NOTES & RECORDS OF THE ROYAL SOCIETY

Notes Rec. R. Soc. (2008) **62**, 197–204
doi:10.1098/rsnr.2007.0024
Published online 5 March 2008

DIVERSIONS OF A RADIO TELESCOPE

by

SIR FRANCIS GRAHAM-SMITH AND SIR BERNARD LOVELL*

University of Manchester, Jodrell Bank Observatory, Macclesfield, Cheshire SK11 9DL, UK

The first use of the 250-foot radio telescope at Jodrell Bank, an instrument designed for academic research, was as a radar, when it obtained echoes from the rocket launcher of Sputnik 1 in October 1957. It was soon realized that this was the only radar system capable of detecting intercontinental missiles soon after their launch from within the USSR. The Air Ministry then organized the installation of a more powerful radar on the telescope. It has been revealed only recently that for several years Jodrell Bank played a role in defence during a critical period of the Cold War.

Keywords: radar defence; meteors; ballistic missiles; Earth satellites; ICBM rockets; Cuban crisis 1962

INTRODUCTION

The launch of Sputnik 1 on 4 October 1957 was the start of a new era of space research and communications, and also of a period of intense rivalry between the USSR and the West to develop and deploy intercontinental ballistic missiles (ICBMs). The 250-foot radio telescope at Jodrell Bank played a secret part in this Cold War rivalry that can now be recorded. At the time of the launch, there were no large radio telescopes capable of tracking by radar even such large targets as the carrier rocket that launched the Sputnik, and it was alarming to realize that this rocket was usable as an ICBM, against which there was no defence and whose launch would not even be detected by radar. The 250-foot radio telescope at Jodrell Bank suddenly and totally unexpectedly appeared as the only instrument that could be used as a long-distance radar capable of giving warning of the launch of an ICBM in the USSR.

On the day of the launch of Sputnik 1 the 250-foot radio telescope was incomplete and in severe debt, and the contractors were on strike because they could not be paid.[1] A telephone call to Bernard Lovell from Robert Cockburn, the Controller of Guided Weapons and Electronics at the Ministry of Supply,[2] changed the fortunes of the telescope and initiated an involvement of Jodrell Bank in secret defence operations that continued through the intense phase of the Cold War between the USSR and the West from January 1962 until November 1963, including the Cuban crisis of October 1962.

* acbl@jb.man.ac.uk

Plans for space research

In 1952 the International Council of Scientific Unions established a Special Committee (CSAGI)[3] to plan a third International Geophysical Year (IGY). Because so many terrestrial phenomena are associated with solar events it was agreed to designate 1957–58 as the third IGY to cover the next period of sunspot maximum. Scientific satellites were to be part of the IGY. At its meeting in Rome on 4 October 1954, CSAGI adopted the following recommendation:

> In view of the great importance of observations, during extended periods of time, of extra-terrestrial radiations and geophysical phenomena in the upper atmosphere, and in view of the advanced state of present rocket techniques, CSAGI recommends that thought be given to the launching of small satellite vehicles, to their scientific instrumentation, and to the new problems associated with satellite experiments, such as power supply, telemetering and orientation of the vehicle.

In accordance with this recommendation, President Eisenhower announced on 29 July 1955 that the USA would launch a satellite during the IGY, and a similar announcement was made one day later by the USSR.

The detailed proposals for the 250-foot radio telescope, based on meteor radar and radio astronomy, were submitted to the Department of Scientific and Industrial Research in February 1951,[4] three years before the scientific case was made for launching Earth satellites during the IGY. The use of the telescope during the IGY to track the proposed American Vanguard satellite was added to the original list of research projects, but no radar equipment had been proposed for this purpose.

