in early October Astra started 1D's month-long space drift back to 19 East.

Astra 2A has 32 transponders, four for backup while 28 transmit. By launch time 24 had already been "sold" – 14 of them to BSkyB, the rest to the BBC and other broadcasters. Astra 1D has only 18 transponders with six spares, so 2A was essential for a full Sky Digital launch.

COSMODROME

The Russian Baikonur Cosmodrome was built in June 1955, in a 7,000 square kilometer area of desert leased from the Republic of Kazakhstan by the Russian Government. The sky is clear 300 days of the year. It's close to the Aral Sea, some thousand miles east of Moscow, and is still a closed area.

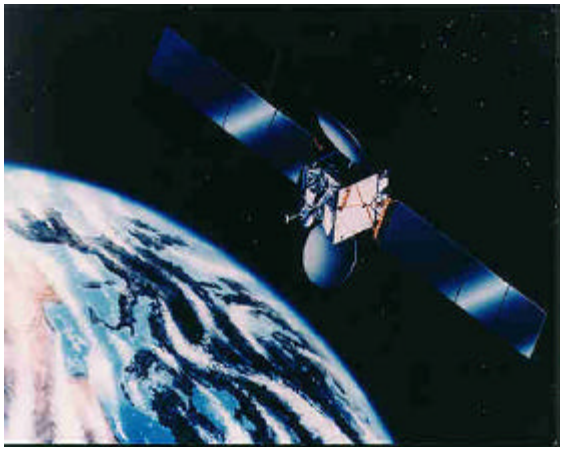
The nearest air strip is Yubileine ("Anniversary") which was built ten years ago as a landing runway for the Russian shuttle, called Buran. The runway is 87 meters wide, and 4,500 meters long, with a 500

ASTRA 2A

There is something very special about the Astra 2A satellite. New technology on board could mean it is still working in the year 2025 – outliving Sky's owner Rupert Murdoch.

All satellites need an on-board jet system which fires every day to compensate for the tugs of solar or lunar gravity which continually pull the craft out of its allocated 75km square box in space. Until now all satellites have used chemical jets, usually produced by burning a "bi-propellant" mix of monomethyl hydrazine and nitrogen tetroxide.

When the station-keeping fuel runs out, the satellite wanders out of control, making reception of its signals unreliable. There is also the risk that the craft will bump into another, damaging it. So the last few drops of fuel are used to dump the satellite into a graveyard orbit where it sits useless but safe before falling to earth and burning up. Early satellites lasted only a few years. More recent models have a life of seven to ten years.



Artist's impression of Astra 2A in orbit

Hughes Space and Communications of California started looking for an alternative thrust system in the early 1960s, and first tried putting an electrical charge on vaporized caesium or mercury so that it jetted from the craft at high speed. The gasses corroded the jets. In 1984 Hughes engineers found that they could ionize xenon to create as much thrust as a chemical jet. Xenon is inert so causes no corrosion.

The Xenon Ion Propulsion System (XIPS), known as "zips", feeds Xenon gas to a chamber where the gas is electrically charged and ionized. A series of grid electrodes, like those in an old-fashioned vacuum tube valve, are oppositely charged to accelerate the gas into 3000 parallel streams. These streams leave the chamber through a 13cm outlet, at a speed of 30km/second, driving the satellite in the opposite direction.

A neutralizer electrode, mounted outside the jet, produces oppositely charged ions which stop the thrust streams being attracted back to the thruster

Two angled thrusters operate twice a day for up to 5 hours, drawing 500 watts. Until recently this drained power from the transmitters. However, recent developments in gallium arsenide technology now let the solar panels deliver up to 10 kilowatts, which is enough to drive the thrusters and power the transmitters.

The Xenon is 90 per cent lighter than the equivalent bi-prop fuel, so the satellite can carry more and work for up to 15 years. XIPS was first built into a PanAmsat communications satellite launched last year and is now used on board Astra 2A. Astra asked Hughes also to include a full bi-propellant system, with control software that lets engineers at Astra's control center in Luxembourg switch at will between XIPS and bi-prop. This provides full redundancy if one system fails. If both systems work as intended, 2A's working life will be at least 25 years instead of the guaranteed 15.

