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VERENIGING
TER BEOEFENING
VAN DE
KRIJGSWETENSCHAP

OPGERICHT 6 MEI 1865

MARS IN CATHEDRA

15 JULI 1975

26

IN DIT NUMMER

MEDEDELINGEN VAN HET BESTUUR

Bijeenkomst te Schaarsbergen

dinsdag 29 april 1975

De *voorzitter* opent de bijeenkomst met een woord van welkom tot de vele leden en introducés, speciaal tot de leden van het Royal Air Force Aerospace Briefing Team.

Hij vraagt eerst de aandacht voor het huishoudelijke gedeelte van de bijeenkomst. Ter voorziening in de vacatures, ontstaan door het aftreden van vice-admiraal F. H. Heckman en de ondervoorzitter commodore J. M. J. Kort worden de door het bestuur voorgedragen candidaten kapitein-luitenant ter zee A. W. Gerretsen en kolonel Klu H. J. L. Janssen bij acclamatie gekozen. Evenzeer vindt instemming de aanwijzing van laatstgenoemde tot ondervoorzitter van de Koninklijke Vereniging.

Daarna sluit de voorzitter het huishoudelijke gedeelte van de bijeenkomst en verleent het woord aan Wing Commander P. E. Cornell en diens teamgenoten.

MEDEDELING

Sedert 1 januari 1972 ontvangen de leden maandelijks de Militaire Spectator. Ten einde de toezending aan thans nog actief dienende officieren van Land- en Luchtmacht, tevens lid van de Koninklijke Vereniging ter beoefening van de Krijgswetenschap, ook na hun dienstverlating zeker te stellen, wordt belanghebbenden verzocht het secretariaat, Nassaulaan 6, Zoetermeer, in voorkomend geval in te lichten.

Military applications of space

The Royal Air Force Aerospace Briefing Team

RAF College of Air Warfare

Much military activity in space is highly classified. But military satellites have a great deal in common with their scientific counterparts. By collecting, studying and collating the scientific information which is freely published, it is possible to discern military developments with sufficient accuracy to form judgements as a basis for presentations. This is part of the task of the RAF Aerospace Briefing Team.

The team consists of members of the RAF College of Air Warfare. Briefings are given to senior officers, key civil servants and military staff colleges at home and abroad. During these briefings, a persistent pattern of questions has emerged, indicating the broad areas of uncertainty and the need for further information.

Zoals in de convocatie aangekondigd, vond op 29 april jl. in de lokaliteiten van de Koninklijke Kaderschool Luchtmacht te Schaarsbergen de bijeenkomst plaats waar, na afhandeling van het huishoudelijke gedeelte, een presentatie werd geboden door het Royal Air Force Aerospace Briefing Team over het onderwerp „Military applications of space". De opkomst van leden en introducés bleek verheugend groot. Ondanks de omstandigheid dat juist op deze datum een respectabel aantal commandanten wel verhinderd moest zijn vanwege hun plicht tot het uitreiken van onderscheidingen, was de animo tot het bijwonen van de voordrachten dermate groot dat verschillenden hunner zich de moeite hadden getroost althans een deel van de dag aanwezig te zijn.

Uiteraard betreurt het bestuur het, dat er niet een gunstiger datum beschikbaar was. Het beseft dat de hierbij afgedrukte samenvatting van het behandelde slechts een zeer gedeeltelijke compensatie kan bieden aan de leden die niet aanwezig konden zijn. Mede op grond van de levendige belangstelling die bij het verwezenlijken van dit initiatief uit brede kring is mogen blijken, is het bestuur dan ook voornemens pogingen in het werk te stellen op een latere datum een herhaling van deze voordrachtencyclus te kunnen aanbieden. Te zijner tijd zal daarvan op de gebruikelijke wijze worden kennis gegeven.

Satellite paths in space

In this article we will try to answer these questions, but first we should provide some background to orbital mechanics. This is a wide ranging subject, but the essential facts are the following.

Earth orbitting satellites may follow circular or elliptical paths. In a circular orbit, the speed and height of the satellite remain constant; in an elliptical orbit, speed and height vary. The maximum speed occurs at perigee (the nearest point to the earth) and the minimum speed is at apogee (the furthest point from the earth).

The plane of the orbit must pass through the centre of the earth. This means that a satellite can only be placed directly into an equatorial orbit from a launch site on the equator. From any launch site, the minimum inclination which can be achieved is the same as the latitude of the launch site. For example, a Soviet satellite launched from Tyuratam (46 degrees north latitude) cannot achieve an initial orbit inclined at less than 46 degrees to the equator. However, as a satellite crosses the equator, power can be applied to turn the satellite into the equatorial plane (fig. 1).

This manoeuvre would require an enormous amount of energy, and as far as we know, the USSR has never attempted it. American satellites launched from Cape Kennedy (28.5 degrees north latitude) on large boosters like Titan and Atlas, with powerful upper stages, have been placed in equatorial orbit after achieving the necessary 28.5 degree plane change, but

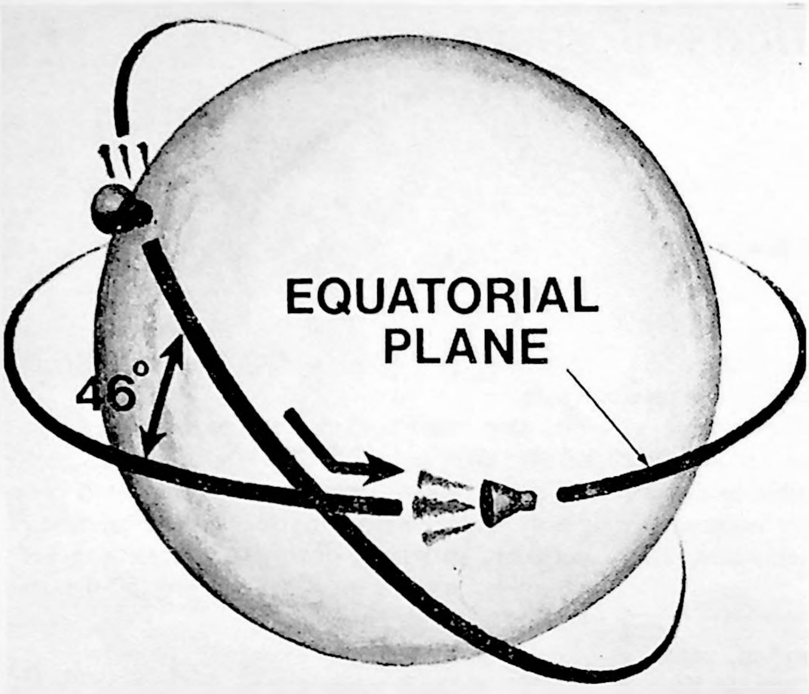


Fig. 1 Plane change

the manoeuvre is still difficult and has sometimes failed. One of the two original British Skynet communications satellites was lost in space while attempting this plane change into equatorial orbit.

The time taken by a satellite to complete one revolution is called the orbital period. For a satellite in near earth orbit (100-300 nms) the period is about 1½ hours. At 5,500 nms altitude the orbital period is about six hours. Thus, orbital period increases with height, and a satellite in circular orbit at 19,360 nms has an orbital period of 24 hours. This, of course, makes it synchronous with the earth's rotation. If the satellite is in an equatorial orbit, it will appear to hover motionless over one point on the equator. Such a satellite is said to be in a geostationary orbit.

Factors governing satellite lifetime

We are frequently asked why some satellites last thousands of years, while others stay in space for only a few weeks. The lifetime of a satellite in orbit depends on its altitude. A satellite in a high orbit is in a near total vacuum, and there are no drag forces to slow it down. However, a satellite orbitting within a few hundred miles of the Earth soon feels the effect of the outer layers of the atmosphere. Even the tenuous atmosphere on the fringe of space causes drag, which slows the craft so that it gradually spirals in towards the Earth, eventually burning up as it enters the heavier atmosphere. At the lowest point in its orbit, the perigee, the satellite is travelling at maximum speed and encounters the greatest air resistance; drag is at a maximum.

So it is primarily the height of perigee which determines a satellite's orbital lifetime. Table 1 gives some military examples.

If technology permitted, it would be most economical if working lifetime could match orbital lifetime. But the relatively short working life of batteries and solar cells, the unreliability of components under extreme stress, and the capacity of cameras and tape recorders are just a few of the factors which determine a useful lifetime for the average satellite of between one and three years.

Many satellites spend much of their orbital lifetime, after they have ceased to function, or have completed their missions, as 'space debris'. The

TABLE 1

Satellite	Date of launch	Perigee (nms)	Lifetime
USAF Reconnaissance Satellite	14 Jan 70	73	18 days
Transit 5B (USA navigation satellite)	28 Sep 63	581	1000 years
Skynet I	22 Nov 69	19,200	1,000,000 years

number of objects in space is constantly increasing: on 3 January 1971 it was 2,114, and on 4 August 1973 it was 2,952. Fortunately, for the foreseeable future this collection of debris is unlikely to cause any problems. It is a question of relating the debris to the immensity of space. The chances of a collision at this time are minimal; they were discounted for the Apollo missions. But there may well come a time when the collection of debris from space could become necessary.

Fig. 2 FOBS trajectory

Nuclear attack from space

The possibility of using nuclear weapons from space prompts many questions. It is, of course, entirely feasible to install a nuclear warhead in a satellite. The satellite could then be placed in orbit and left there until required, when it could be deboosted to re-enter the Earth's atmosphere and seek its target. This concept is called the Multiple Orbital Bombardment Satellite system (MOBS). Alternatively, the satellite could be stored on Earth, and launched at the beginning of any hostility. Then it would complete only part of a single orbit before being deboosted on to its target. This is the Fractional Orbital Bombardment Satellite system (FOBS) (fig. 2).

The MOBS concept looks very attractive to the military man at first glance. But it has severe disadvantages. The greatest is that the satellite spends very little time over its target. The satellite circles the Earth, while the Earth rotates beneath it (fig. 3). The pattern of tracks over the ground is very complex, and after the satellite has passed over one point on Earth, there may be an interval of several days or weeks before it passes over that same point again. It is only possible to change the satellite's path in space by small amounts as the amount of fuel which can be carried is relatively small. The possible deviations might be no more than 100 miles either side of the unpowered track of the satellite. So the opportunities for deboosting a satellite on to a specific target are few and far between.

