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Chapter 5

The High Altitude Research Project: Australia's First Rockoon Program*

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Abstract

A previous paper by the author outlined the history of the Australian sounding rocket program, which operated between 1957 and 1975. Briefly mentioned in that paper was the High Altitude Research Project (HARP), a rockoon development program that was the Weapons Research Establishment's first attempt at developing a sounding rocket for the International Geophysical Year. Due to repeated failures of the HARP rockoon, the project was abandoned in 1958 and quickly forgotten when the more-conventional Long Tom sounding rocket proved successful, marking the genuine beginning of Australia's sounding rocket activities.

However, the recent rediscovery of archival files relating to HARP, which had been thought destroyed, has shed new light on this early project that was a significant contributor to the perception of Australia as a space-active nation at the very beginning of the Space Age. These files have revealed that the HARP program had both an interesting technological background that demonstrated the innovativeness of the Australian Defense Scientific Service, and also represented

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an important political turning point in Australia's relationship with Britain within the Anglo-Australian Joint Project, for which the Woomera Rocket Range was developed.

This chapter will present the first detailed history of the previously overlooked High Altitude Research Project. It will examine the political, scientific, and technical origins of the program and the reasons for selecting a rockoon design for Australia's first sounding rocket. It will discuss the technical innovation represented by the small "Harpy" rocket developed for the project and also highlight the unexpected reason for HARP's failure, which was not due to any technical issues, but to the meteorological environment at the Woomera Range.

I. Introduction

In a previous paper [1], the author provided an account of the Australian sounding rocket program that operated between 1957 and 1975. Briefly mentioned in that paper was Australia's first sounding rocket program, the High Altitude Research Project (HARP). HARP had been intended to investigate the upper reaches of the atmosphere during the International Geophysical Year using a rockoon, a combination of rocket and high altitude research balloon. Because it was ultimately unsuccessful, for reasons that will be discussed in this chapter, the HARP program was it was largely forgotten and very little was known about its origin and development, since the files which related to it had been thought destroyed.

However, in early 2019, at the request of the author, an investigation by the National Archives of Australia rediscovered the long-missing HARP files. These archival records have shed new light on this early project that was a significant contributor to the perception of Australia as a space-active nation at the very beginning of the Space Age. The HARP files have revealed that the program had an interesting technical background that demonstrated the innovativeness of the Weapons Research Establishment, a division of the Australian Defense Scientific Service (ADSS). The development of HARP also represented an important political turning point in Australia's relationship with Britain within the Anglo-Australian Joint Project, the weapons development program for which the Woomera Rocket Range was established.

Drawing upon these newly recovered files, this chapter presents the first detailed history of the High Altitude Research Project, from its complex inception during a troubled period in the history of the Joint Project to its cancellation in 1958.

II. Background: The IGY and Upper Atmosphere Research

Initially proposed in the early 1950s, the International Geophysical Year (IGY) was a global cooperative program for the scientific study of the Earth and its relationship to the space environment, undertaken between July 1, 1957, and December 31, 1958. This eighteen-month period was specifically selected because it encompassed an anticipated period of maximum solar activity, which would allow the study of the effects of solar radiation on the upper atmosphere. The rapid development of rocket technology following World War 2 had enabled the development of sounding rockets. These relatively cheap launchers, while incapable of putting an object into orbit, could carry instrument packages to altitudes of 100km and more before falling back to Earth, making accessible for the first time regions of the upper atmosphere that could not be reached by research balloons.

By the early 1950s, sounding rockets had become a valuable tool for exploring the upper levels of the atmosphere and their new availability prompted calls for their use during the IGY. At its first Plenary Meeting in July 1953, the Comité Spéciale de l'Année Géophysique Internationale (CSAGI)[*] recommended that "a number of firings of rockets should take place in New Mexico and Australia" to obtain "[i]nformation regarding temperature and density, as well as other atmospheric properties" [2].

The reference to Australia in this context is particularly interesting. Although the Australian Government would publicly proclaim in 1957 that "[n]o country will benefit more from this attack on the relatively unknown than Australia" [3], sounding rocket programs were not included among the range of IGY scientific programs that it had approved and funded. The government would, in fact, repeatedly play down any association of HARP with space research. The HARP program would, instead, arise from a complex set of circumstances that involved initiatives in Britain and within the Weapons Research Establishment (WRE) and its precursor agency the Long Range Weapons Establishment (LRWE).