"This has a mixed meaning for us," admits Hal McDonnell of Hughes. His job is to sell satellites to broadcasters and so far they have needed a new one every decade at least.

meter emergency extension at each end. This makes it the largest in the world. The project was to have employed 30,000 Russians, with up to 30 launches a year. The shuttle was capable of putting equipment weighing up to 200 metric tonnes into orbit.

"It was like a truck, a military cargo vehicle," says Erik Laursen, Chief Engineer at ILS.

Buran could launch in winds of up to 60 miles per hour, whereas the US shuttle missions have to be postponed if the wind on the exposed Cape Kennedy site in Florida rise to 16 miles an hour.

Buran only made one flight in 1988. It was un-manned and landed after one orbit. Although the mission was successful, Russia's money for the shuttle project ran out. Russia still has two fully finished shuttles, and three shuttle launchers moth-balled in the hope that one day the shuttle program can be re-born.

The first artificial earth satellite, Sputnik, was launched from the site on October 4 1957 by the Russian Ministry of Defense. Yuri Gagarin went up from the Cosmodrome in 1961. Baikonur is now run by the Russian Strategic Rocket Forces. In all over 1,100 rockets have been launched from the pads there, accounting for one-fifth of the world's satellites. The remote site houses the world's largest liquefied oxygen plant.

ROCKET FACTORY

There are two rival rocket manufacturers in Russia, Khrunichev and RSC (Russian Space Complex) Energia. Both are based in Moscow and, until recently, were secret, closed plants. Both built Inter-Continental Ballistic Missiles (ICBMs) and both have modified their military technology to launch commercial rockets to earn hard currency from the West.

Khrunichev developed the Proton launch vehicle in the early 1960s and the first launch took place in July 1965. Originally a two stage rocket which carried a 150 megaton warhead, Proton was converted to a four stage launcher for satellites. There were also plans to modify it to carry a man to the moon like Apollo 8, but the Russians dropped out of the manned space race. Proton can now lift a satellite weighing over 2,000 kilograms into geostationary orbit. It has flown more than 200 space missions, including the launch of the Salyut and Mir space stations.

The Khrunichev factory can produce at least 15 rockets a year depending on demand. Most use four stages, the first three stages powered by nitrogen tetroxide and dimethyl-hydrazine fuel. The fourth stage, made by Energia, uses liquid oxygen and synthetic kerosene or synthin.

US JOINT VENTURE

In 1993, the Lockheed Corporation of the US, Khrunichev and RSC Energia signed a joint venture deal to use Russian-built Proton rockets to launch commercial satellites from Baikonur. In 1995 Lockheed merged with Martin Marietta, to form Lockheed Martin which now makes the Atlas rockets which launch from the Vandenberg Air Force Base in California and Cape Canaveral in Florida, near the Kennedy Space Center. The same year the American and Russian companies tied the knot to form ILS, International Launch Services.

Proton was first used for a commercial launch on April 9th 1996, to launch Astra 1F into the 19 East slot. Since then Proton has been used to launch Inmarsat, Telstar, Iridium, Panamsat, and Echostar satellites. It failed when launching Asiasat 3, on December 25, 1997.

Will Trapton Executive Vice President of ILS refuses to break down the cost between satellite, rocket, services, software and insurance but confirms "All contracts are in dollars". Others are more forthcoming. Astra is paying between $250 and $300 million for Astra 2A, split between the price of the satellite, the launch and insurance. Significantly all payments are now made in US dollars. The rouble is so unsteady that hotels and businesses in Russia are now all billing in dollars, although sometimes they use the word "unit" instead of "dollar" to save face.

BUREAUCRACY

Russia may be trying to bury Communism, but the old bureaucracy persists. Queuing is a way of life. So is crime.