No major nation is likely to initiate a global nuclear exchange by exploding a single nuclear device; a first strike must involve many hundreds

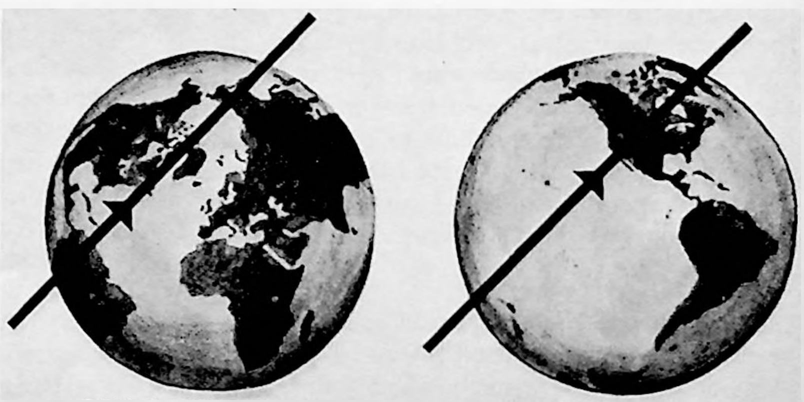


Fig. 3 Satellite ground tracks

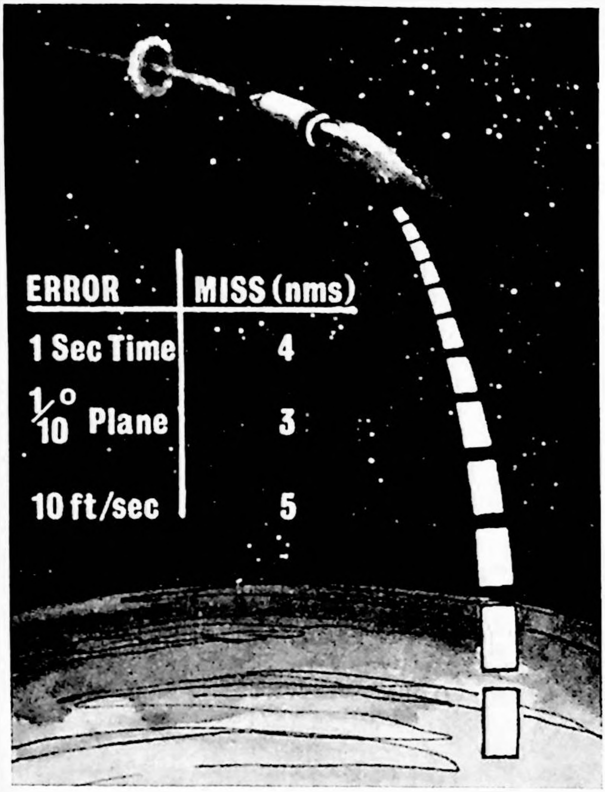


Fig. 4 Deboosting errors

of weapons. Under the SALT agreement the USA will be permitted to possess 1,054 ICBMs, and the USSR 1,618 ICBMs, which is an indication of the potential first strike order of battle. The expense of maintaining hundreds of MOBS satellites in orbit would be enormous, and it would be impossible to ensure that they were all over their targets at the same time for the necessary simultaneous first strike.

On the grounds of availability and cost alone, the MOBS system can be seen to be impracticable. There are many other problems, including the large miss distances which would be likely when the satellites were deboosted from orbit (fig. 4), the vulnerability of the satellites to interception or enemy countermeasures and the hazards involved when nuclear warheads were recovered for repair or inspection, or when they decayed naturally into the atmosphere.

Thus there were sound technical reasons underpinning the signing by the USA and USSR (and 58 other nations) of a treaty which forbade 'nuclear weapons or any other kinds of weapons of

TABLE 2

	1967	C139, 160, 169, 170, 171, 178, 179, 183, 187
Apr	1968	C218
Oct	1968	C244
Sep	1969	C298
Dec	1969	C316?
Jul	1970	C354
Sep	1970	C365
Aug	1971	C433

mass destruction' in space. The treaty was signed in October 1967, but only a month later the US Secretary of Defence announced that the USSR had developed a FOBS system.

The USSR rarely releases any information on military satellites. However, we believe that the Cosmos programme, which accounts for about three quarters of all Soviet space activity, conceals numerous military activities. Within Cosmos, there have been a number of low altitude, single orbit flights which may well have been related to the development of a FOBS capability. These flights are listed in table 2.

A number of re-entry tests in 1966, and the nine test firings in the Cosmos programme in 1967, led to the American statement in November 1967. Thereafter, C218, C244 and C298 appeared to be routine test firings of the FOBS vehicle, but C316, in December 1969, was rather unusual. It had the same inclination as previous FOBS tests but had a much higher apogee. One possible explanation of the unusual orbit is that C316 was a FOBS test, but that the spacecraft was misaligned at deboost, and the boost became posigrade instead of retrograde. Once the engine propellant had been expended there would be nothing that the Soviet controllers could do except wait for C316 to decay naturally. The craft re-entered the Earth's atmosphere in August 1970 and parts of it reached the ground in the midwest of the United States. Under the terms of the space treaty, the pieces were offered back to the USSR, but she refused to acknowledge ownership.

If C316 was a failed FOBS test, one would expect further test firings to restore confidence in the system, and in 1970 came the flights of C354 and C365. C433 flew in August 1971, but no further flights have taken place since then. These facts tend to confirm that Russia has developed a FOBS system and that at least some of her nuclear warheads could be used in this way.

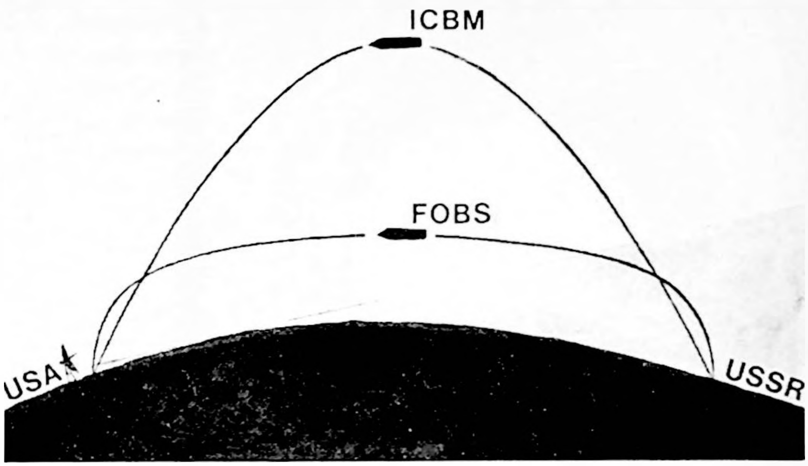


Fig. 5 FOBS and ICBM trajectories

As discussed, MOBS has many serious disadvantages. FOBS, on the other hand, has some notable advantages when compared with the ICBM. It is possible to draw a great circle connecting any two points on the surface of the Earth, and it follows that a FOBS weapon can be launched from any launch site against any target. Operationally, the FOBS could be fired in a north-westerly or south-easterly direction against the USA. Launched north-westward it would enter the target area through the BMEWS radar screen but it would penetrate the radar beam much later in its flight than the ICBM, which climbs about seven times as high as FOBS (fig. 5). Thus, the warning time would be considerably reduced. Another problem is that the impact point could not be determined until after the ignition of the deboosting motor, and that would occur only about three minutes before impact.

Launched south-eastwards across the Indian Ocean at an orbital inclination of about 72°, FOBS would approach the USA from the south, where the radar cover is more limited (fig. 6). So FOBS clearly has some advantages over the ICBM, but there are also disadvantages. In order to achieve orbit, the launch vehicle must accelerate the payload to at least 15,350 knots, whereas an ICBM requires about 13,500 knots. Also, an engine must be attached to the FOBS payload to deboost it from orbit. These requirements dictate that a given launch vehicle can lift a bigger warhead in the ICBM mode than in the FOBS mode. Nevertheless

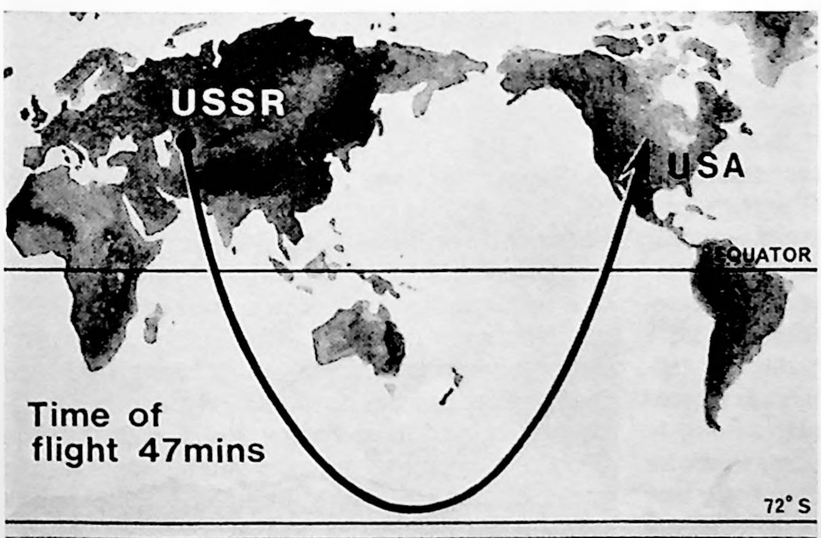


Fig. 6 72° ground track

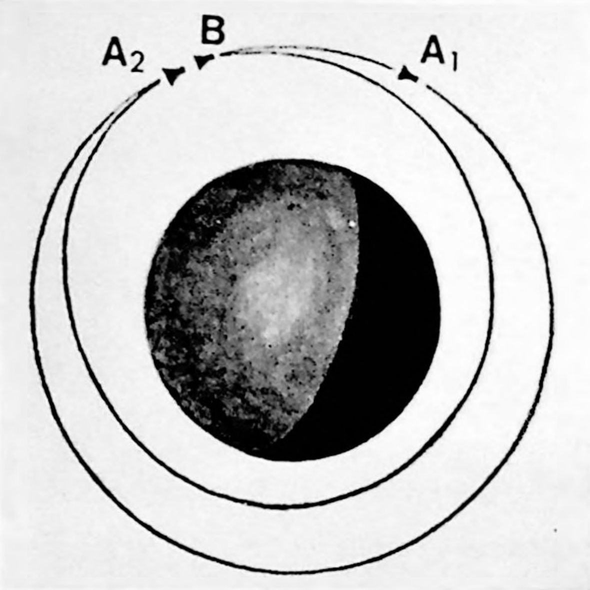


Fig. 7 Rendezvous manoeuvre

the SS 9 SCARP vehicle used for the FOBS tests is powerful enough to carry a multi-megaton FOBS warhead. The second disadvantage of FOBS is that like MOBS, and for the same reasons, it is probably less accurate than the ICBM.

USA reaction to FOBS

Despite the Soviet interest, the United States has not developed a FOBS system. FOBS is not a completely new weapons system, but a variation on a known theme, and it does not increase the Soviet striking power. However, it does compound the United States' defensive problems, and the Americans have been forced to take a number of extra defensive measures against FOBS, and at the same time, the SLBM threat. These included greater dispersal of the manned bombers of Strategic Air Command, the continued development of the Safeguard Anti-Ballistic Missile (ABM) system, and the introduction of new early warning sensors/satellites and Over The Horizon Radar (OTHR).
The American position, expressed by the Secretary of Defence, was that the development of a FOBS capability was unnecessary, as their balanced force of aircraft and land and sea based missiles provided sufficient deterrence.
However, our view is that the primary reason for the American confidence is that they have now deployed a far more effective weapons system in the Multiple Independently Targetable Re-entry Vehicle (MIRV) which so far the Soviet Union has been unable to match. However, there are recent indications that the Russians must now be considered to have reached an advanced state of development of MIRVs. The MIRV is a significant improvement on Multiple Re-entry Vehicles (MRV). Whilst MRV certainly increases ABM defence problems, the trajectories of the independent warheads can be predicted since they fall ballistically in a predetermined pattern. MIRV, on the other hand, consists of independently aimed warheads and decoys which can manoeuvre to some degree so that prediction is much more difficult.
Viewed in this context, it can be seen that FOBS is a relatively primitive weapons system compared with MIRV, so there is no need for the United States to include FOBS in its missile armoury.