The development of the American and Soviet satellites

President Eisenhower ruled that the development of the American satellites (Project Vanguard) should have no interaction with or divert any effort from the US ballistic weapon development.[5] Many Americans objected to this ruling imposed by the President. In particular, General James M. Gavin[6] led a campaign for the use of the American ballistic rockets as the launching rocket for the American satellite but he received a firm directive from the President that 'the Redstone and Jupiter missiles will *not* be used to launch the satellites'. In the event the Vanguard project was undertaken by the Naval Research Laboratory in Washington under the direction of Dr John P. Hagen.

The American satellite project Vanguard was not only late but almost a total failure. It was eventually launched on 17 March 1958, but by that date the American attitude had changed drastically. President Eisenhower agreed that the Army missiles could be used to launch a satellite,[7] and the American Explorer was successfully launched at the end of January 1958.

In contrast, the USSR imposed no such restrictions. In April 1955, three months before the USSR made the formal announcement of the intention to launch a satellite, the Soviet Academy of Sciences had set up a permanent commission of interplanetary communications. The Chairman of this commission, Professor Leonid Sedov, said at a press conference during the Sixth International Astronautical Congress held in Copenhagen in August 1955 that the USSR would launch a satellite within two years and that it would be heavier than the one proposed by the Americans. In June 1957 Aleksandr Nesmeyanov, the President of the Soviet Academy of Sciences, said that the carrier rocket and satellite were ready, and that the first launching would occur within a few months. In August 1957 the rocket was

tested successfully. On 26 August, Soviet Premier Khrushchev said that a super long-distance intercontinental multi-stage ballistic missile had been launched and that the results showed that it was possible to direct missiles to any part of the world.[8] In September, Radio Moscow broadcast that the Sputnik would soon be launched; the transmission frequencies were announced on 1 October, and on 4 October Sputnik was launched.

Tracking Sputnik 1 and its ICBM launcher

The 40 MHz 'bleep-bleep' signal from Sputnik 1 was easily detected by conventional radio receivers: Martin Ryle and his colleagues in Cambridge were able to adapt their newly developed interferometer techniques to some remarkably accurate tracking of the satellite.[9] Their success with the series of Sputniks even led to the first published proposal to use satellites for navigation.[10] Adapting the unfinished 250-foot telescope for radar was, in contrast, a formidable task.

The telephone call from Cockburn transformed the situation at Jodrell Bank.[11] The contractors returned and within a few days the telescope was under computer control from the control room, a 36 MHz radar transmitter was installed on the telescope, and on 12 October 1957 the rocket was located at a range and azimuth indicating that it was passing over Cumbria.[12]

Three months after the launch of the American Explorer satellite, Lovell received an urgent request to receive a visit from a colonel of the United States Air Force. Shrouded in secrecy, the reason for this visit was not revealed to Lovell until the meeting occurred in his office at Jodrell Bank. Identified only as Colonel L., the visitor delivered the message that the Americans had successfully tested their first intercontinental missile and intended to use it to send a rocket to the Moon but had no means of tracking it, so could they use the Jodrell Bank telescope? The first attempt was to be made in August, and a team of Americans with trailers full of recording equipment were duly sent from America.

The American collaboration continued on various projects until May 1960, when the Americans launched Pioneer V with the original intention of reaching the planet Venus. On this occasion a signal from the Jodrell Bank telescope released the bolts to separate the probe from the rocket shortly after the launch from Cape Canaveral, and successfully commanded the probe and collected scientific data until 26 June, by which date the probe had travelled 22 000 000 miles into space.[13]

In the meantime, on 13 September 1959 the Soviets launched a rocket to the Moon. Although no formal request was made to Jodrell Bank for help, detailed coordinates for locating the probe from Jodrell Bank and the downlink frequency appeared on the telex at Jodrell Bank, and subsequently the Director of the probe told Lovell that they depended on Jodrell Bank for the tracking of the probe. It is as well that they did so because the measurement of the Doppler shift as the probe accelerated in its final approach to the Moon provided conclusive evidence that the probe had, indeed, reached the moon.[14]

For several years after the launching of Sputnik on 4 October 1957 both the Americans and the Soviets used military ballistic missiles to launch probes to the Moon or into deep space. Neither had the ability to track the payloads and depended on the Jodrell Bank telescope for these purposes. These events were well publicized and published, but during the years 1960–63 the Jodrell Bank telescope was involved in another unusual and unexpected role, which could not be published until the lifting of the security regulations and the appearance of a critical paper in the Public Records Office.