[*] CSAGI was the international organizing body for the IGY, established by the International Council of Scientific Unions in 1952.

III. Background: Defence Requirements for Upper Atmosphere Research

The specific reference to Australia in the July 1953 CSAGI recommendation was the result of the British delegates' awareness of sounding rocket developments that were commencing in the UK at that time. In 1952, the Chiefs of Staff Committee's Review of Global Strategy supported the development of a long-range missile delivery system for the British nuclear deterrent, even though Britain had previously cancelled similar plans that had been original reason for the establishment of Woomera [4]. This decision led to the Blue Streak ballistic missile program, which was formally initiated in 1954 [5].

Since an operational ballistic missile traverses the space environment on its trajectory, there was a crucial need to understand the basic parameters of the upper atmosphere (such as pressure, temperature, density, wind speed and direction) through which the missile would travel, to determine if those conditions would in any way affect the missile or its warhead [6]. This was fundamental scientific data that sounding rockets could provide [7] and British and Australian defense planners saw the IGY as a means to engage civilian researchers alongside defense scientists in exploring the characteristics of the upper atmosphere using sounding rockets [8].

In May 1953, the British Ministry of Supply (MoS) approached the Royal Society's Gassiot Committee* with an offer to collaborate on a new sounding rocket for upper atmosphere research [9]. The Committee had already considered the possibility of using military rockets to carry scientific instruments above the atmosphere [10] and its Chair, Australian-born physicist Professor Harrie Massey, welcomed the approach from the MoS. The new sounding rocket, which would eventually be named Skylark [11], was to be derived from the CTV 5, Series III research vehicle that was being used to test missile technologies at Woomera [12]. While the Skylark was being developed for defense research purposes, Massey recognized that the data it would obtain was also relevant to the IGY scientific program. He joined the UK National Committee for the IGY (also under the auspices of the Royal Society) shortly before the July 1953 CSAGI meeting noted above [13] and his awareness of the embryonic MoS sounding rocket proposal prompted the reference to launching sounding rockets from Australia.

* The Gassiot Committee, established in 1871, had become the Royal Society's main group for meteorological research. During World War 2 it also turned its attention to atmospheric research.

IV. UK-Australia Civil Space Research Collaboration Proposal

Since the Skylark rocket would be launched from Woomera, Massey was interested in engaging Australian upper atmosphere researchers in the civil scientific work that could be done for the IGY. To further this idea, he had informal discussions during the CSAGI meeting with his Royal Society colleague Dr. David Forbes Martyn, who was playing a prominent role in encouraging Australian participation in the IGY [14]. A world-recognized expert in the ionosphere, Martyn was a researcher with Australia's national civil science research agency, the Commonwealth Scientific and Industrial Research Organization (CSIRO). In the months following the July 1953 meeting, Massey and Martyn explored the idea of collaboration on upper atmosphere research between the ADSS and the soon-to-be-established Australian Academy of Science along similar lines to the Gassiot Committee-MoS collaboration in the UK [15].

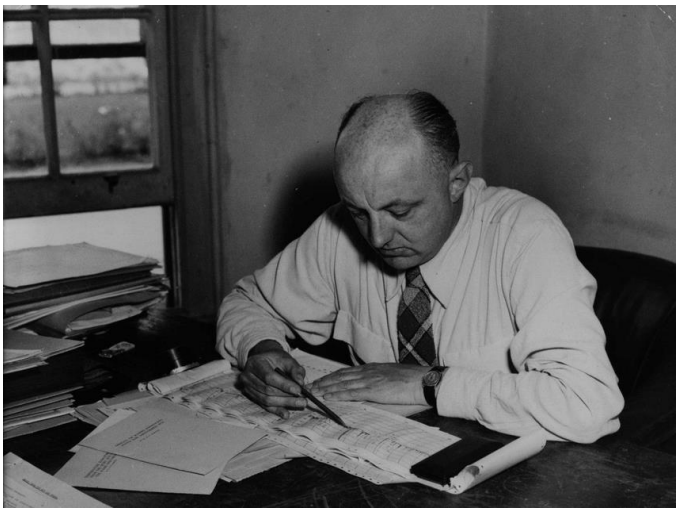

Figure 5–1: Dr. David Forbes Martyn, one of the founders of the Australian Academy of Science, who played an important role in the inception of the High Altitude Research Project. Credit: ATNF Historical Collection.