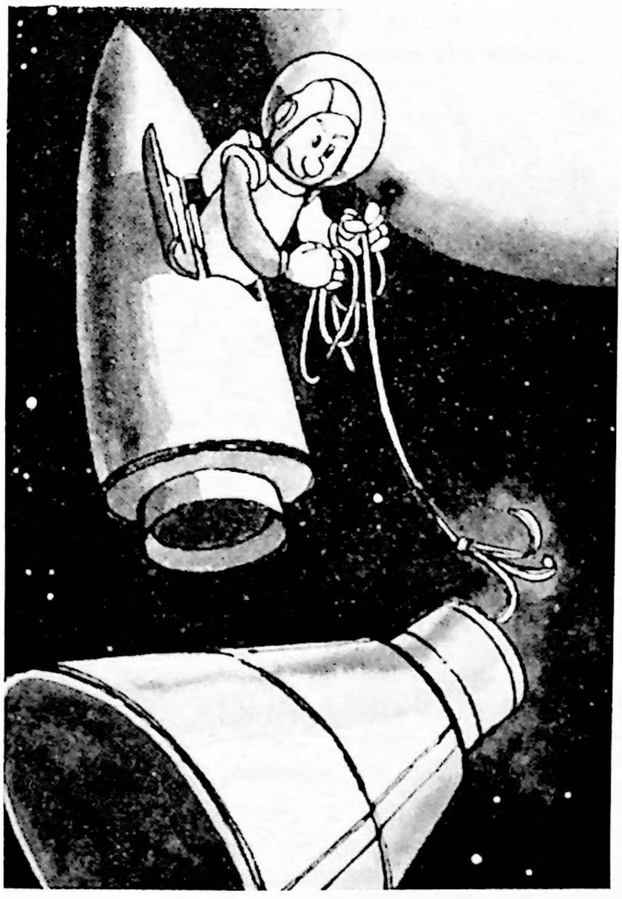
Spacecraft combat

In general war, some form of combat between opposing spacecraft is inevitable. However, one must immediately discount any thoughts of a space 'dogfight'; there are far too many constraints in space to allow the manoeuvres which aircraft can carry out.
An aircraft can change its flight path by use of the control surfaces, using aerodynamic forces. In space, with no atmosphere, this cannot be done. The only way to change the direction is to change the velocity, and that means using energy; a scarce commodity on board a spacecraft.
The spacecraft itself has enormous momentum, and a great deal of energy is needed to change its orbit. One can visualize the effort required to change the direction of a 10,000 ton ship travelling at 150 knots. A satellite in near-earth orbit, weighing only 1 ton, would have approximately the same kinetic energy as the ship, and would have to rely on its rocket motors, rather than any hydrodynamic forces, in order to manoeuvre.
The next question is how to solve the problem of getting near to the target. You will recall that all paths in space are curved, and when planning an interception one has to consider the relative circular motion of three bodies: the launch platform (Earth), the target, and the interceptor. It is a problem which can only be solved rapidly by a computer. This inability to travel in straight lines

in space produces some unexpected results. For example, if an interceptor was following a target satellite, it would have to slow down to overtake. The reason is that if power was applied, the spacecraft would go into a wider orbit and progressively fall behind. The interceptor would have to deboost, or slow down, relative to the target, and fall into a tighter elliptical orbit, which would eventually produce a rendezvous. The situation would look like this (fig. 7): satellite B wishes to intercept satellite A. B deboosts, transfers to the interior elliptical orbit, and intercepts at point A2. The final closing to the target might be a docking manoeuvre when thrust is used conventionally, but with the unwanted orbit changes eliminated by opposing reaction jets. Alternatively, the final stage could be a form of grappling (fig. 8).

From our early description of the problems of achieving the large plane changes normally required to attain equatorial orbit, you will appreciate that satellites in such orbits are relatively safe

Fig. 8 Interception!



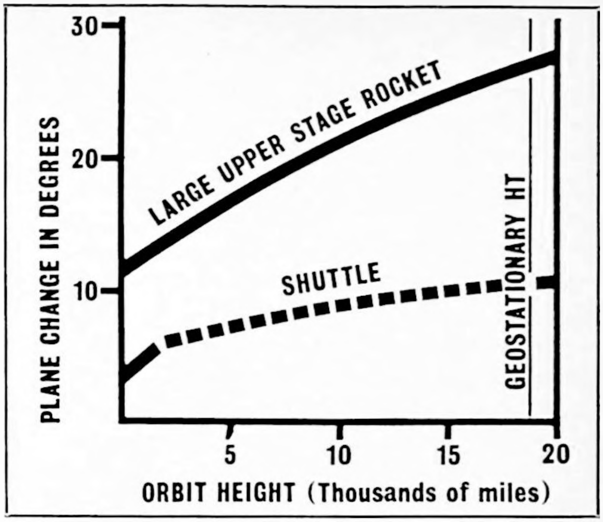


Fig. 9 Plane change capability

from interceptors launched from higher latitudes. Even if large plane changes are possible, the achievement of rendezvous requires the precise matching of orbits, and in practice this means launching within tightly prescribed time limits. So any idea of a quick reaction alert, with 'fighter' satellites poised on a launch pad to make interceptions, is not practical.

Enough has been said to make it obvious that any space interceptor would need to be large and powerful, especially if it is to reach satellites in high orbits, or if it has to perform plane change manoeuvres. The new Space Shuttle, which is being developed in the USA to perform a variety of different space missions, will only be able to reach an altitude of about 300 miles, and its manoeuvring capability will be limited to about 4° of plane change (fig. 9). For higher orbits, or for larger plane changes, conventional rockets will have to be retained for the time being. However, the Shuttle will have a most useful military capability to intercept satellites in near earth orbit.

Let us assume that an interceptor has come close to the hostile satellite: how would it destroy the target? A guided missile might be used, but in space, with no atmosphere, there is no blast, and so one of the primary kill mechanisms of high explosive and nuclear warheads is not available. If a high explosive device were used, it would have to be attached to the skin of the target vehicle like a limpet mine, or employ a fragmentation warhead.

A nuclear explosion would use radiation effects to incapacitate or destroy the target. The Electro Magnetic Pulse (EMP) generated by such an explosion would have an effect over a wide area in space and could damage both the fabric of the spacecraft and any electrical circuits on board. With mini-nuclear weapons a possibility, this would appear to be the most effective anti-satellite weapon, provided that the powers chose to deliberately ignore the space treaty of 1967. Finally, the laser might be able to damage a satellite, and particularly any optical equipment on board, so necessary for reconnaissance. However, we believe that at the moment it would not be possible to generate within a satellite interceptor the very high levels of power needed to produce a laser beam strong enough to incapacitate another satellite.

Despite all these problems, we believe that the USSR has been developing seek and destroy satellites. We base this belief on a series of Cosmos flights between October 1968 and December 1971. In these tests, satellites were launched into orbits between 150 and 400 nautical miles high, and then further satellites were launched which passed very close to the first craft and then fragmented. We do not know whether the first launch in each series contained a weapons system and subsequent launches were targets, or if the first launch was the target and the follow-on launches were destruction systems. But the fact remains that the Soviets appear to have a rudimentary system which could be used against reconnaissance satellites in near earth orbit.

So far, it would appear that America has not developed any similar interceptors, though she has been showing some interest in the subject, probably as a result of Soviet tests.

Surface to space anti-satellite systems

The only way to destroy a satellite from the ground is to use a surface to air missile. No other earth based weapon has the range to reach a satellite in orbit, which normally would be at an altitude of at least 100 miles. In the distant future, it is conceivable that the development of laser weapons might change the situation, if sufficient power can be concentrated in a laser beam.

However, even to reach a satellite in near Earth orbit would require a very large and powerful missile. As far as we know, no missiles have been developed specially to destroy satellites, but both the USSR and USA have developed Anti-Ballistic Missile systems. The Galosh and Spartan missiles associated with these systems are designed to intercept missiles outside the atmosphere, and we believe that they could also be used against satellites which flew through their area of cover (which extends up to 200-300 miles altitude, and 400-500 miles range).

So satellites flying within these parameters could be vulnerable. But without further extensive development of current ABM systems, satellites operating above 300 miles could be considered to be safe from attack from the ground.

Meteorology

It is often suggested, somewhat cynically, that meteorological satellites have not led to any noticeable improvement in weather forecasting. It cannot be denied that satellites are exceptionally useful tools for the forecaster, but they are only tools, and the speedy interpretation of the extensive weather data remains a problem for the forecaster. The extent of the space meteorological programme is significant, and points to the eventual development of completely accurate, world-wide forecasting and perhaps some measure of weather control.

The significant meteorological programmes to date have been the following.

Television Infra-red Observation Satellite (Tiros)

Ten satellites flew in the Tiros programme between 1960-1965. It was an American research and development programme evaluating photographic and infra-red camera systems for producing cloud cover pictures. One of the most important developments in this programme was the Automatic Picture Transmission (APT) system for transmitting cloud cover pictures to ground stations, using relatively simple equipment. It is estimated that APT is now in use in over 700 stations in more than 50 countries, and the RAF has APT facilities available from the meteorological offices at Bracknell, Cyprus, Gan and Gibraltar.

Nimbus

Nimbus is a continuing American experimental programme of satellites which produce day and night cloud pictures as well as carrying many other sensors. These have included:

— IRIS. An Infra-Red Interferometer Spectrometer which measures the atmosphere's vertical temperature, water vapour content and ozone distribution.

— MUSE. A Monitor of Ultraviolet Solar Energy.

— IRLS. A system for Interrogation, Recording and Locating, which enables data to be collected from remote platforms attached to balloons, buoys, icebergs and even migratory animals. Not only could data be recorded, but a fix worked out on the location of the station to an accuracy of about 2 miles.

Environmental Survey Services Administration satellites (ESSA)

The ESSA satellites were the first operational American meteorological satellites, and nine satellites were launched in the programme between 1965 and 1969.

Improved Television Observation Satellite (ITOS)

ITOS is the latest American meteorological programme. The ITOS satellites are providing complete world coverage, with televison and infra-red sensors, twice every 24 hours, with a best resolution of about 0.5 mile. Like Nimbus, ITOS carries additional sensors, and the most recent ITOS satellite, launched in October 1972, carries a Vertical Temperature Profile Radiometer, taking atmospheric temperature readings from sea level to 20 miles altitude, and a Solar Proton Monitor to give solar energy readings near earth.

— METEOR. The Russian meteorological satellite programme is called Meteor. 15 satellites have been launched in the Meteor series, and these carry sensors and transmission systems similar to those on the latest American satellites.

— EOLE. This was a French meteorological satellite launched in 1971. This satellite interrogated equipment carried in a number of high altitude balloons.

In the future, satellites in geostationary orbit will will be used in meteorological programmes. Current American plans are to place two or more geostationary satellites over the Equator, each of

Fig. 10 Lunar surface

which would provide cloud cover pictures of an area covering from 52.5° North to 52.5° South latitude and about 140° longitude at the Equator. Each picture would take only 20 minutes to produce and resolution at picture centre should be 1-2 miles. A full system would use three satellites positioned at 120° longitude intervals around the Equator, with one polar orbit satellite of the ITOS type to cover the polar regions.

Sensors

Discussion of meteorological satellites, with their ability to photograph cloud cover, inevitably focusses attention on other sensors for use in reconnaissance and study of the earth's resources. Broadly, the main systems at present in use in satellites are the following.

Daylight photography using cameras with long focal length lenses for maximum resolution. In some reconnaissance systems, the exposed film is returned to earth for development and analysis, while in other systems the film is exposed and developed on board, then scanned electronically for radio transmission to earth. An indication of the quality of the transmitted information is given by the picture of the moon's surface (fig. 10). The photograph was taken by a Lunar Orbiter satellite 85 nms above the moon, and the information was transmitted back to earth. The smaller of the two boulders shown is about 15 feet in diameter, and the track it made as it rolled down the slope is clearly visible. The quality of the film returned to earth for development may be even better; we believe that 2-3 feet resolution can now be achieved in the right conditions from low earth orbit. It should be possible to improve resolution to as little as one foot.

Television cameras (vidicon and similar types) which produce images in electrical form for transmission back to earth.

Multispectral cameras which take several simultaneous photographs of the same scene, with each lens accepting light from a different part of the visible and near infra-red spectrum. The different images can be combined to produce a colour composite picture which is better than the best individual input.

Infra-red cameras which are able to build up pictures by day or night from the thermal radiation emitted from the surface of the earth.

Sideways looking radar which is being studied for possible use in future reconnaissance satellites.

None of these systems can approach the resolution capability of the photographic cameras, and most of them can only be expected to have resolution capabilities, depending on conditions, measured in tens or hundreds of yards.