Compuserve has withdrawn its access numbers in Russia because of fraud. Money changers in the street offer a high rouble rate per dollar, and then off-load counterfeit notes. But the money changers only buy dollars if they were printed after 1993, which is when the US Government started watermarking because of counterfeiting.

Shop staff have no urgency. While three of us browsed goods in a souvenir shop, a saleswoman chatted on the phone until we left.

SES was so concerned about flying its executives, VIP guests and press to the Baikonur launch site, that it insisted on having the charter aircraft serviced in Germany, and checking the full service record.

Inside the Khrunichev factory where a dozen or so Proton rockets are being built

The Russian military have a rigid requirement of 30 days notice for entering the Baikonur launch zone. No-one, not even ILS staff, can visit if they have missed the deadline by even a day.

When the charter plane landed on the desert airstrip, now surrounded by abandoned, decaying buildings, three Customs officials and guards weighed down with medals and epaulettes, took over an hour to check the papers of everyone on board. We needed our boarding passes to get off!

Visitors to the Kremlin grounds cannot carry knapsacks; but if they fold them, they can carry them as handbags.

Anyone who passes through an airport faces repeated passport and paper checks, by slow-motion officials who must stamp form after form. It can take three hours to get through Immigration, and then another hour or two through Customs. Little things tell a lot.

At the airport there is no attempt to warn a queue that a position is closing. The guard simply slams the door shut, leaving the queue to disperse and join the rear of other lines. All Russians returning from holiday are automatically sent through the Red Channel and searched. Aboard the flight, the air hostess prefaced the safety demonstration with a curt, "Pay attention".

Government VIPs have their own fast track lane through immigration and customs. They are also cocooned from traffic jams in Moscow's clogged streets. In the days of Communism, all Russian streets had a central lane, reserved for the Politburo, or political elite. The lanes are still there – used today for VIPs.

AMERICAN SATELLITES

The old shuttle airstrip is now used by the Americans to fly in their satellites. The rockets are shipped from Moscow by train. Twelve carriages are used and the journey takes five days.

Because the Proton rocket was originally developed as an ICBM, it is transported and assembled in a horizontal position, unlike US rocket launchers which are assembled vertically. Only at the very last stage is the 60 meter column raised to a vertical position on metal centering posts.

The rockets are so powerful that they can be launched in even high winds. "The Proton is a beast. You could hit it with a sledgehammer", says one of the ILS team.

ILS staff spend at least a month at a time at Baikonur, with no entertainment other than a

bar, and TV with VCR to show American movies they have brought in. The nearest town is an hour's drive away, and the only thing there is a market and bar with a few different beers. There is only one path allowed for walking. To avoid the tortuous use of unpronounceable names, the joint Russian-American team simply give each other numbers, most involving seven, with a nod at James Bond.

The land is flat, sandy scrub, that stretches as far as the eye can see, with wolves and eagles preying on rodents which come out at night. The desert round the old Shuttle airstrip is already reclaiming the decaying buildings, cracking structures, rusting pipes and crumbling runway. From the air Kazakhstan looks like Death Valley in North America.

2A LAUNCH

The VIP launch viewing site is a sandy mound built over a safety bunker, with a hut on top and a generator to provide some electric light, a bowl of water for washing, and a couple of portable camping toilets brought in by the Western visitors. A circular strip around the perimeter looks suspiciously like a mine field.

The stars are astonishingly bright. The 2A launch took place at 6.31am in the morning, just as dawn was breaking, and with no count-down, just a blaze of light followed a few seconds later by the roar and vibration of the motors which lift the rocket up into the sky and over to the East into transfer orbit 200 miles above the Equator.

After two or three minutes the rocket is just a bright spot in the sky, with the discarded first stages falling in flames to the earth, on ground rented by Russia from Kazakhstan. After five minutes all visible trace has gone.

A crackly Tesla loudspeaker carries the voice of the interpreter intoning, "Stable, flight is nominal, pitch roll is nominal. Flight is normal".