The Australian Academy of Science was founded on February 16, 1954, by Australian Fellows of the Royal Society of London, with leading physicist Professor Marcus (Mark) Oliphant as President. Martyn was among the Academy's founders, becoming its first Secretary of Physical Sciences [16]. Martyn also instituted the Academy's Upper Atmosphere Research (UAR) Committee, of which he was the Chair.

To enable the UAR Committee to participate in the Skylark project [17], in 1954 Massey recommended to the Australian Defense Research and Development Policy Committee that the Academy's UAR Committee and the Long Range Weapons Establishment (LRWE), at that time the managing agency for the Woomera Range, collaborate on sounding rocket research [18]. The intention was that the UAR Committee and LRWE should work with their British counterparts in conducting mutually beneficial dual-use upper atmosphere research using the Skylark vehicle.

However, the unexpected outcome of Massey's approach was that, instead of an Australian scientific collaboration on Skylark, the ADSS and the UAR Committee embarked on the creation of an Australian sounding rocket program, designated the High Altitude Research Project (HARP) [19].

V. The Birth of the High Altitude Research Project

As early as 1949, the Australian Defense Scientific Service had recognized the military need to determine the physical characteristics of the upper atmosphere [20]. Occasional experiments with high-flying aircraft had been conducted since then and by 1953, when the British were formulating their sounding rocket plans, the ADSS was also considering the possibility of developing a sounding rocket and actively seeking information from the United States about rockoons [21].

The rockoon (rocket-balloon) technique uses a large research balloon to carry a small rocket high into the atmosphere, after which the motor is fired by remote control to carry the payload to a much greater altitude than could be achieved if the rocket launched directly from the ground. Pioneered by renowned ionosphere expert James van Allen in 1952, rockoons were successfully used for upper atmosphere research for many years [22]. The ADSS interest in rockoons, rather than a more conventional sounding rocket design, stemmed from its relatively cheap cost and apparently simple launch method—a deceptive simplicity as the ultimate fate of HARP will show.

When the LRWE was first briefed on the plans for the Skylark program, the rockoon project seems to have gone into abeyance, to judge from the lack of documentation for it across the latter part of 1953 and 1954. However, the British sounding rocket program was initiated during a tumultuous period for the Anglo-Australian Joint Project, in which a major internecine battle over the administration of the program was occurring [23].

During the first half of the 1950s, the Australian side of the Joint Project became increasingly dissatisfied with the British dominance of the Project's sen-

ior administrative positions: until 1955, the two most senior Long Range Weapons Establishment positions in Australia (the CEO, based with the Department of Supply in Melbourne, and the Chief Superintendent, based at LRWE's headquarters in Salisbury, South Australia) had always been held by British appointees. Australia sought more representation within the Joint Project, resulting in reorganizations within the ADSS in 1953 [24].

Conflict between ADSS Chief Scientist Dr. W.A.S. Butement and LRWE Chief Superintendent Dr. C.F. Bareford finally brought matters to a head at the end of 1954, with Australia emerging in a far stronger position: in January 1955 the LRWE and the ADSS' Defence Research Laboratories were amalgamated to form the Weapons Research Establish (WRE), which would be headed by an Australian until its dissolution in 1978 [25].

While not explicitly stated in the HARP files, the troubled period in which the Australian collaboration with the British sounding rocket program was proposed can be assumed to have led the newly-created WRE to revive the rockoon project as an assertion of Australian independence. Ultimately, whatever the underlying reason, the Australian rockoon idea of 1953 had become, by early 1955, the High Altitude Research Project, conceived from the outset to meet a particular defense research need that, fortuitously, could also contribute to civil space research.

VI. The Development of HARP

As a rockoon, the HARP vehicle consisted of two major components, the lifting balloon and the sounding rocket itself. The WRE's Propulsion Division was assigned the task of developing the rocket, while the Aerodynamics Division was responsible for sourcing the research balloon that would carry the rocket aloft.