Satellites and terrestrial navigation

It is common knowledge that the nuclear submarine fleets make use of satellites to help solve their navigational problems. But precisely how the system works, and whether it could be used by other vehicles, including aircraft, is a frequent query.

The only operational system in the West is the United States Navy navigation satellite system, known as Transit. Starting in 1963, over twenty satellites have been launched in this series; however, only the last four or five are now operational. The satellites are placed in near circular, polar orbits, to give world wide coverage, and their orbital height is 65-700 nms. The complete system uses four satellites spaced at 45° intervals of longitude. In polar regions, a fix is usually obtainable from one or other of the satellites about once every half hour, but at the Equator, a user sometimes has to wait up to four hours between fixes. This time interval is acceptable for submarine operations, but obviously not for aircraft.

The Transit fixing is based on the measurement of Doppler shift in frequency, to obtain the range of the receiver from the satellite. The satellite transmits on very accurately maintained frequencies in the VHF/UHF band (150 and 400 MHz). The signals are combined to counteract the effect of ionospheric refraction and measured at the receiver to an accuracy of $1:10^9$. The measured shift in frequency indicates that the receiver is on a curved hyperbolic position line. If several readings are taken as the satellite moves across the sky, a series of position lines is built up and a fix can be obtained. In order to determine the satellite's position to calculate the range lines, the ship's computer must have accurate orbital parameters and timing signals fed into it. These details are transmitted every two minutes by the satellite, which itself is fed the information every twelve hours by a ground tracking station.

Transit was declared fully operational in 1964, and in 1967 it was offered for use by the commercial ships of the world, which, equipped with a suitable receiver and computer, can now obtain fixes to an accuracy of about 250 yards. But although Transit has proved very useful for shipping, it is not suitable for use in aircraft. An accurate fix takes several minutes to obtain, and fixing cover is far from continuous. In addition, for an accurate fix it is necessary to know very precisely the height (above sea level) and velocity (groundspeed) of the receiver. A height inaccuracy of one foot gives a one foot fix error, and for each knot of velocity error, fix errors of up to a quarter of a mile may occur. Thus, an aircraft would need a very accurate Doppler or IN system before it would be able to use the system.

Although Transit is likely to remain in use for several years, studies are being carried out in the west on a new satellite navigation system, which would be able to provide fixing information to land, sea and air forces. The system concept is shown in fig. 11; it consists of one geostationary satellite about which rotate three or four similar satellites in elliptical inclined orbits so phased that they appear from earth to follow a common cir-

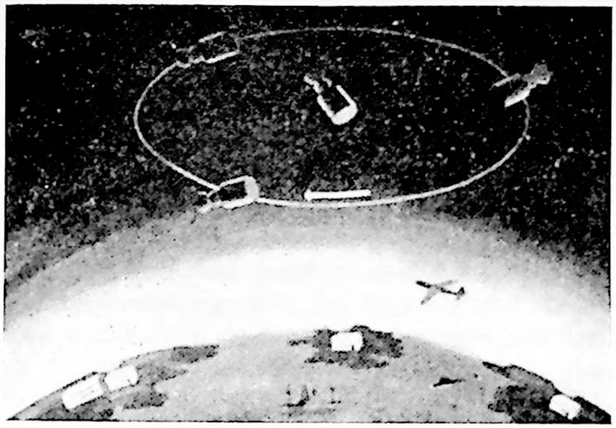


Fig. 11 Future navigation system

cular path. Each satellite transmits a signal to the user at an exact time. The user measures the time taken for the signal to reach him from each satellite. In the case shown here a four position line fix would be obtained from the four range circles obtained from the time measurements. As with Transit, the satellites would have to pass their orbital parameters and a time signal with each fixing transmission.

Such a system would be very expensive, as three constellations of satellites would be needed to give coverage of 85 per cent of the world's surface, and four constellations would be needed for complete world cover. However, if the system were to attract commercial as well as military buyers, the system might still be worth developing. Much study remains to be done, and it is unlikely that such a system would become operational before the early 1980s.

The Soviet Union also has a satellite navigation system, although few details of it are available. The Soviets have claimed to have a working system, and are reported to have agreed with the International Telecommunications Union (ITU) in Geneva to use the frequencies of 150, 200 and 400 MHz for navigation satellites. It seems likely, therefore, that the fixing system of the Russian satellites is similar to that of Transit, and uses the Doppler shift in frequency principle.

It seems certain that the navigation satellites are launched under the cover of the Cosmos programme, and the most likely series is one in which the satellites are launched into 74°, near circular orbits from Plesetsk. The series is complex; there are at least two types of satellites, both of which are transmitting, and three different height bands (170 nms, 550 nms and 750-800 nms). There have been both single and multiple launches, and on no less than six occasions, eight satellites have been launched on a single booster; 17 satellites were launched into this series in 1970, 28 in 1971 and 24 in 1972. Obviously, far too many satellites have been launched into the 74° orbit for them all to be associated with navigation, and it is impossible to identify the function of each satellite. But it seems probable that navigation satellites fly in 550 nms orbits, and that ferret (electronic intelligence gathering) satellites, scientific satellites and, possibly, military communications satellites are flying in the other height bands.

Satellite communications and the jamming problem

Satellite communications have become commonplace, but their apparent vulnerability to jamming always excites the interest of the military. However, before we discuss jamming, a brief word is needed on satellite communications systems. Although one can bounce radio waves off a satellite, using it as a passive reflector, all current operational systems are active. The active satellite has a receiver, amplifier, frequency changer, and a transmission system, which will normally be directional. Western communications satellites are placed in 24 hour geostationary orbits, hovering over one point on the Equator. Because the satellite appears from the ground to be virtually stationary, it can easily be tracked. Its great height (19,360 nms) means that it is in line of sight contact with a large part of the earth's surface, and since communications can be established along this line of sight, very high frequencies can be used. Most satellites operate in the UHF and SHF bands, and so a very large number of communications channels are available.

About two thirds of all long range communications now take place via satellite, and in the west, the USA, Britain and NATO all have military communications satellite systems. Although these systems can be jammed, careful system design has reduced their vulnerability. Jamming may be directed against a receiving ground station, which would affect only part of the communications system, or against the satellite, which would affect the whole system. If an enemy knew, and could reproduce, the modulation characteristics of the system, he might be able to use coherent (or deception) jamming. However, it would be extremely difficult to match the complex characteristics of modern military systems, and enemy jamming is far more likely to be incoherent (or noise) jamming.

The effectiveness of the enemy jamming depends very much on the type of modulation used by the satellite system. One particular modulation technique, Spread Spectrum Modulation (SSM), is particularly resistant to jamming. In this technique, the bandwidth of the communications signal is increased, or spread, by combining the signal with a high speed digital code. A voice signal, with a bandwidth of several kHz, may be spread over a bandwidth of a few tens of MHz. In the receiver, an identical high speed code is synchronized with the transmitter code, and the wanted signal is recovered by the process of correlation. The recovery of the signal, with a reduction to the original bandwidth, is accompanied by a significant increase in the signal to noise ratio. The effect of the jamming does not become serious until the jamming power arriving at the satellite is substantially greater than the total power arriving in all the up links. The level of jamming required to cause significant degradation in system performance would be many tens or even hundreds of kilowatts, and only a technologically advanced country would be capable of achieving this.

While it would be very difficult to jam successfully a satellite system which uses SSM, it would be possible to jam individual ground stations, particularly small mobile stations deployed tactically in a forward area. Jamming signals might be introduced through the aerial side lobes. Such small stations with their relatively small aerials and limited power are also the first to be affected when jammer power at the satellite approaches the capture level.

Thus it would be possible for an enemy to jam at least part, if not all, of a satellite communications system, though the techniques we have described make this task a very difficult and complex one. However, there is another way an enemy can interfere with a communications satellite: by sending spurious command signals. It might be possible for him to order the satellite to shut down, or to move off station. For this reason, it is essential that a military communications system should incorporate safeguards to prevent unauthorized access to the command and control channels. Such safeguards are being incorporated into the latest western satellite systems, like Skynet 2.

Thus the vulnerability of modern satellite communications systems to interference can be much reduced, and such systems can provide long range communications links with a quality, security and flexibility which no other class of systems can easily match.

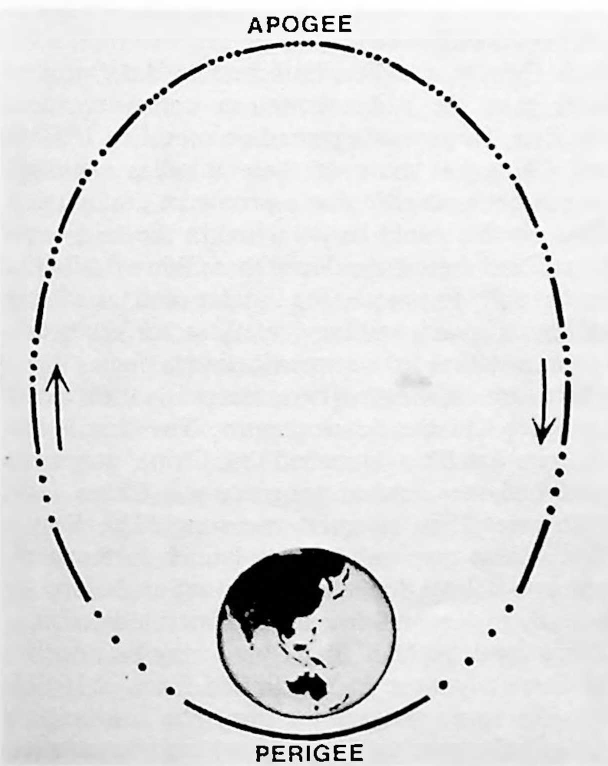
Soviet satellite communications

The western satellite communications systems, both military and civil, have received considerable publicity, but we are often asked to describe the extent and development of the Soviet counterparts. The standard Soviet communications satellite is the Molniya 1 series and starting in April 1965, 23 of these satellites have been launched. It is a relatively powerful satellite, carrying three 40W transmitters, operating at a frequency around 3 GHz. It appears, though, that Molniya 1 is being replaced by a new and more advanced series of satellites, Molniya 2. The first of these new satellites was launched in November 1971, and since then four Molniya 1 and five more Molniya 2 satellites have been placed in orbit. Molniya 2 operates at a much higher frequency, about 6 GHz, but in many ways looks similar to the earlier satellites.

The Molniya orbit is not the synchronous, equatorial orbit which has become so familiar in the west. Apart from the fact that the USSR has never demonstrated the ability to place a satellite in equatorial orbit, a satellite in such an orbit would appear low in the sky from ground stations in the north of the Soviet Union, and that is an unfavourable condition for the operation of communications satellites. For point to point communications within the Soviet Union, an orbit is required which ensures that the satellite spends as long as possible overhead that country. The chosen orbit is shown in fig. 12. It lies at 65° to the equatorial plane, in a highly elliptical, 12 hour orbit. Molniya moves slowly through apogee (at about 22,000 nms) over the northern hemisphere, and dives quickly through perigee (270 nms) over the southern hemisphere. Since the orbital period is 12 hours, Molniya orbits twice while the earth rotates once. Each satellite rises to apogee over the USSR, where it is available for point to point communications within the Soviet Union for about eight hours. It then dives through perigee to rise to a second apogee over Canada, where it is visible from the Soviet Union for about six hours. Thus, using only three Molniya satellites, correctly phased eight hours apart, and using only the Soviet apogee, 24 hours cover is possible. This the Soviets achieved for the first time in 1968. Using both apogees, only two satellites could provide almost continuous service. At present (August 1973) five Molniya 1 and five Molniya 2 satellites are thought to be operational, so the USSR has not just continuous cover, but considerable reserve capacity as well.

