PCA HERITAGE

Shoreham Airfield dome trainer

Conservation Management Plan

Client:
The Community Stadium Ltd

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1. INTRODUCTION AND METHODOLOGY

1.1.1. PCA Heritage has been commissioned by The Community Stadium Ltd (TCSL, the 'client') to prepare a conservation management plan (CMP) for Shoreham Airfield dome trainer (Plate 1). The structure is situated to the north-west of Shoreham Airport (now called Brighton City Airport) in Lancing, West Sussex (National Grid Reference TQ 19863 05839, Fig 1). The A27 road between Lancing and Shoreham is situated *c.*80m to the north of the structure.

1.1.2. The dome is a designated scheduled monument (National Heritage List for England number 1005818) with the full asset name 'Shoreham Airfield dome trainer, 240m south west of Sussex Pad Hotel'. The reason for its designation is given as:

> *Dome trainers are dome-shaped buildings housing training apparatus, including a projector, for training ground gunners in the art of airfield defence. Despite partial damage by fire in the past, Shoreham Airfield dome trainer survives in good condition. It is a rare example of a Second World War dome trainer. There are now few surviving examples although one of similar design is a scheduled ancient monument at Langham Airfield, Norfolk. As a significant testament to the development of military training and as an example of enterprise and intuition in airfield defence, at a time when Britain faced one of the greatest airborne threats of the twentieth century, it is of national importance.*

1.1.3. The freehold of the land on which the Dome Trainer is situated is owned by Brighton & Hove City Council and Worthing Borough Council. Until 3 June 2020 the leaseholder of this land was Albemarle Shoreham Airport Ltd (ASAL). TCSL assumed the leasehold on that date and have a long-term leasehold interest in the land. There is currently no public access to the structure and, given its location, it is unlikely there ever has been any.

1.1.4. This CMP describes the history of the structure before providing a summary of construction details, its present condition and the reasons behind any weaknesses to the structure and its fabric. The significance of the structure and its vulnerabilities and opportunities are then identified, and corresponding actions recommended. Finally, these actions are grouped together in an action plan, to be found at the rear of this report.

1.1.5. The following guidance has been used to compile this plan:

- Historic England 2017, *Conservation principles for the sustainable management of the historic environment (draft)*
- National Lottery Heritage Fund, *Conservation Planning Guidance*, www.heritagefund.org.uk/good-practice-guidance/conservation-planning-guidance
- Kerr, J S, 2003, *The Seventh Edition Conservation Plan 2013: A guide to the prepration of conservation plans for places of European Cultural Significance, ICOMOS, Seventh edition*

- Institute of Structural Engineers, 2010, *Appraisal of Existing Structures,* Third edition

1.1.6. The preparation of the CMP is part of a wider suite of archaeological and built heritage mitigation measures being undertaken as part of the redevelopment of an area of land called New Monks Farm and parts of Brighton City Airport, within which the dome was formerly situated. Planning permission has been granted by Adur District Council for the development (application no. AWDM/0961/17), subject to a number of conditions. Planning condition 05 is relevant to this report:

Within one calendar year from commencement of the development a written Conservation Management Plan for the Shoreham Airfield Dome Trainer shall be submitted to and approved in writing by the Local Planning Authority. Thereafter works shall be carried out in full accordance with the approved details.

1.1.7. A site inspection to inform this CMP was undertaken by PCA Heritage and a conservation engineer from Ramboll on 3 July 2020. A laser scan of the structure was undertaken by Ramboll on 24 June 2020 (see Figs 2 and 3), and a Historic England Level 3 historic building record was made by Archaeology South-East on 9 July 2020 (Russell 2020, Appendix 2). Earlier site visits by PCA Heritage were undertaken in October 2016, March 2017, April 2017 (with representatives from Historic England) and March 2020.

1.1.8. Consultations regarding the dome trainer have been undertaken with representatives of Historic England and West Sussex County Council's County Archaeologist, acting as Adur District Council's archaeological advisor.

2. HISTORICAL BACKGROUND

2.1.1. Shoreham Airport, then known as Brighton and Shoreham Aerodrome, opened in 1911, the land having been used for two years prior to this as a site for aircraft development (Webb and Bird 1999, Chapter 1). In 1914 the airfield was requisitioned for the Royal Flying Corps and used for flying instruction, before being abandoned and returned to pasture after WWI.

2.1.2. Activity, in the form of the Gnat Aero Company, returned to the airfield in 1925 and in 1933 Brighton, Hove and Worthing councils jointly purchased the airfield with a view to creating a municipal airport. Construction of a terminal building, designed by S H Tiltman, and a Boulton and Paul-supplied hangar to the west of it, began in 1934. The airport was opened on 13 June 1936 and Tiltman's building, designed in the Art Moderne style, received much acclaim. It and the hangar survive and are designated listed buildings.

2.1.3. In 1940, with the advent of WWII the previous year, the airport was requisitioned by the Government and a series of defences were quickly developed. A large number of military planes either passed through or were temporarily stationed at the airport, and many buildings were hastily erected to service them and their crews.

2.1.4. The airfield had light anti-aircraft positions around its perimeter from 1940 onwards, as well as pillboxes, trenches and breastworks. These positions were intended to combat low

flying aircraft strafing or dive-bombing the airfield. Later in the war, as supply became available, larger guns arrived at the airfield. Large calibre anti-aircraft weapons were suited to combat aircraft at higher altitudes and were not stationed at airfields for defence.