After ten minutes the commentator switches off and it's all over, bar the bumpy drive back across the now sunny desert to the derelict airstrip and the two hour flight back to Moscow. While we are still showing our papers to the form stampers in Immigration and Customs, word comes through from California, by GSM cellphone, that the fourth and final stage has successfully fired and released the satellite. It has taken longer to negotiate Russian bureaucracy than it took the rocket to reach orbit.

CRIPPLING

The unspoken concern all round is that the state of the Russian economy will cripple the space launch venture. Khrunichev and ILS hope that billing in dollars will save the day. But once again, little things tell a lot.

ILS engineers find themselves frustrated by some of the old-fashioned designs at Baikonur. A crane, designed to lift heavy objects, takes literally four hours to crawl from floor to ceiling of a hanger. It was probably designed for nuclear war-heads, which had to be very carefully handled. There is no switch or gearing to speed up the movement for satellite parts.

The 2A launch had to be delayed by four days, due to the need for "longer processing time during the spacecraft prep-aration at Baikonur". This careful wording concealed the real reason. When Hughes shipped the spacecraft they also had to ship all the necessary equipment, including a cable to hoist the satellite into position. The cable was the wrong length and the cash-starved Cosmodrome had absolutely nothing else to do the job.

"There is no back-up in Russia. So when they got the wrong cable, the new one had to be shipped in from the USA. It would have taken half a day to get it to Cape Canaveral. It took four days to Russia. But you just can't 'make do' " says Hal McDonnell, Vice President of Hughes.

The ILS engineers have admiration for the Russian Proton design. "They are masters of fluid engineering" says McDonnell. "Once a plan has been drawn up, engineers will follow it meticulously".

"We are proud to tell our children that we were part of the conversion to commercial use," said one Russian who works at Baikonur.

PAST THE SELL-BY DATE

But McDonnell worries about the lack of cash available to the engineers. When Asiasat 3 failed at Christmas 1997, it was not because the Proton rocket exploded. The fourth stage rocket motor made by Energia failed to fire as intended. It shut down after just one second. An inquiry estab-lished the cause. Russian engineers, strapped for cash, had used out-of-date sealing material for one of the fuel lines.

The firing procedure is controlled by a computer, which senses the chemistry of the jets. Because the material was wrong, the computer judged that the burn had finished too early, and automatically shut it down.

So the satellite was stranded in low orbit. After the insurance was paid, Hughes experimented with the craft, using remaining fuel on board to swing it twice round the moon and into geo-stationary orbit for tests. The exercise was successful, but the satellite is useless, because it has virtually no positioning fuel left on board.

Says McDonnell "The problem with the fourth stage of Asiasat is worrying. When we say, 'has this part been refurbished', and someone says 'yes', how do we know it has been done? Three years ago Hughes said we won't supply satellites until some of the local problems are fixed. Some have been fixed. They have invested in the most modern data processing system in the world for Baikonur. But if the crisis worsens, how much money will be sucked off from Khrunichev by the Russian Government?"

BACK-UP

There is already considerable rivalry between Khrunichev and Energia, because their success depends on continued support from the Russian Government.

"Khrunichev is held responsible for the failure of Asiastat," complains one of the rocket engineers, "But the upper stage that failed was made by Energia."

Alexander Lebedev, Deputy General Director of Khrunichev, tries to reassure his American partners: "We are backed by the Moscow International Bank. We have no reason to worry. We have reserves in roubles and dollars. We have contracts to launch rockets for five more Western clients this year. The Cosmodrome has its own power and water supplies, independent of both the Russian or Kazakhstan governments. All contracts with ILS are in dollars. We pay the Russian Federation program only paltry sums – it has no effect."

But Will Trapton reminds that ILS has a dual launch strategy, with dual rocket suppliers – launches can be switched to Atlas rocket in the USA.