To work with the satellites, a number of ground stations have been built, forming the Orbita communications system. In 1970, TASS announced that there were more than 30 stations within the Soviet Union, that a station had been built at Ulan Bator in the People's Republic of Mongolia, and

Fig. 12 Molniya orbit



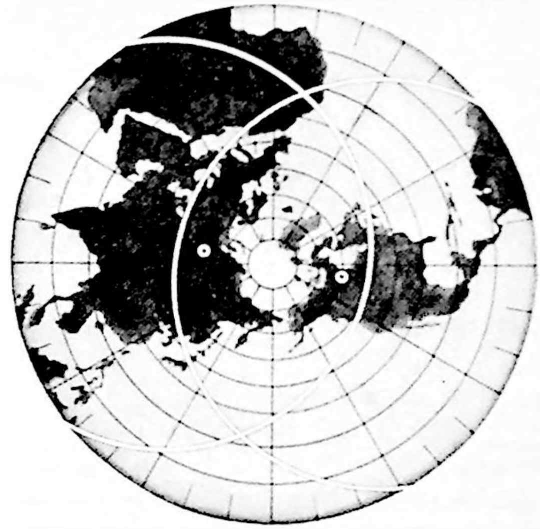


Fig. 13 Molniya ground cover

that more stations both inside and outside the Soviet Union were planned. In September 1971 an agreement was signed by the USA and USSR to develop a new satellite-borne 'hotline' between Washington and Moscow. As a result, a satellite ground station for use with Molniya has been constructed at Fort Detrick in Maryland, and it became ready for use in 1974.

As has already been suggested, the USSR is striving to extend her satellite cover ever wider. Fig. 13 shows the ground cover that can be achieved by using both Molniya's apogees. Communications are already possible between Moscow and naval units in the north Pacific, north Atlantic and the Indian Ocean, provided that a suitable shipborne terminal is available. The tracking fleet of the Soviet Academy of Sciences carries the right sort of terminals, as possibly do many other Soviet ships, and the flagship of the tracking fleet, the Cosmonaut Yuri Gagarin (fig. 14) has an impressive array of antennas, including one intended specifically for use with the Molniya satellites. Trials have been reported in which the Cosmonaut Yuri Gagarin, stationed in the southern hemisphere, received data from, and transmitted to Molniya during its rapid pass through perigee. Doubtless, this was an attempt to extend Molniya's cover still further.

Further evidence of attempts to increase earth coverage by the Soviet satellites came with the signing, by the USSR and a number of her allies

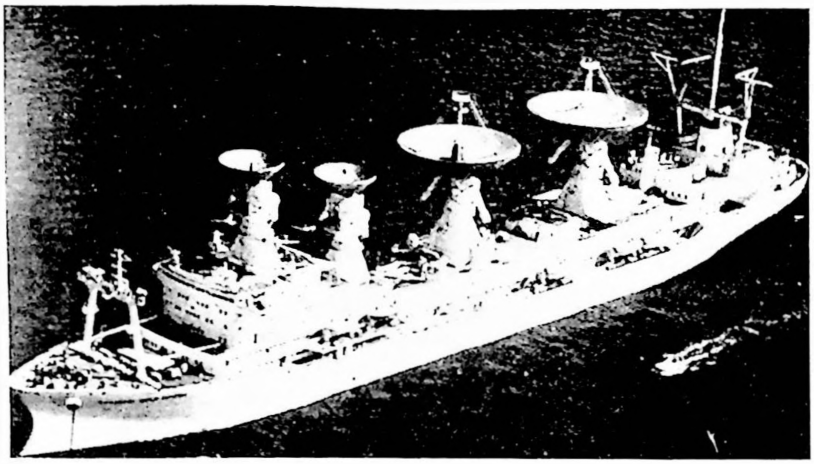


Fig. 14 Cosmonaut Yuri Gagarin

in November 1971, of the Intersputnik agreement. This established a communist bloc international communications satellite consortium, the equivalent of the West's Intelsat. Intersputnik is controlled by a council of representatives, which coordinates its activities with the ITU in Geneva. The USSR has also announced plans for a new satellite called Statsionar 1, which is to be placed in geostationary orbit between 75°E and 85°E over the equator. Frequencies for use with the new satellite were reserved with the ITU from December 1970, but the satellite has still not been launched. Despite the obvious delay it is unlikely that Russia has abandoned her plans for launching a geostationary satellite. If and when Statsionar is launched, it will extend Soviet satellite communications cover well into the southern hemisphere, and this capability, we suggest, will have both military and political significance.

Chinese communications satellites?

China has launched two satellites, and has deployed a modest force of IRBMs, so that her capability in space is often probed.

Certainly, Chinese space development appears to have been swift, and since her admission to the United Nations, China has been showing considerable interest in the field of space communications. When her first satellite was launched in April 1970, China proudly pointed to the fact that her satellite was over twice as heavy as the first Soviet satellite, and over 10 times as heavy as the first American satellite. She also reminded the world that only five years elapsed between China's first atomic test and the launching of her first satellite. In the Soviet Union, the two events had been separated by eight years, and in America by twelve years.

Just before President Nixon's visit to China in early 1972, an American-built satellite ground terminal was installed near Shanghai, and since then two further ground stations have been built to work with the Intelsat satellites. In November 1972, Dr. Tsien Wei-ch'ang, one of the leading Chinese propulsion specialists, was quoted as saying 'We will launch a communications satellite in the very near future'.

Both Chinese satellites launched to date weighed more than the early American communications satellites. They were launched on modified IRBMs, and China has more of these missiles available. So it is quite possible that a prototype communications satellite could be launched in the fairly near future, and there is no doubt that China would like to be able to match the Soviet and American ability to launch military satellites for reconnaissance as well as for communications.

There are, however, two factors which could influence Chinese developments. The first is that the two satellites launched by China appear to have had very limited programmes; China I did little more than transmit the song 'The East is Red'. China may well have to launch further technology satellites for system evaluation before she is ready to place an operational satellite in orbit.

The second factor is that China may be reluctant to divert any more of her limited force of IRBMs into the space programme until she has built up her missile force to the point where she feels less vulnerable to attack by her potential enemies. However, this is mere speculation, and it is certain that China will continue her space programme.

Reconnaissance from space

The subject which attracts more questions than any other is space reconnaissance. Practically no official information has been released on the reconnaissance programmes of the USA and USSR, and yet these programmes, between them, form a large part of the overall space effort.

Reconnaissance satellites can survey the whole world very rapidly, they are relatively invulnerable, and they can be fitted with sensors to gather information across the whole of the electromagnetic spectrum.

For instance, if we consider first the low frequency end of the spectrum, where radio and radar operate, there is little difficulty in fitting a satellite with sensors tuned to particular frequencies within that band. The satellite can then be launched on a trajectory which will repeatedly take it across a potential enemy's territory, where it can listen to and record radio and radar transmissions. When it returns over friendly airspace again, the tape recorders on board can be made to relay the recorded transmissions back to a ground station. We believe that one of these 'Ferret' satellites is launched by the United States two or three times a year, in order to gather electronic intelligence over the Soviet Union and China, and that each satellite has a working lifetime of between six and twelve months.

In the infra-red part of the spectrum, photography from space has been commonplace for several years. Infra-red photography is carried out by meteorological and earth resource satellites as well as in the reconnaissance programmes. These IR films can detect objects not revealed by normal photographic film, but the major limitation of infra-red sensors in the reconnaissance role is that, like conventional cameras, they cannot penetrate cloud cover.

In the early 1960s the United States was developing infra-red sensors for another important reconnaissance role, that of providing early warning of a ballistic missile attack. The Midas programme used sensors mounted in satellites to detect the infra-red emissions from the exhaust trails of ballistic missiles which might be launched against the western nations. Despite many early problems, Midas has now evolved into the apparently highly successful Integrated Missile Early Warning Satellite (IMEWS) programme. Since 1970, three of the four IMEW satellites launched by the USA have gone into the correct near geostationary orbit over the Indian and Pacific oceans. They reportedly have on board infra-red sensors to detect missile launches, as well as sensors, originally developed in the Vela series of satellites (1963-1970), which are able to detect any nuclear tests on earth. From their great height, the sensors are able to survey most of the Soviet Union and China, as well as large areas of the oceans, and early in 1972, Dr. John Foster, director of defence research and engineering, testified before Senate Armed Services Committee: 'We now have a satellite which is capable of immediately reporting ICBM launches from the Sino Soviet area'. IMEWS, then, is obviously an important addition to the United States early warning network against, not just ICBMs, but also SLBMs and FOBS.

There seems little doubt that the USSR also has satellites gathering information across most of the electromagnetic spectrum, but the main reconnaissance effort in the USA and the USSR is photographic. For over 10 years the USA has operated two basic types of photographic satellite, 'area surveillance' and 'close look'. Some, if not all, of the area surveillance craft have equipment which exposes and develops the film on board, for subsequent radio transmission to ground stations. However, as we mentioned earlier, the close look satellite films are returned to earth in a recoverable capsule for development and analysis.

For the last few years, the area surveillance craft, launched on a Thrust Augmented Thor booster with an Agena upper stage, have been averaging about four flights a year. The close look craft, launched on a Titan 3B, but also using the Agena upper stage, have averaged four - six launches a year. But in 1972 there were only three close look and two area surveillance craft, and in the first half of 1973, just one close look satellite. The reason for the decline in numbers is the emergence of a new and more advanced satellite, unofficially christened 'Big Bird' and launched on a Titan 3D. Big Bird weighs over 13 tons at launch, and is about 50 feet long. It probably carries several different sensors, the most important being a new camera system claimed by its makers to be twice as good as anything yet put into space and with a reported resolution capability of 1 ft from 100 nms altitude! Although it flies a conventional reconnaissance orbit, with a near polar orbital inclination and a perigee below 100 miles, it remains in space for about three months compared with the two - four weeks of other satellites in similar orbits. It is prevented from decay by periodic boostings into slightly higher orbit. The first of these new craft was launched in July 1971; by July 1973, six had been successfully orbited, and Big Bird is evidently the primary American photographic reconnaissance satellite.

The United States has steadily developed and improved her space reconnaissance capability. Not surprisingly, there has been similar activity in the USSR. Once again, we must look within the Cosmos programme for evidence of reconnaissance effort, and there is certainly plenty of evidence. Cosmos 4 was the first Soviet reconnaissance satellite in April 1962. By 30 July 1973, 577 Cosmos satellites had been launched, and 250 of these were reconnaissance vehicles.

The favoured orbital inclinations for the Soviet reconnaissance satellites are around 65 degrees, though occasionally higher and lower inclinations are used. The orbits are low, with a perigee about 100 miles high, so that the orbital period is about 90 minutes. During flight, the satellite transmits telemetry signals, and it is possible that interrogation takes place whenever the satellite is within line of sight of a Soviet ground station. Eventually, the vehicle is recovered on land, in the steppes of Kazakhstan, to the NE of the Aral Sea, and the film exposed during flight can be retrieved for processing and analysis.

Until early in 1968, the reconnaissance satellites flew for eight days before recovery from orbit. With their orbital parameters, it took exactly eight days to survey all the ground beneath the orbit, and a longer time in orbit would only have produced repeated photography. However, in March 1968, Cosmos 208 flew for 12 days before recovery, and since then, more and more satellites have flown with a 12 or 13 day flight time. We believe that these extended duration satellites are a second generation reconnaissance system. The increased flight time is necessary because the ground tracks are closer together so that it takes about 12 days to completely cover the ground beneath the orbit. The new craft have displayed some manoeuvre capability, and the closer ground tracks suggest longer focal length cameras and better photographic resolution.