Although the Propulsion Division was at that time developing the Marloo motor,[*] for the WRE's Malkara anti-tank missile [26], its staff recognized that they were still relatively inexperienced in rocket motor design. Consequently, the Propulsion Division decided to base the HARP rocket around a modified British Mayfly solid rocket motor. Mayfly motors had been used for the CTV5, Series I and II vehicles, which were the predecessors of the CTV5, Series III on which the Skylark rocket was based [27]. Since a quantity of these obsolescent motors

[*] The Marloo motor would become the predecessor of several ADSS-designed and built rocket motors, used for both weapons applications and in later Australian sounding rockets.

was still available in Australia, they were donated to the HARP program by the UK Ministry of Supply [28].

While Britain supplied the rocket motor, the Propulsion Division designed the stabilizing fins and instrument capsule that were attached to the Mayfly. To keep the rocket as light as possible, to improve its maximum altitude, these components were made of a glass fiber reinforced plastic (fiberglass) [29]. Developed during World War II, glass fiber reinforced plastics were first used in defense applications and the Manhattan Project. Fiberglass was frequently used for rocket motor casings and other space applications from the 1960s, but the HARP rocket may represent one of the earliest—if not the earliest—experiments in using this composite material in rocket design. It stands as just one example of ADSS innovation that was in advance of overseas developments, and which has been discussed at length in a previous paper by the author [30].

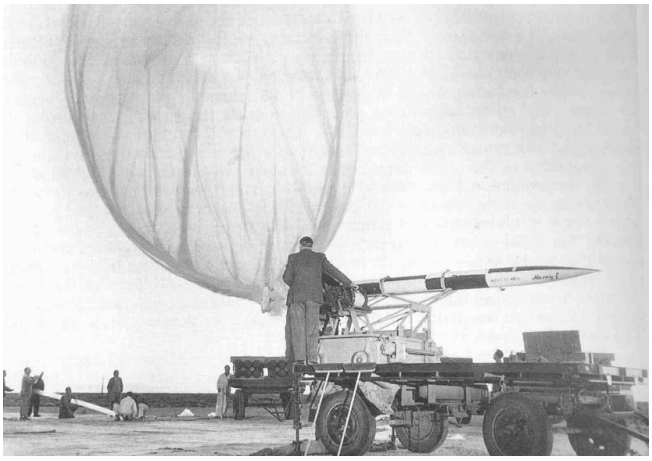

Figure 5–2: The complete HARP vehicle ready for flight during the January 1957 launch attempt. The Harpy 1 rocket was a dummy for this first all-up test flight of the rockoon system. Credit: Defence Science and Technology Group.

While complete dimensions for the "Harpy"[*] rocket have yet to be found, the Mayfly motor was 3.10m in length, with the instrument capsule 0.26m in diameter. It had an anticipated maximum acceleration of between 80–90g.

Without its balloon lift, the "Harpy" could only have achieved an altitude of 24km [31]: balloon-launched at approximately 12km, the rocket was expected to attain an altitude of 100km [32]. The 12 km launch altitude was chosen (even

[*] Although not used formally, Harpy was the nickname of the HARP sounding rocket. The legend *Harpy 1* can be seen inscribed on the dummy rocket's nose in the few images available of the first launch attempt.

though the balloon could have carried the rocket higher), because it was feared that jet stream winds at higher altitudes might carry the balloon a long distance from its launching point, making tracking difficult [33].

Although designed by the WRE, the HARP rocket was manufactured by the Special Projects Division of the Fairey Aviation Co. of Australasia Pty. Ltd. Initially named the Fairey-Clyde Aviation Company,* it was a joint venture between the British Fairey Aviation Company and Sydney-based Clyde Engineering [34]. Fairey-Clyde's Special Projects Division, founded in 1948, would have extensive involvement in defense projects at Woomera: as early as 1949, only two years after the Range was established, it became the first company to move into the Contractors Area adjacent to the LRWE headquarters at Salisbury, near Adelaide [35].

Fairey established its own design and manufacturing facility at Salisbury, which gradually moved from assembling rockets from imported parts, to full local manufacture [36]. In addition to the HARP rocket, Fairey also constructed WRE-designed miniature cameras for defense trials and sounding rocket applications [37].