The Soviet ICBMs and the Jodrell Bank telescope

In the course of tracking the Soviet rockets, considerable information about the nature of radar echoes from the rockets was accumulated at Jodrell Bank. Although these data were not published they were presented to the appropriate committees in the UK, with which Lovell had remained in touch; for example a paper on 'the radar detection of the Russian Earth satellites and carrier rockets and its bearing on the missile detection problem' was presented to the Combined Guided Weapon Advisory Board and Radio Signals Advisory Board.[15]

On 16 May 1958 E. H. Truefitt, deputy scientific advisor to the Air Ministry, visited Jodrell Bank to discuss the possible use of the telescope to detect ballistic missiles in the event of an emergency. He felt, at first, that a serious interruption to our astronomical research would not be justified. However, he wrote on 16 October 1958 to report that at a meeting chaired by Air Vice Marshal D. S. Morris[16] it was agreed that if the telescope were equipped with a powerful radar transmitter that was available from Marconi, valuable information could be obtained on the background of echoes from meteor trails and aurorae. This would be an extension of our existing meteor research programme but was not, as yet, a proposal to use the telescope as a defence radar.

The Marconi transmitter that was installed on the telescope did indeed create a powerful radar system. The klystron transmitter produced 100 kW of peak power on frequencies of 300 or 500 MHz, using a pulse length of 170 μs and a repetition frequency of 50 Hz. With this system the 250-foot telescope could detect a 10 cm^2 target at a range of 500 km. Reception was carried out with two orthogonal polarizations. The results were recorded by photographing cathode-ray tubes on continuously moving 35 mm film. The Air Ministry entered into a contract with Jodrell Bank for the investigation of radar echoes from meteor trails and aurorae, and the results of this investigation were published by Barber *et al.*[17]

Soon it became apparent that the ballistic missile problem was not the only one concerning the Air Ministry. They wanted to use the telescope in an emergency for the detection of aircraft in the event that the normal defence radars were jammed. In addition, because there was no defence radar with sufficient power to detect very high flying aircraft, on 29 December 1958 Air Marshal Weston[18] wrote to ask whether the telescope could be used to search for a high flying aircraft. Arrangements were made and in the spring of 1959 a Canberra aircraft flying at over 40 000 ft was successfully located and followed by the telescope. (The ceiling of the Canberra was 48 000 ft; Soviet Tu-95 bombers ('Bear') could operate at up to 39 000 ft.)

The primary issue of the possible use of the telescope to detect ballistic missiles continued to be discussed somewhat vaguely, to the extent that in April 1960 Solly Zuckerman[19] (then Chief Scientific Advisor to the Secretary of State for Defence) wrote to Lovell seeking his views on this problem. Because he was 'disturbed by the over-optimistic attitude of some of his people to the problems' he wished to know whether Lovell thought it enough for an official such as Cockburn to say 'the UK attitude to ballistic missile defence was an extremely reserved one'. Cockburn[20] was by then the Chief Scientist to the Ministry of Aviation.

The defence role of the Jodrell Bank telescope, 1962–63

At this time, when the Cold War between the USSR and the West was becoming intense, the issue of the use of the Jodrell Bank telescope was soon to be resolved decisively.