The number of Soviet reconnaissance satellites increased steadily from five in 1962 to 32 in 1969, and has now stabilized at about 30 per year. In 1972 there were 29 Soviet photographic reconnaissance satellites, compared with only eight American. But we must remember that the American satellites, especially Big Bird, remain in orbit for much longer than the 12 day Soviet satellites, so that as far as coverage in time is concerned, one Big Bird may be considered as equivalent to four or five Soviet satellites. It is impossible to compare the results achieved by the two nations, but we have no reason to suppose that the Soviet cameras are either markedly superior or inferior to their American counterparts. What we do know is that they are operating, in effect, the 'Open Skies' policy advocated by President Eisenhower in 1955. Both have demonstrated a capability of carrying out routine surveillance from space, and of adapting their programmes to allow coverage of any events of special interest. For example, in 1967 the USA launched a satellite with the unusual inclination of 60 degrees, to survey the Suez Canal area during the ceasefire following the Arab-Israeli war. On 25 May 1972, an American area-surveillance satellite was launched for a flight which lasted only 10 days, instead of the normal three - four weeks. Could this have had any connection with the signing in Moscow on 26 May of the Strategic Arms Limitation Agreement?

In 1969, Russia launched 32 reconnaissance satellites, more than in any other year. During the border incidents involving the Soviet Union and China in February and March that year, no fewer than six reconnaissance satellites were launched in a four week period. Other launchings later in the year coincided with each fresh outbreak of violence, suggesting a fairly fast reaction capability. In December 1971, Cosmos 463 and 464 flew for only five and six days respectively, and were manoeuvred in flight to obtain maximum coverage of East Pakistan (now Bangladesh) during the Indo-Pakistani war. The orbital manoeuvres also allowed the two satellites to be recovered in Russia only two orbits (three hours) after the last pass over East Pakistan.

Only two reconnaissance satellites have been launched from Tyuratam into orbits with inclinations of 71.3 degrees. These were Cosmos 243 in 1968 and Cosmos 519 in 1972. Their flights coincided with NATO exercises Silver Tower (1968) and Strong Express (1972), both of which involved activity in north Norway. The North Cape of Norway lies at 71° North latitude, and so these two satellites would have been able to survey the whole of the exercise area. The standard satellites, because of their lower inclinations, can only cover the area up to 65° north and south of the equator. The capability of conducting detailed world-wide surveillance from space has given the great powers the ability to detect any covert build up of strategic forces, and so has reduced their vulnerability to a surprise attack. It could well be claimed that reconnaissance satellites are exerting a strong stabilizing influence on world affairs.

RAF participation in space in the 1970s and 1980s

There are no signs that RAF involvement in space will increase significantly during the remainder of this decade. We already have our own satellite communications system, Skynet, and the first of two Skynet Mk 2 satellites have already been launched from Cape Kennedy by the time you read this article. We are also participating in the NATO satellite communications network and, like the UK, NATO has plans for new satellites and ground terminals. Reconnaissance is being conducted on a large scale by the USA on behalf of the western world, and there is no stated intention by the UK government to duplicate this work. The possibilities of greater and more exciting involvement by the RAF in space open up in the 1980s if as a nation we have the will to become involved.

Peering into the future in space is not merely a matter of assessing future technological developments. Existing technology has given man the ability to conduct widespread military and civil space operations. The pace of development will depend on national decisions to spend money. These decisions are the signposts to RAF involvement in space in the 1980s.

In 1970, the present government appointed a Select Committee to consider science and technology. In October 1971 the Committee published its report on UK space activities. In its report, the Committee recommended that there should be 'an overall recognition on the part of Government that for an advanced industrial country such as the United Kingdom participation in space activity is inescapable'. There was also a recommendation that 'the Government should now consider the establishment of a single independent space agency to be responsible to the Minister of Aerospace for all the UK's civil interests in space' and a call for the Government to 'make a statement clearly defining national space policy and objectives so that industry may meet the technological and investment challenge they present'. These two recommendations have not yet been implemented and UK space activities continue to be controlled by the MOD, MOD Procurement Executive, Ministry of Posts and Telecommunications (through the Post Office), Department of Trade and Industry, Department of Education and Science (through the Science Research Council), the Foreign Office and the Treasury.

On many points, though, the Select Committee and the Government were in accord. The Committee endorsed the government decision to cancel the Black Arrow launcher programme and to withdraw from the ELDO (European) launcher programme and it agreed that we 'should continue to purchase American launchings as required'. The Committee also approved of continuing government efforts to co-operate in space activities with other European countries and the USA. Much of the discussion between Britain, Europe and the USA for the last three years has centred on possible European participation in the US post-Apollo programme, and in particular, the development of the Space Shuttle (fig. 15). If the negotiations are successful, the European nations could play a part in the development of this new space transportation system, and at the same time finally solve the recurring problem of how to launch our European satellites.

One other hopeful sign for future progress in Europe is that the decision was taken by the European nations in December 1972 to adopt Mr

Michael Heseltine's plan for a European Space Agency (ESA). This has come into being on 1 April 1974, and from that date all the national and international civil space programmes in Europe will be progressively integrated into the Agency, so that Europe may eventually have one centrally controlled space programme.

In late July 1973, the UK participated most forcefully in a further European space conference. In summary, the conference reaffirmed the intention to establish the ESA, settled its differences over future co-operative satellite programmes, and agreed to participate in the Shuttle programme, whilst at the same time developing a new European launcher based on the French L3S rocket. To achieve these positive steps the UK modified its previous views on the European launcher and abandoned a national communications technology satellite in favour of a joint venture.

There is now much greater hope that the ESA will prove to be effective, and that it will be a more stable and less expensive organization for the European countries to continue and extend their space interests.

Provided that the governments of the day are determined to continue our national interest in space, and that the economic outlook is sound, the RAF Aerospace Briefing Team venture to predict that RAF space activities in the 1980s could include:

• RAF astronauts as Shuttle crewmen (exchange tours?).

• RAF astronaut scientists manning the cargo module for the following purposes.

— Satellite inspection and repair.

— Global reconnaissance (the Shuttle could open up possibilities of more RAF participation in the US reconnaissance programme).

— Reconnaissance in areas of immediate common interest (for example, a further flare-up in the Middle East).

— Investigation of potentially hostile satellites. The USA may well welcome NATO involvement and support if international tension arises in space.

• Development of common Air Traffic Control procedures for returning Shuttle craft, and possible integration of present aircraft control procedures into a new satellite-borne master control system.

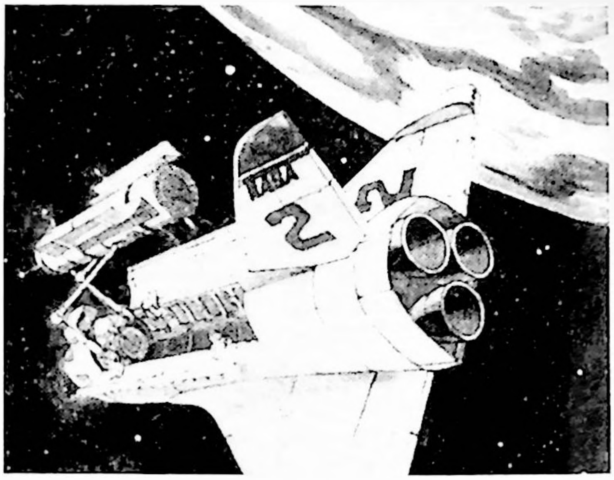


Fig. 15 Space Shuttle

• Use by RAF aircraft of proposed new American navigation satellite systems.

• Continued and increased study by RAF aviation medicine experts of the physiological effects of spaceflights.

Conclusion

The space briefing period held at the RAF College of Air Warfare lasts for nearly three days. In this article, we have only highlighted the most important aspects of military space activity. If you wish to delve further into this fascinating and important extension of air power, you may find the following books and publications particularly helpful.

Sourcebook on the Space Sciences, by Samuel Glasstone (D. Van Nostrand Co. Inc.).

The New Space Encyclopedia (Artemis Press Ltd.).

Collins Concise Encyclopedia of Astronautics.

Secret Sentries in Space, by Philip J. Klass (Random House).

Fifth Report from the Select Committee on Science and Technology (UK Space Activities) (HMSO).

Reports on Soviet Space Activities 1957-67, and 1966-70, prepared by the Library of Congress for the United States Senate (US Government Printing Office).

Day to day developments are best covered by the weekly and monthly aviation journals, such as Flight, Aviation Week and Interavia.

Illustrations by Mr B. J. Morgan-Anstee (RAF College of Air Warfare Graphics Studio).

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MiC

De nucleaire proliferatie

Van „balance of terror" naar de terreur van de onevenwichtigen?

J. R. Evenhuis

journalist, Rome

Technische oorlogvoering lijkt soms speciaal een kind en noodlot van ons tijdsgewricht. Het is echter maar wat men onder techniek verstaat. Gaat men niet slechts uit van de hedendaagse techniek, dan kan men ook zeggen dat de Byzantijnen al omstreeks het jaar 700 met hun Grieks vuur en de Westeuropeanen rond 1400 met hun buskruit aan de techniek als „oorlogsbeslisser" een zeer ruime plaats hebben gegeven. (Zie: *Mars in Cathedra* (1975)(25)1129).
Het effect op hen die getuigen waren van het eerste gebruik van de genoemde wapens verschilde dan ook niet zo wezenlijk van de consternatie die in 1945 door de eerste atoombom werd veroorzaakt. Wellicht kwam destijds de schok zelfs nog harder aan, want de mensen leefden toen niet zoals wij in een technologische tijd. Welbeschouwd waren het Griekse vuur in de 8e en het buskruit in de 15e eeuw veel meer „Fremdkörper" dan de atoombom in de 20e eeuw. Een bevestiging daarvan zou men ook kunnen zien in het grote verschil in „proliferatie", tussen de technische wapens van toen en de atoombom van nu.

Trage ontwikkeling

Bij het Griekse vuur heeft zich na de uitvinding nauwelijks enige ontwikkeling en verfijning voorgedaan. Het procédé bleef wat het was, mede omdat men het bijna als een apothekersrecept behandelde. In feite is de hele zaak dan ook verkommerd.
De proliferatie van het buskruit schijnt evenmin zo onweerstaanbaar te zijn verlopen als zij er in de geschiedenisboekjes uitziet. In de eerste eeuw van hun bestaan bleef het schieten met kanonnen, blijkbaar ook door de afkeer die men van het technische gedrocht had, in West-Europa een nogal beperkte aangelegenheid. De doorbraak is pas gekomen toen een niet-Europese macht, het Osmanenrijk, dat nieuwe wapen overnam en zich daarmee in het bezit van Konstantinopel wist te stellen.
De Franse byzantinist Gustave Schlumberger heeft in zijn klassieke werk *Le siège, la prise et le sac de Constantinople par les Turcs en 1453* (6e dr., 1922), voorgesteld met deze „premier grand siège gagné par l'artillerie" de Middeleeuwen te laten eindigen en de moderne tijd te laten beginnen.
Daarvoor is ook om een andere reden zeer veel te zeggen: zolang namelijk die moderne tijd heeft geduurd — d.w.z. voordat ónze moderne tijd begon die met zijn technologie meer heeft veranderd dan alle oorlogen en revoluties die er na de val van Konstantinopel zijn geweest — is hij merkwaardigerwijze in principe nooit uitgekomen boven het buskruit als zijn voornaamste „ultima ratio". Ook de Eerste Wereldoorlog was eigenlijk nog steeds een „buskruitoorlog". In het bijzonder de granaatkartetsen maakten de strijd in wezen zeer „ouderwets". Ten slotte waren, naar de woorden van Sir Frederick Morgan, een militair die zowel kartetsen als atoombommen had leren kennen, de shrapnels een

refined version of that same gunpowder that had first sullied the knightly battlefield at Crécy.