The balloon segment of the HARP vehicle was the responsibility of the WRE's Aerodynamics Division, which selected a design already successfully used by the University of Bristol [38]. The balloons used for the initial HARP trials were manufactured in Bristol, although there were plans to produce further supplies in Australia had the project successfully continued [39]. The launch advantage provided by the huge hydrogen-filled polythene balloons (18m across and 30m high when fully expanded [40]) enabled the 235kg rocket to carry a payload of 23kg of scientific instruments [41].

VII. HARP Scientific Payloads

The Australian collaboration originally envisaged by Massey for the Skylark program, came to fruition instead in HARP, with the WRE working in collaboration with the Upper Atmosphere Research Committee of the Australian Academy of Science [42]. This Committee, which was Chaired by the influential David Forbes Martyn, included representatives of several Australian universities, as well as divisions of the CSIRO.

Although HARP was funded under the Joint Project, rather than through the official funding mechanisms for IGY programs [43], the WRE and UAR

* Fairey-Clyde changed its name to the Fairey Aviation Company of Australasia Pty. Ltd in 1951.

Committee intended from the outset that the HARP program should be regarded as part of Australia's contribution to the IGY [44], as well as being a defense research program under the Joint Project. Characterizing HARP as an IGY project made the participation of civilian scientists more palatable to the Academy of Science and especially the CSIRO, which had a long-standing aversion to defense research [45]. Had HARP succeeded, it would also have made it possible for ADSS scientists, who had long complained that security classification made it difficult for them to maintain a professional profile through publication, to publish nonclassified aspects of their work on the project [46]. Associating HARP with the IGY additionally enabled the participating universities to access the IGY research grants available from the Australian National Committee for the IGY [47].

Five payloads were developed for HARP,* designed to complement the data that would be acquired from Skylark launches:

- The University of Adelaide planned to measure high altitude winds by using Doppler radar to track an ionized sodium cloud ejected from the rocket. Adelaide researchers were also interested in using radio means to measure the ionization height profile.
- The WRE was interested in taking atmospheric pressure measurements by means of an instrumented aluminum sphere released from the instrument capsule to float back to Earth by parachute while radioing its data to the ground.
- The CSIRO, the University of Adelaide and the Australian National University planned an experiment for the detection of meteoritic dust. This would investigate a theory at the time that rainwater droplets might form around particles of meteoritic dust. As rainmaking was a topic of interest to the CSIRO in the 1950s, due to droughts that were affecting agricultural production, confirmation of a relationship between meteoritic dust and rain formation was thought to be a key to developing means of artificial rainmaking.†

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* Although the article "IGY Woomera build-up," *Aircraft*, March 1957, p. 46, states that six British universities were providing scientific payloads for the HARP project, this seems to have been confusion with the Skylark program. When Massey visited Australia in 1955, discussions on the possibility of British instruments being launched as part of HARP did take place, but no British experiments are included among the known HARP payloads.

† There are also indications that this experiment may have been intended to detect high altitude fallout from the British nuclear tests at Maralinga, in South Australia. Fallout and the impact of atmospheric nuclear tests on weather patterns were becoming matters of public concern in the mid-1950s. See, for example, "The Atom and Our Weather," *The World's News* (Sydney), 12 March 1955, p. 20.

- An additional experiment to study the composition of the atmosphere at high altitudes using a mass spectrometer was planned for later in the HARP program.
- Alongside these scientific experiments, the WRE also planned to use its miniaturized ultra-wide-angle lens cameras to take high altitude photographs of the cloud cover and the Earth, as well as providing instruments that would report on various flight characteristics of the rocket [48].

VIII. HARP's Flight Tests and Failure

As outlined by reports in National Archives of Australia file D174, A326/1 Part 2, (High Altitude Research Project (HARP), 1955–1959), an initial series of tests was carried out in 1956 to establish the feasibility of the rockoon technique. These included: several launches of meteorological balloons, to tests the systems for remotely controlling the firing of the rocket once the planned altitude was reached; and ground firings of 3-inch rockets attached to prototype "skyhooks," to test the way in which the rockets would be launched from the balloons. The success of these tests encouraged the WRE to plan a flight program of test launches of the complete rockoon system in the first half of 1957, prior to the commencement of the IGY, with at least ten research flights to follow during the IGY itself.