On 18 October 1960, H. I. Roberts (Scientific Advisor to the Air Ministry) visited Jodrell Bank to see Lovell at the request of the Vice Chief of Air Staff (VCAS; Sir Edmund Huddleston).[21] He wished to know whether the telescope could detect the

launching of Soviet ballistic missiles given the coordinates of the launching site and whether it would be possible to make arrangements for the training of selected RAF staff to use the telescope for these purposes in the event of an emergency. The telescope was evidently uniquely capable, especially as it could operate down to the horizon. Such dedicated use was, however, well beyond the research role already undertaken. The telescope belonged to the University of Manchester; Lovell had no authority to enter into these arrangements. He therefore asked Roberts to advise Huddleston to write in general terms to the Vice-Chancellor and also to inform him that the instructions already circulated that all transmissions must cease in the event of a declaration of a military emergency should not apply to Jodrell Bank.

On 1 November Roberts wrote to say that VCAS was anxious to go ahead, and on 7 November VCAS sent the following minute to the Permanent Under Secretary of State to the Air Ministry (Sir Maurice Dean)[22] with circulation to the Chief of Air Staff (CAS) and other relevant members of the Air Staff.

S E C R E T

P.U.S. VCAS.4674

Copies to: P.S. to S. of S
P.S. to C.A.S.
P.S. to D.C.A.S.
A.M.S.O.
A.C.A.S. (Ops)
A.C.A.S. (I)
D.G.S.
S.A.A.M.

Jodrell Bank

1. On my instructions D.S.A.A.M. recently paid a visit to Professor Lovell at Jodrell Bank to explore with him possibilities of our making use of the Jodrell Bank radar telescope as a ballistic missile warning radar at least until such time as the Fylingdales B.M.E.W. station is available to us, and possibly thereafter as reinforcement of it.

2. Professor Lovell was most receptive to the concept and it is clear that with certain minor modification the Jodrell Bank radar could be used for this purpose. The great attraction is that, modification costs will be comparatively negligible and the time scale is very short, readiness for operational use being anticipated to be four to six months from the go ahead. Personnel requirements do not exceed some six all ranks.

3. While Professor Lovell advises that false alarm rates from meteorites and other spurious signals may not be too serious with this equipment, it is clear that experience will be needed for proper interpretation, since the time between first observation and possible missile arrival is short (some 7 minutes on the 1,000 mile missile). This would be sufficient however, in times of tensions, to allow the Bomber Force to be scrambled under positive control. Clearly all these matters need much thought and trial before precise procedures can be formulated.

4. It may be necessary for us to establish a cover story to explain the presence of R.A.F. personnel at Jodrell Bank. If this should become necessary, we would say that our object is to give R.A.F. personnel some preliminary grounding in space tracking

techniques, drawing on the experience already acquired by the Jodrell Bank team. A.C.A.S. (I) is examining this aspect. D.S.A.A.M. is currently discussing with Professor Lovell through what channels we should place our formal request for the use of the telescope and whether he envisages any security problems.

5. This proposal will in part fill in the gaps in our warning system prior to the installation of B.M.E.W. and will also provide a most valuable lead to determining the techniques we will want to adopt when we have B.M.E.W.S. In view of this and the fact that the additional facility can be obtained quickly using equipment (with minor modifications) surplus R.A.F. requirements and with a personnel requirement of less than 10, I should be grateful for your formal endorsement of this project.

7th November 1960 V.C.A.S.

Many points had to be cleared before the arrangements proposed in this minute could be implemented. Huddleston had to clear the arrangements with the Air Staff and with Lord Hailsham (the Minister for Science). Originally the code name Verify was allocated, but this was changed on two occasions and finally Lord Hailsham ruled that no code name should be allocated.

By early January 1962 all these problems had been dealt with and the training of operational staff commenced. It was agreed that Lovell would receive a telephone call from C & C Fighter Command if a state of emergency was imminent and would implement the plans for the telescope operations to be placed in the hands of the trained RAF personnel.