Snelle nucleaire proliferatie

Vergelijkt men deze trage proliferaties met die van de nucleaire wapens sedert 1945, dan weet men meteen wat het betekent indien technische wapens niet worden uitgevonden in ontechnische maar in zéér technisch georiënteerde tijden. Mét andere remmen, is ook die van een onvoorbereide psychologie er niet langer.
Daaraan hebben helaas ook de diverse anti-atoombomacties niet veel kunnen wijzigen. Het vernieti-

gingsvermogen van de nieuwe nucleaire wapens zou ongetwijfeld nog sterker indruk op de publieke opinie hebben kunnen maken indien de mensheid zich in deze technologische tijd nog niet volledig aan de gedachte had gewend dat „alles mogelijk is". Zo fungeerde in zekere zin het incasseringsvermogen van het publiek als neutraliseringsfactor voor waarheden die men in ontechnische tijden als zo onverdraaglijk zou hebben ervaren dat — gesteld dat iets dergelijks toen ware uitgevonden — die uitvinding nóg slechter van de grond zou zijn gekomen dan het Griekse vuur in Byzantium en zich nóg langzamer zou hebben verbreid dan het buskruit in de Europese Middeleeuwen.
De Amerikaanse senator Symington heeft onlangs als zijn opinie gegeven dat alleen de Verenigde Staten nu al het equivalent van 600.000 atoombommen hebben indien men de eerste op Hirosjima geworpen bom als maatstaf neemt. Dit betekent dat het tellen van atoombommen als het tellen van geweren is geworden. Hieruit valt slechts één conclusie te trekken: De opvoering van het vernietigingsvermogen ging, in een democratische tijd die wíst wat er gebeurde, gepaard met een opmerkelijke verruwing van het psychologische incasseringsvermogen.
De reden daarvoor moet ongetwijfeld ook in „internationale situaties" worden gezocht die soms niet veel keus lieten. Aan de andere kant was het publiek echter de slaaf in plaats van de arbiter van de technologie geworden, en dat maakte nogal wat verschil uit.
De rest is speculatie, zoals die van de journalist die het hoofd van de Amerikaanse SALT-delegatie, Johnson, de volgende vraag stelde:
Mr. Ambassador, just on a philosophical note, do you feel that perhaps it might have been better not to have nuclear weaponry at all in the last 25-30 years?

Voor zulke vragen, die destijds in Byzantium misschien nog zin zouden hebben gehad, is het getij helaas verlopen.

Afschrikking, of alternatief?

Na het ontploffen van de eerste atoombom kon het eerst nog ernaar uitzien dat het verschijnsel oorlog nu eenvoudig aan een teveel aan techniek zou bezwijken. Vandaar dat toen alle oorlogen „in de ban werden gedaan", ook die waarvoor vorige pacifistische generaties nog moeite hadden gedaan ze als „rechtvaardige" oorlogen uit te zonderen. Het motief was duidelijk en eerbaar: een voor een ieder destructieve atoomoorlog scheen immers de enige van alle nog mogelijke vormen van oorlogvoering te zijn.
De periode daarna heeft bewezen dat dit in elk geval een simplificatie was. Onder andere is gebleken dat onze technologische tijd niet slechts vindingrijk is op zijn speciale terrein, maar gelukkig ook nog nét vindingrijk genoeg om zich door zijn uitvindingen niet alles te laten voorschrijven, ook niet op militair gebied: Voor zover er oorlogen zijn gevoerd, zijn zij conventioneel, althans subatomair verlopen.

De-escalatie

Tegenover de escalatie van de technologie heeft dus tot nu toe niet dezelfde escalatie van de oorlogvoering gestaan. Sommigen zien er bij wijze van spreken slechts uitstel van atomaire executie in, maar men kan het ook anders opvatten. Dat men wederzijds welbewust onder de maat van zijn extreemste machtsmiddelen blijft, is een zeer oude ervaring van de mensheid. Zulke de-escalaties komen echter altijd in gevaar als die mensheid door revolutionaire koortsen wordt geschokt die tot nu toe steeds op grotere hecatomben zijn uitgelopen. Een typische periode van de-escalatie was de tijd vóór de Franse revolutie. De grote historicus Edward Gibbon kon toen terecht menen dat de Europese mogendheden het bij botsingen nooit echt erop lieten aankomen. Zij gaven aan „temperate and indecisive contests" verre de voorkeur boven het maken van aanstalten om hun tegenstanders radicaal te vernietigen.
Ondanks een atoombewapeningswedloop die op zich zelf schrikwekkend genoeg was, geldt dat in feite evenzeer voor de periode 1945-1970. Ware het niet zo geweest, dan zou de oorlog in Vietnam zeker niet de „temperate and indecisive contest" zijn gebleven als hoedanig hij, op de militair-historische keper beschouwd en los van alle propaganda en polemiek, wel zal worden gerubriceerd.
Het is een schrale troost voor allen die eronder hebben geleden. Maar alles had ook veel erger kunnen zijn. Toynbee heeft met dat argument vroeger al eens de Italianen willen troosten die veel langere tijd, namelijk van 1494 tot 1866,

evenmin aan hun eigen belangen toekwamen en de strijd van de groten moesten betalen. Hun schiereiland was toen aan één stuk door het opmarsgebied van vreemde legers. Hij zegt daarover in *A study of history* (III, 311/12):

In all the warfare between French and Spanish armies, and French and Austrian armies, that met in battle on Italian soil in the course of nearly four centuries of European contests, no combatant, from first to last, ever dealt his adversary a mortal blow; the Balance of Power between the great Transalpine states continued to fluctuate without being overthrown. Let us hope that the history of the comparable relations between a latter-day Great Society and Europe may be no more unhappy than this during the centuries to come.

Het is interessant te bedenken dat het al veertig jaar geleden is dat Toynbee deze vergelijking tussen een machteloos Italië en een machteloos Europa trok; maar daarop komt het voor ons in dit verband niet aan. De kwestie waar het om gaat, is de de-escalatie in het groot. In hoeverre mogen wij erop vertrouwen dat de door Toynbee uitgesproken hoop in vervulling gaat?
Er is al direct de moeilijkheid dat wat voor de één de-escalatie is, er voor de ander geheel anders uitziet. Objectief, maar wat abstract gesproken was de oorlog in Vietnam een „temperate and indecisive contest", vooral gelet op de militaire machtsmiddelen waarover Amerika beschikte en die het niet verkoos in te zetten. Maar komt men meer in de subjectieve sfeer en denkt men bijvoorbeeld aan de Vietnamezen zelf die onder het oorlogsgeweld hebben geleden, dan zou het bijna als ironie kunnen klinken indien men de zaak zo zou bezien. En toch ligt zij in laatste instantie wel degelijk zo.
Toynbee dacht ook niet in de allereerste plaats aan de Italianen, die het overigens op elk denkbaar moment tussen 1494 en 1866 waarschijnlijk met zijn conclusie volkomen oneens zouden zijn geweest, indien zij de gelegenheid zouden hebben gehad zich tegen dergelijke abstracte interpretaties van hun lijdensweg uit te spreken.
De eerste Franse invasie in Italië (1494) was slechts een voorproef van wat er later zou komen. Maar zij was voldoende ingrijpend om alle begrippen die de Italianen vóór 1494 met het verschijnsel oorlog verbonden een zware escalatie te doen ondergaan. In de Italiaanse geschiedenis is alle ellende in feite met het jaar 1494 begonnen.

Veranderende methoden, verschuivende rollen

In Francesco Guicciardini's beroemde *Ricordi* (Herinneringen) is deze verandering vastgelegd. De komst van Karel VIII naar Italië was voor deze Florentijn het einde van de oorlog zoals hij die had gekend, en voortaan kon er nog slechts van ondergang sprake zijn omdat in zijn Italiaanse perspectief alles op ondergang duidde.

Vóór 1494 waren de oorlogen lang, hun verloop niet bloedig, de wijze van veroveren langzaam en moeilijk. Al was er al artillerie in gebruik, toch werd deze zo onbekwaam gehanteerd dat zij weinig schade aanrichtte. Wie ergens de heerschappij had, kon die bijna onmogelijk verliezen. Toen kwamen de Fransen in Italië en maakten de oorlog zóveel levendiger dat met de veldtochten hele heerschappijen verloren gingen.

Aldus Guicciardini. Waar hij op zinspeelt, is het einde van de oorlogvoeringsmethoden van de Condottieri, die twee eeuwen lang het beeld dat Italianen zich van de oorlog maakten, hadden bepaald.
Ook de Europeanen hadden tot 1945 een zeer bepaalde opvatting over oorlogvoeren die toen eensklaps niet meer gold. Men kan hun reactie op de uitschakeling van hun militielegers in de mondiale context zeer wel vergelijken met die van de Italianen op de waardeloosheid van hun Condottieri, toen zij met de Franse en de Spaanse militaire methoden werden geconfronteerd.
In elk geval hielden beide tot het laatst aan hun overgeleverde defensiepatronen vast. Het was zo bijna onvermijdelijk dat zij, eenmaal ter zijde geschoven, overal escalatie zagen (en zien), ook waar zich in feite het tegendeel voordeed. Dit lag aan hun perspectief, hun achtergrond.
Er liep in wezen een rechte lijn van hun specifieke, traditionele wijze van oorlogvoeren naar hun latere overtuiging dat oorlogvoeren geen zin meer had, enkel en uitsluitend omdat zij zelf niet meer eraan te pas kwamen. Allerlei acties om „de oorlog uit te bannen" zijn daarvan het gevolg geweest; alleen op die wijze kon men van zijn bestaan nog doen blijken.
Al die acties doen echter sterk denken aan de tegenkanting die de edele en niet zo edele ridders van de Middeleeuwen reeds tegen het buskruit toonden. Men hoeft echter niet eens alleen de Europese landen het verwijt van een paradoxale bekering te maken. Zij kan zich ook in omgekeer-

de richting manifesteren: wie zou bijvoorbeeld hebben kunnen denken dat India, het land dat met zijn „geweldloosheid" zoveel heeft bereikt — hoewel het natuurlijk al een veeg teken is dat geweldloosheid wordt georganiseerd om politieke doelen te bereiken! — zó spoedig zóveel ambitie zou hebben om atoommacht te worden?
Hoe dan ook, evenals in de Middeleeuwen elke ridder ermee eindigde dat hij zelf ook kanonnen wilde hebben, zo is nu de proliferatie van de nucleaire energie in volle gang, meestal nog onder het mom dat het slechts voor vredelievende doeleinden is. Daarmee wordt dan echter op de enige ignorantie gespeculeerd die op dit terrein nog bepaald krampachtig in stand wordt gehouden. In feite is er namelijk geen verschil tussen atoomenergie voor het ene en voor het andere doel. Beide vormen van gebruik zijn even explosief.
Tot op zekere hoogte is het buskruit aan het misverstand schuld want daarbij had men nog wél de keus. Men kon er, al naar wens en noodzaak, oorlog mee voeren of het zijn kinderen voor het afsteken van voetzoekers geven. Dit geeft nu, achteraf gezien, zelfs een „discrete charm" aan de buskruitperiode in de oorlogvoering.