Two attempts to launch the full-size hydrogen balloons in late 1956 failed, with the balloons destroyed by gusting winds. The difficulties experienced with these trials presaged the problems that were to come. Plans were made for the first test of the full-size balloon with a dummy "Harpy" rocket to occur in January 1957, with a live test flight to follow soon after. However, the first dummy flight was unsuccessful, with the balloon failing before it could be released, being torn by high winds.

The WRE quickly discovered that HARP's massive balloon (much larger than the meteorological balloons with which the feasibility tests were carried out and made of more fragile material) was difficult to handle in Woomera's random wind gusts, and easily damaged. Across 1957, only four launch attempts proceeded to the point of filling the balloon, while several other planned launch attempts were abandoned due to unsuitable wind conditions. Of the four launch attempts that went ahead (all using dummy rockets), two failed before launch because high winds destroyed the balloons during filling. During the very first launch attempt in January, although the balloon was partially filled and began to lift the rocket from the ground, it was torn apart by the wind before filling was completed. The other launch attempt actually succeeded in carrying the dummy

rocket to release altitude, but the difficulties of getting it airborne convinced the launch team that it was too dangerous to attempt a live launch until the wind problems could be resolved.

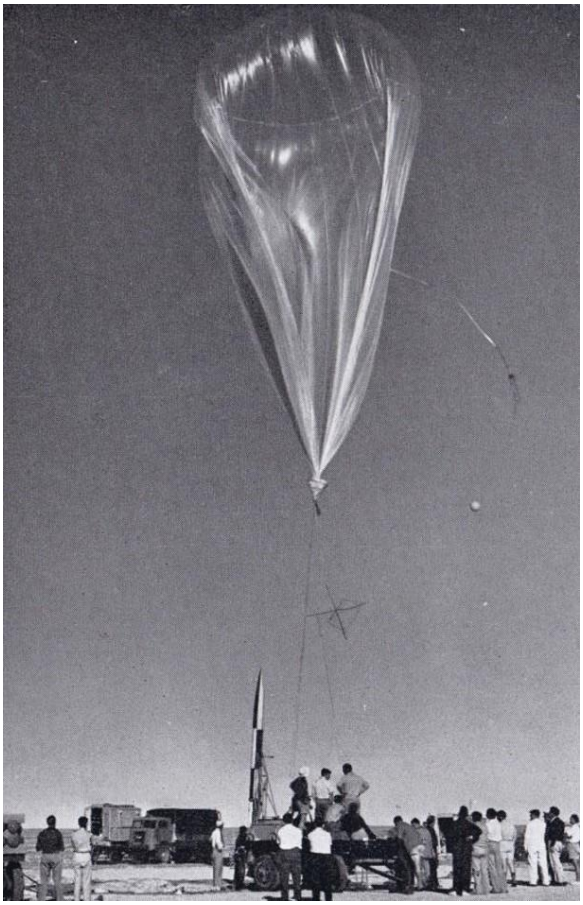


Figure 5–3: Dummy HARP rocket being lifted from its launch cradle by the partially-filled balloon during the January 1957 test flight, shortly before a wind gust tore the balloon open. Credit: Defence Science and Technology Group.

After persevering with HARP launch attempts for twelve months, in January 1958 the WRE called in a consultant from the University of Bristol's scientific balloon team, in an attempt to rescue the program. However, he was unable to find a practicable solution for the wind problem. In Woomera's relatively flat terrain, there was no suitably sheltered location on the Range that would reduce the wind effects at launch, while the cost of constructing an artificial shelter large

enough to encompass and protect a fully inflated balloon was prohibitively expensive.

Consequently, in February, the WRE and the UAR Committee agreed to switch the HARP experiments to the Long Tom, a sighter rocket developed by the WRE for Range testing, which had comparable performance characteristics to the HARP rockoon. This decision paved the way for the Long Tom to become Australia's first successful sounding rocket [49], while the HARP program, formally cancelled in September 1958, faded into obscurity.