KHRUNICHEV

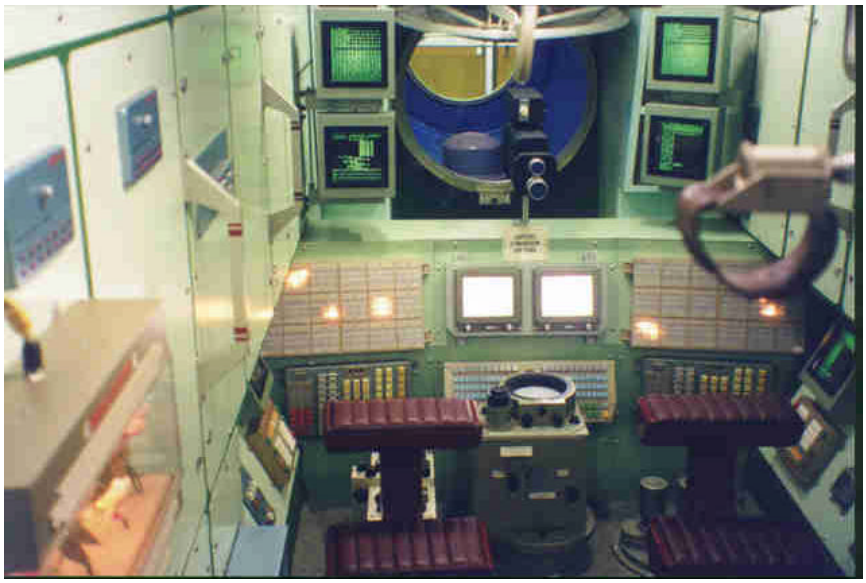
The Khrunichev factory is on the outskirts of Moscow. The giant, decaying brick buildings are as large as a small town. Our Russian guide admitted that although he had lived in the area for thirty years he had not even known it was there or what it did. Russians have been brought up not to ask questions.

The factory was built in the 1920s, using German equipment to build cars. In the 1940s it switched to aircraft production and then in the 1960s started making ICBMs and space launchers. Khrunichev also built the original Mir spacecraft and still has a full-sized mock-up. Mir used an IBM 86 computer. One of the few luxuries on board is a steam bath chamber, complete with birch twigs.

ALPHA STATION

The Khrunichev factory is now helping to make the Alpha station, the first stage of which was due to be launched in November from Baikonur. A mock-up of the first stages has been built for zero gravity training. American and Russian crew will wear space suits, weighted with lead, to move round the chamber while submerged in water to simulate weightlessness.

Alpha manning should begin in July 1999 after the shuttle launch of another component from Kennedy



Full-size mock-up of the Mir spacecraft

Space Center in December. Mir will then be pushed out of orbit, and left to burn up as it re-enters Earth on 8 June 1999.

The Proton rocket was completely secret until 1985, when a few details were disclosed in an obscure Russian language technical encyclopaedia. The Khrunichev factory is now extraordinarily open. Visitors are allowed to roam the immense hangers, touching the dozen or so Proton rockets now being built. The metal engineering is precise and clean, while very basic. Although it will be destroyed during the launch, even the smallest fault can destroy the mission.

"The trick is to make it cheaper but as reliable," says Hal MacDonnell.

In the 1980s, 25,000 people worked at Khrunichev, there are still 18,000, thanks largely to the dollar earning ILS project. Energia is now helping with the Sea Launch project promoted by Boeing; the plan is to launch satellites from a sea-based platform.

DISTRESSING

I left Moscow with a sense of relief; no more standing in queues while petty officials enjoy their moment of power and justify their jobs. I left too with a deeply distressing concern. If the space project, which is earning hard currency, is struggling to survive, what hope have the authorities of maintaining nuclear power stations, ships and submarines in a safe condition?

But I also brought away one nice memory of the indefatigable Russian sense of humor.

At the post-launch press conference in Moscow. Hal McDonnell sat next Alexander Lebedev. After the Russian finished speaking, the interpreter said he was handing over to "Mr Hughes".

"Mr Hughes is dead", said McDonnell, "but I'll take questions." As the room full of press laughed, a few heard the Russian translator say quietly into his microphone, "And people who make fun of interpreters do not live long either."