All these arrangements were made with little interference to the normal use of the telescope for astronomical research. During the training periods, equipment was used for the radar observation of meteor trails and as a receiver for the study of the angular diameter of the remote radio sources that were eventually identified as quasars.[23]

This decisive action by VCAS had been stimulated by President Eisenhower's budget address to Congress on 18 January 1960, which 'included provision for a ballistic missile early warning system station in Britain, now being negotiated'. This became the Ballistic Missile Early Warning System (BMEWS) at Fylingdales in Yorkshire. Two years later, with BMEWS not yet complete, Lovell was made aware of the significance of the arrangements for the use of the telescope in an emergency.

In 1962 Sir Maurice Dean had asked Lovell to join a small committee of scientists[24] advising CAS. At one of these meetings in early autumn 1962 CAS asked Lovell to remain after the meeting. His message was alarming. The Soviets had mounted ICBMs targeted on London. BMEWS, then under construction at Fylingdales, was seriously delayed by a series of strikes. He wanted to be assured that the arrangements were in place for using the Jodrell Bank telescope to give early warning should the ICBMs be launched. Lovell replied that it would be possible to give notice of lift-off of the ICBMs but nothing further could be done. CAS's response was, 'On the contrary, we estimate that an interval of about 7 minutes would elapse between the launching and the descent of the ICBMs on London, during which time at least a million people in London could be saved and the Bomber Force would be scrambled.'

The arrangements for the use of the telescope in the event of a declaration of a military emergency commenced in January 1962 and continued through the Cuban crisis of October 1962 until the autumn of 1963. On 3 August 1963 Maurice Dean had informed Lovell that Fylingdales was scheduled to become operational in mid-November 1963. On 9 August 1963 he landed at Manchester Airport and flew Lovell to the RAF station at Leconfield

where they transferred with the C & C Fighter Command (Air Marshal Douglas Morris)[25] to his jet helicopter and continued the journey to Fylingdales. After this courtesy visit a return visit to Jodrell Bank of the senior staff of Fylingdales was made and a letter of thanks from the Air Ministry ended a unique and anxious phase in the history of the Jodrell Bank telescope.

During those years, Lovell inevitably accumulated a number of Secret and Most Secret files. Before his official retirement as Director of Jodrell Bank on 30 September 1981 he asked the Ministry of Defence to remove the files they thought necessary. In June 1981 Squadron Leader Reeve of the Ministry visited Jodrell Bank and decided to remove a number of files for destruction. These included the files relevant to the use of the telescope for the detection of ballistic missiles described in this paper. The minute from VCAS reproduced above was released by the Public Records Office in the 1990s and as far as is known is the only surviving document of the events described in this paper. The remaining files of this period are deposited in the University of Manchester's John Rylands Library.

Notes

1 B. Lovell, *The story of Jodrell Bank* (Oxford University Press, 1968), ch. 30.

2 Sir Robert Cockburn was Controller of Guided Weapons and Electronics, Ministry of Supply, 1956–59.

3 CSAGI (Comité Spécial de l'Anneé Géophysique Internationale). International collaboration in science had been fostered during the twentieth century by the growth of International Scientific Unions. When CSAGI was established there were 16 of these unions, effectively covering nearly all scientific disciplines. Although there had been political exclusions in 1952, any nation with scientific activities of any significance had been, without question, an adhering member, with the national scientific organizations (in the UK this was the Royal Society) providing the financial support for the work of the international body.

4 'A steerable radio telescope', a collection of papers describing the proposal written by B. Lovell, J. A. Clegg and J. G. Davies (the 'Blue Book') deposited in the University of Manchester John Rylands Library.

5 Dr John P. Hagen, the radio-physicist in the Naval Research Laboratory who was appointed director of the Vanguard project, subsequently described some of the unbelievable difficulties that the project faced. The most revealing of these was that the Army turned down his request to be allowed to use its rocket testing pads at Cape Canaveral on the grounds that this would interfere with their missile test programme. The Vanguard team therefore had to build its own launch complex and blockhouse, for which no funds had been provided. This construction work took one and a half years.