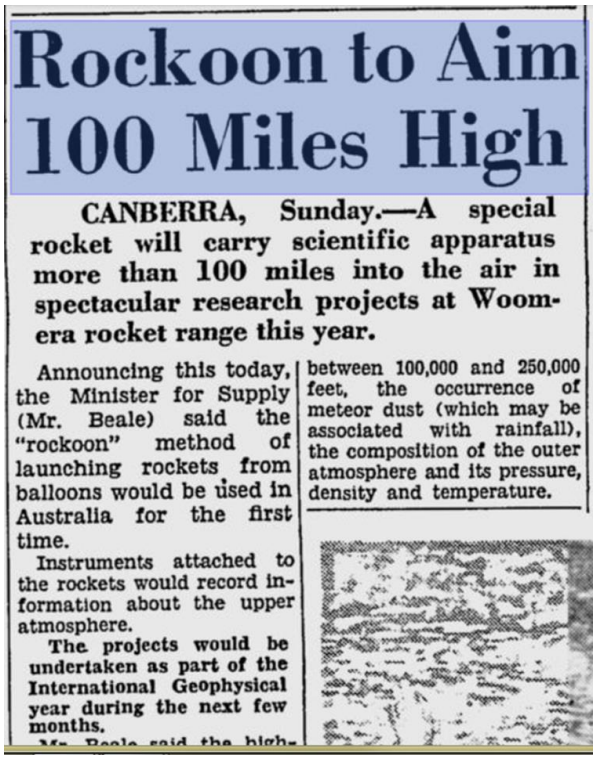
Figure 5–4: The Long Tom sounding rocket, a repurposed sighter rocket that replaced HARP to become Australia's first successful sounding rocket. Credit: DST Group.

IX. HARP's Role in Creating the Perception of Australia as a Space-Active Nation

Despite the eventual failure of the HARP program, and the fact that the Australian Government consistently played down any suggestion of the country becoming involved in space research during the IGY [50], by 1960 Australia was

internationally perceived as a nation at the forefront of space activities at the beginning of the Space Age [51]. It was invited to become one of the seven founding members of the Committee on Space Research (COSPAR), established in 1958, and, through the tireless international scientific diplomacy of David Forbes Martyn, was also one of the original participants in the United Nations' Ad Hoc Committee on the Peaceful Uses of Outer Space [52].

While other activities at the Woomera Rocket Range gave more concrete substance to this perception of a "space-active Australia" (the British Skylark and Black Knight programs, the pre-NASA US tracking facilities installed for the Vanguard program and operated by the WRE, and the Long Tom sounding rocket program), the role played by HARP in initiating the view that Australia was an active participant in the Space Age should not be overlooked.



Rockoon to Aim 100 Miles High

CANBERRA, Sunday.—A special rocket will carry scientific apparatus more than 100 miles into the air in spectacular research projects at Woomera rocket range this year.

Announcing this today, the Minister for Supply (Mr. Beale) said the "rockoon" method of launching rockets from balloons would be used in Australia for the first time.

Instruments attached to the rockets would record information about the upper atmosphere.

The projects would be undertaken as part of the International Geophysical year during the next few months.

between 100,000 and 250,000 feet, the occurrence of meteor dust (which may be associated with rainfall), the composition of the outer atmosphere and its pressure, density and temperature.

Figure 5–5: Part of a story that appeared *The Age* newspaper (Melbourne) on January 7, 1957, in advance of the first HARP flight test. It marks one of the few times that an Australian Government representative directly associated HARP with the IGY. Credit: Trove newspaper collection, National Library of Australia.

Reports about the HARP program in the national press and international scientific and aviation journals covering the IGY, positioned the rockoon program as a significant Australian contribution to IGY space research. Similarly, despite the succession of launch failures, as one of the active IGY sounding rocket programs, HARP was included in the Annals of the International Geophysical Year volume on rockets and satellites [53], alongside Skylark and the space programs of the other COSPAR founders. Regardless of the reality of the HARP program's difficulties, its high profile in contemporary publications was important in building an initial perception of Australia at the forefront of early space activities.

X. Conclusion

Despite the innovative features of the HARP sounding rocket, which marked the beginning of WRE technical capability in sounding rocket design, the HARP program was flawed from the outset. However, its lack of success was not due to any failure of the concept, but to the WRE's inability to fully appreciate the environmental requirements for launching a large balloon, and Woomera's inherent unsuitability for this particular technique. HARP was an important learning experience for the WRE, which would soon bring that experience to bear in the creation of a new Australian sounding rocket program using the Long Tom vehicle, utilizing spare Mayfly rocket motors from the HARP project. Commencing in 1958, the new approach undertaken with the Long Tom would see the creation of an Australian sounding rocket program that would operate at Woomera until 1975.

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