Amerikaans atoommonopolie geen 20e-eeuws Grieks vuur

Er zou slechts één manier zijn geweest om aan het noodlot van de proliferatie te ontkomen, namelijk wanneer Amerika in 1945 zou hebben besloten een nieuw „Byzantium" te worden.
Het had er, theoretisch gezien, misschien de macht toe gehad. Maar Amerika was niet alleen een machtige maar ook een democratische staat en het was dus in zekere zin „logisch" dat onder deze omstandigheden het zogenaamde atoomgeheim, conditio sine qua non van deze unieke positie, niet gehandhaafd kon blijven. Het zou waarschijnlijk anders zijn gegaan indien een niet-democratische staat als eerste het geheim had gekend. Maar dan zouden er zeker ook tal van andere dingen anders zijn gegaan.
De democratische staat Amerika gedroeg zich in elk geval alsof hij niét in een bijna dictatoriale uitzonderingspositie onder alle staten van de wereld verkeerde. Dit is deze staat ook kwalijk genomen, merkwaardigerwijs niet door mensen met een sterke behoefte om met de sabel te kletteren — daarvoor zou in Amerika toen volop gelegenheid zijn geweest — maar door zachtere naturen. Bertrand Russell bijvoorbeeld kon zich in die tijd bepaald als „byzantijn" opstellen als hij het gevoel had dat Amerika niet zuinig genoeg op zijn atoomgeheim was. Dreigden de Russen ook achter het geheim te komen? Dan zat er, zo meende Russell toen, niet veel anders op dan dat de geheimhouding werd verscherpt, ja, dat de Amerikanen, hooghartig wijzend op hun monopolie, de Russen aan het verstand brachten dat zij van het nieuwe wapen dienden af te blijven.
Natuurlijk, het ging Russell niet om een eeuwigdurende bestendiging van de Amerikaanse machtspositie. Het ging hem reeds toen om een beperking van het kwaad dat met het nieuwe wapen in de wereld was gekomen. Maar hij had, hoe dan ook, zoveel vertrouwen in de monopoliebezitter dat hij hem durfde aan te bevelen, eventuele kapers-op-de-kust exemplair te straffen:

Lord Russell even suggested the United States should threaten to blow up the Soviet Union if it ventured inside the forbidden domain. (C. L. Sulzberger — *Int. Herald Trib.* (1974) (dec. 14/15)).

Russells raad is in Washington niet opgevolgd. Amerika gaf er de voorkeur aan dat het atoomgeheim onder zijn neus werd weggekaapt en ook elders werd omgezet in atoombommen, als potentieel maar daarom niet minder potent middel voor het voeren van buitenlandse politiek. Men weet vaak niet of de weg naar de hemel niet even goed met slechte voornemens is geplaveid als de weg naar de hel met goede. Feit is dat de „balance of terror" in laatste instantie niets slechters, eerder iets beters, heeft opgeleverd dan de destijdse aanbeveling van Russell; althans, géén pre-emptive strike.
Daarmee was de mogelijkheid van een „byzantijnse" oplossing van het atoomdilemma van de baan. Sindsdien kon men nog slechts afwachten of een verdere proliferatie zich min of meer aan het tempo van de proliferatie van het buskruit zou houden, dan wel veel sneller zou verlopen.

Nucleaire club niet langer exclusief

Tot ca. 1974 kon men daarover nog enige illusies hebben, ondanks het feit dat China in 1964 de vijfde atoommacht was geworden. Daarna trad een opmerkelijke pauze in. Maar het was nog een onrevolutionaire periode. Naarmate er in de wereld meer revolutionaire gezindheid om zich heen greep, kwam ook deze vorm van de-escalatie steeds meer in gevaar. (Revolutionaire perioden staan, zoals bekend, in zeer ambivalente relatie met alle vormen van geweld en vernietiging; exrevolutionairen hebben sinds de Franse revolutie gezorgd voor de grootste escalatie in de oorlogvoering).

The Economist bracht het verschil tussen tien jaar geleden en nu in zijn nummer van 23 november 1974 als volgt tot uitdrukking:

With confident scepticism, people asked: 'Why on earth would Country X want nukes?'. The question that was seldom asked was: 'What reason is there to assume that national governments are going to abandon the habit of equipping themselves with the most powerful weapons available?'.

In elk geval was het nog in 1968 mogelijk een non-proliferatieverdrag te lanceren dat in de volgende jaren ook door 84 staten werd getekend én geratificeerd. Daartegenover staan echter 22 staten die wel het ene maar nog steeds niet het andere hebben gedaan. Zij neigen voor een groot deel al naar de kant van die staten die bij voorbaat hebben geweigerd het verdrag te tekenen.
Elke revolutie is zo'n beetje geboren uit een antioligarchische stemming. Dat schijnt zich langzamerhand ook op atomair terrein af te tekenen, al heeft dan tot dusverre nog niemand direct de moed gevonden om meer „atoom-democratie" te eisen. Het is zelfs denkbaar geworden dat de „inspraak" niet tot het nationale niveau beperkt blijft, en dat de atoombom ook nog eens een rol zal gaan spelen in zuiver interne kwesties van individuele staten. Zo is het ten slotte ook met de kanonnen gebeurd. Maar, afgezien daarvan, de nationale ambities zijn op dit punt een concreet feit geworden. Slechts enkelen hoefden het voorbeeld te geven om velen te doen volgen.

De kwestie is, dat in 1968 elk kleiner land betrekkelijk blij was met de „balance of terror" zoals die zich had ontwikkeld. De kleineren vertrouwden zich toen nog gaarne aan de „atoomoligarchie" toe. Inmiddels is het gevoel ontstaan dat deze laatste de toestand niet meer geheel meester is.

Twee- of veelzijdig evenwicht?

De polemoloog Gaston Bouthoul uitte reeds in 1966 zijn scepsis over de „paix bicéphale", de tweehoofdige vrede. Een constellatie die volgens hem door allerlei factoren kan worden bedreigd maar die nog de meeste kans heeft eenvoudig te worden vervangen door iets anders, namelijk een „pluricefale" evenwichtstoestand.
In de toenmalige *Revue de Paris* (maart 1966) profeteerde Bouthoul:

Jusqu'à présent les types historiques connus de „Paix Bicéphale" n'ont pas été durables. L'équilibre de coexistence redevient pluricéphale.

Zo men dat nog evenwicht wil noemen! Er is eerder aan te nemen dat wij een nieuw atoomtijdperk van „zoveel hoofden, zoveel zinnen" tegemoet gaan. Er zijn Amerikanen die de situatie al vergelijken met de tijd toen iedereen in de Far West een Colt-revolver kocht omdat daarmee sterken en zwakken zich in dezelfde mate konden verweren. Die vergelijking zou echter alleen maar opgaan indien er ook een sheriff in functie zou zijn. Maar in dat opzicht zou de huidige situatie zeer wel nog slechter kunnen worden dan in de oude Far West. Want zo'n sheriff, op wereldniveau, is nergens te zien.
Met het oog op deze om zich heen grijpende „atoomdemocratie" was de „balance of terror" nog niet de kwaadste zaak. Men ziet dan ook overal pogingen een gevreesde ontwikkeling binnen deze oligarchische matrijs te houden; met het risico overigens er blijk van te geven nooit goed te hebben gezien wat dat precies inhield.

The bursting through the exclusion rules of history's most select club confuses everyone except those who broke in . . .

spotte Sulzberger in zijn reeds geciteerde artikel . . .

Nato's Dutch member is so worried about nuclear ripples that it wants to oust U.S. warheads from Europe in exchange for Russian withdrawal of tanks — like trading brass knuckles against a tommy gun.

De voornaamste illusie is geweest dat men met anti-proliferatieverdragen zo'n ontwikkeling zou kunnen tegenhouden. Dergelijke verdragen hebben dezelfde waarde als overeenkomstige verzekeringen en plechtige bezweringen uit het verleden: zij zijn geldig zolang men niet zelf de „beatus pos-

sidens" is van een wapen waarmee men anderen kan bedreigen. Wie zou bijvoorbeeld hebben gedacht dat het land van Gandhi de eerste de beste gelegenheid zou aangrijpen om zich van de filosofie van de Mahatma te ontdoen en zich als lid van de atoomclub te presenteren?
Het Lateraans concilie van 1139 had nog geen atoomproblemen, zoals het Vaticaanse van onlangs. In die 12de eeuw sprak het een anathema uit over de „dodelijke, door God gehate kunst van kruisboogschutters": die mocht in elk geval niet tegen katholieken worden gebruikt (en dus, impliciet, wél tegen ongelovigen).
Het verwerven van het atoomwapen is nog „heiliger"; het gaat gepaard met de mededeling dat het tegen níémand is gericht.
Een grote teleurstelling ligt helaas volledig voor de hand, alleen al om zuiver historische redenen.

Loos dreigement of realiteit?

Eén teleurstelling hebben wij al moeten slikken. Toen namelijk de atoomclub nog zeer beperkt was, heette het van de zijde van de wetenschap dat de wereld slechts een beperkt aantal atoomontploffingen zou kunnen verdragen. Ja, de aanvaller zelf zou misschien nog het meeste lijden onder de door zijn toedoen tot ontploffing gebrachte bom. Een ongunstige wind, in zijn richting blazend, zou hem zijn „trekken thuis" geven.
Deze ex cathedra verkondigde waarheden schijnen niet meer op te gaan, nu het atoomwapen zich zozeer vermenigvuldigt dat er van „overproduktie" moet worden gesproken.
De vraag die men moet stellen is: „Hebben de wetenschappers destijds maar wat gezegd en zwijgen zij nu omdat het intussen veel „democratischer" is geworden om proliferatie op grote schaal toe te laten?"
Het een óf het ander: óf zij hadden gelijk met hun omineuze voorspellingen, óf al die atomaire staten in spe die de nucleaire energie in de wereld denken te gaan vermenigvuldigen tot een toentertijd onvoorstelbaar peil, hebben zich zelf inmiddels ervan overtuigd dat het slechts bangmakerij was, en dat de „impact" van nucleaire wapens om zo te zeggen ballistisch kan worden uitgerekend.
Het is duidelijk dat slechts in dát láátste geval de atoombewapening militaire, en niet slechts politieke of terroristische, zin heeft!

Ook zij waakten.

Bescherming is iets wat we altijd nodig hebben. En altijd nodig hebben gehad. Jammer maar waar. Zo ook in 1642, toen de schutterscompagnie van Frans Banning Cocq waakte over de veiligheid van de Amsterdamse Burgerij. Waakte over vrijheid, orde en rust. De Grote Meester was daar getuige van. Met al zijn vakmanschap, artisticiteit en precisie vertrouwde hij het beeld feilloos toe aan het geduldige linnen: Rembrandt's meesterwerk, De Nachtwacht.

Wij van Signaal kunnen natuurlijk nauwelijks praten over artisticiteit, als we het hebben over de ontwikkeling en fabricage van onze produkten. Wel over vakmanschap en precisie. Over feilloosheid, dan doelen we op de werking van onze beschermings- en opsporingsapparatuur. Want eigenlijk is er niets nieuws onder de zon. Frans Banning Cocq en zijn fiere schutters zijn er nog steeds. Alleen het gebied dat zij beschermen is veel groter geworden.

En ook de middelen en methoden zijn veranderd. Omdat een gevoelig oor en een scherpe blik alleen niet meer voldoen, ontwikkelt en maakt Signaal radar, computers, enzovoort.

Verdedigingssystemen met ogen en oren die verder reiken.
Dank zij vele jaren ervaring. Ervaring die ons geleerd heeft niet over één (en zelfs niet over tien) nacht(en) ijs te gaan. Want aan elk fabricage-proces gaat een lange periode van proeven vooraf. Van tril-, schok-, val- en temperatuurproeven. Wij vinden namelijk (omdat het om de veiligheid van u en ons gaat) dat er voor onze kwaliteit maar een kwalificatie mogelijk is: de allerbeste. En daar zorgt Signaal voor.

Maar het gaat niet alleen om veiligheid. Ook economisch en wetenschappelijk bewijzen wij de gemeenschap goede diensten. Zoals met een uiterst efficiënte, electronische luchtverkeersregeling op Schiphol.
Of met de unieke 'onboard-computer', aan boord van de eerste Nederlandse kunstmaan ANS. Deze computer werd ontwikkeld door het Natuurkundig Laboratorium van Philips en geproduceerd door Signaal.

Onze klanten zijn overheden. Regeringen en ministers. Maar natuurlijk mag u ook best weten wat we doen. Misschien vindt u 't allemaal wel zo interessant dat u er aan zoudt willen meewerken.

Hollandse Signaalapparaten B.V. Kortweg Signaal. Een modern bedrijf in Hengelo. Een mooi en rustig stukje Nederland. En dat willen wij graag zo houden. Wat er ook gebeurt.

SIGNAAL