6 James M. Gavin, *War and peace in the space age* (Harper, New York, 1958).

7 See note 5.

8 According to the *New York Times* of 27 August 1957, the text of Khrushchev's announcement was as follows: 'A super-long-distance intercontinental multi-stage ballistic missile was launched a few days ago. The tests of the rocket were successful. They fully confirmed the correctness of the calculations and the selected design. The missile flew at a very high, unprecedented altitude. Covering a huge distance in a brief time, the missile landed in the target area. The results obtained show that it is possible to direct missiles into any part of the world.'

9 M. Ryle, 'Observations at the Mullard Radio Astronomy Observatory, Cambridge', *Proc. R. Soc. A* **248**, 3–9 (1958).

10 F. G. Smith, 'A new navigation system using artificial earth satellites', *J. Inst. Navig.* **13**, 109–111 (1960).

11 Lovell, *op. cit.* (note 1), chs 26–31.

12 Staff of Jodrell Bank, 'Radio observations of the first Russian earth satellite and its carrier rocket', *Nature* **180**, 941–942 (1957) and *Proc. R. Soc. A* **248**, 24–33 (1958).
13 Lovell, *op. cit.* (note 1), ch. 32.
14 J. G. Davies and B. Lovell, 'Observations of the Russian moon rocket—Lunik 2', *Nature* **184**, 501–502 (1959).
15 Deposited in the University of Manchester John Rylands Library; see also Staff of Jodrell Bank, *op. cit.* (*Proc. R. Soc. A*, note 12).
16 Air Vice Marshal Douglas Morris was Assistant Chief of Air Staff (Air Defence) from 1957 to 1959.
17 D. Barber, H. K. Sutcliffe and C. D. Watkins, 'Some radar observations of meteors and aurorae at 300 and 500 Mc/s using a large radio telescope – I. Observations of meteors', *J. Atmos. Terrest. Phys.* **24**, 585–597 (1962); *idem*, 'Some radar observations of meteors and aurorae at 300 and 500 Mc/s using a large radio telescope – II. Observations of the Aurora Borealis', *J. Atmos. Terrest. Phys.* **24**, 599–607 (1962).
18 Air Marshal John G. Weston; from 1956 to 1959 he was Assistant Chief of the Air Staff (Signals).
19 Zuckerman (FRS 1943; then Sir Solly) was created a Life Peer in 1971. For an account of his distinguished career in zoology and defence see P. L. Krohn, 'Solly Zuckerman, Baron Zuckerman, of Burnham Thorpe, O.M., K.C.B.', *Biogr. Mems Fell. R. Soc.* **41**, 575–598 (1995).
20 Sir Robert Cockburn; see also note 2.
21 Air Chief Marshal Sir Edmund Huddleston was Vice Chief of Air Staff, 1957–62.
22 Sir Maurice Dean was Permanent Under Secretary of State, Air Ministry, 1955–63.
23 L. R. Allen, B. Anderson, R. G. Conway, H. P. Palmer, V. C. Reddish and B. Rowson, 'Observations of 384 radio sources at a frequency of 158 Mc/s with a long baseline interferometer', *Mon. Not. R. Astron. Soc.* **124**, 477–499 (1962), and L. R. Allen, R. Hanbury Brown and H. P. Palmer, 'An analysis of the angular sizes of radio sources', *Mon. Not. R. Astron. Soc.* **125**, 57–74 (1962).
24 At that time the other members of this committee were Sir William Cook, UK Atomic Energy Authority (FRS 1962), Sir James Lighthill, Director of the Royal Aircraft Establishment (FRS 1953) and Sir Graham Sutton, Director General of the Meteorological Office (FRS 1949).
25 Air Marshal Sir Douglas Morris was Commander in Chief RAF Fighter Command, 1962–66 (see also note 16).