2.1.5. Training in the techniques of light anti-aircraft fire began in a classroom, before moving outside to a target practice area (generally looking out over the sea) where personnel could fire light or medium machine guns at a target towed by an aircraft. Though a useful introduction, this did not incorporate any of the high-speed manoeuvres that might be employed by the German Luftwaffe in a real attack, such as dive bombing or attacks by multiple aircraft. A practical solution, which involved a significant level of realism, was needed before the transition to a genuine ground defence role could take place. The recruits needed to acclimatise themselves not only to the short duration of an attack (30 seconds was an approximate maximum duration) but also to the psychological effects. That solution came in the form of the dome trainer.

2.1.6. Wooden domes were in use from 1926. These used lamps to project images of handheld aircraft, but it was Henry Stephens who came up with an idea which was developed extensively from 1939 (Francis 1996). Two main types of dome were introduced: the 'Apparatus, Dome, A A Training, No 1, Mk 1' with a 20ft radius and the 'Apparatus, Dome, A A Training, No 2, Mk 1' and 'No. 3 Mk 1', each with a 10ft radius. The basic concept involved a film projector which threw footage of aircraft onto a mirror which could be manoeuvred to reflect the aircraft onto the ceiling of the dome. A dummy gun (the 'sighting unit') and operator could then follow the image and practise taking aim and shooting. With aircraft speeds in excess of 300mph, aiming and shooting at the aircraft itself, in a real attack, would have meant projectiles arriving in a space the aircraft had already vacated, and so do no damage. The dome trainer taught gunners to predict the flight path of an aircraft and to aim in front of it, so that projectile and aircraft arrived at the same location simultaneously. To achieve this as a practical exercise, the film footage was manually marked with a yellow dot, frame by frame, the dot representing the aircraft's future position. The sighting unit shone a graticule (crosshair and concentric circle aiming mark) onto the dome ceiling to show where the gun was pointing and when the two coincided a 'hit' was recorded. When gunners had practised this initial version of the simulation, they could then don yellow-coloured glass spectacles, rendering the yellow dot invisible to them, and practise hitting the aircraft without any aid.

2.1.7. All the footage shown in the dome (there were 14 films referenced in the 1944 training manual, each comprising two attacks) was made using models and stop-frame animation by Technicolour. Recordings of aircraft engines in flight were played through speakers and the dummy weapon featured a representative gun noise amplifier. To power all of this, an electricity supply was fed into the dome via an earthenware pipe beneath the floor at the entrance. A wall partitioned off approximately one quarter of the dome interior to provide two extra rooms which were accessed from the entrance lobby. These formed the ventilation plant room and the cloakroom.

2.1.8. Ventilation plant was necessary to extract air from the main room via two fans set in the partition wall as the arc lamps used for illumination produced a significant amount of heat. Meanwhile, fresh air could freely enter through other vents. The partition wall was fitted

with acoustically treated soundproofing quilts (Cabot's Quilt) to deaden the echo generated by the domed roof when all loudspeakers were in operation.

2.1.9. Construction of concrete dome trainers involved the pre-fabrication of steel framework by the Trussed Concrete Steel Company (a US-based company with a facility in South Kensington), which was then shipped to, and assembled, on site. A steel mesh called Hy-Rib, a commercial product of the same company, was then fixed to the frame on internal and external surfaces (Air Ministry plan 73/42). The thin lath mesh, which came in strips that were ribbed to provide strength, could be rolled to accommodate curved surfaces and would retain concrete when poured. The external Hy-Rib extended only up to 2.74m (9ft) from ground floor level on the outer frame, above which the concrete could be kept in place by gravity.

2.1.10. After the concrete had cured, the external surface was cement rendered. The interior was covered in pre-formed fibrous plaster sheets, to create a regular and smooth surface, with a void between the plaster and the concrete. The interface between the floor and walls was then fitted with coving of the same material and vents in the coving allowed air to circulate behind the plaster boards. The internal partition wall did not have the fibrous plasterboard, merely a wire mesh onto which the quilts were attached.

2.1.11. Attempts were made to simplify this manufacturing process and in 1942 Charles Bell undertook tests to see if concrete could be poured over inflatable balloons, thereby removing the complicated steel framework. During the initial stages it became clear that the balloon alone might be used, alleviating the necessity of the permanent and costly concrete dome. Thereafter, the Portobell dome became the dome trainer of choice until the war ended, although it seems some domes of wood or concrete were still constructed until 1945. Approximately forty-four concrete domes were built during the war in the UK, of which six survive.

2.1.12. Construction of Shoreham airfield dome trainer (officially an 'Apparatus, Dome, A.A. Training, No. 1, Mk. 1') began in 1942. A photograph from 15 October 1942 (National Collction of Aerial Photography reference GX 11990 SG0047), though not showing the dome, does appear to show signs that the ground is being prepared for one. A track leading from the site to the south-east is visible, intersecting with the truncated New Salts Farm Road. Aerial photographs of the site from 16 March 1943 (GX12066 SD0049) show an unfinished dome with the track very much in use and by 20 May 1943 (GX11971 SG0277) the dome looks externally complete.

2.1.13. An entry in an RAF file from 12 May 1943 (Shoreham Airport archive) states 'No 7 AA Practice camp almost complete first course on twin Brownings commenced today with approx. 100 trainees. Dome trainer steadily advanced and hopes to complete near future'. The trainees would have been practising using the towed target attached to a Lysander aircraft, in preparation for progression to the dome once it was complete. They were likely to have been accommodated or at least given instruction in the huts which once lay to the west of the dome trainer.

2.1.14. Military use of the airfield began to be wound down in 1944 and the airfield was handed over to the Ministry of Civil Aviation in March 1946. After the last RAF Regiment Squadron

left the airfield it was used by an Air Training Corps for meetings, training and band practice, before being added to a number of premises on the airfield used by the electronics subsidiary of an aircraft manufacturer, F G Miles Ltd.

2.1.15. Since the 1960s it is thought to have remained largely unused for anything other than storage. A fire in the early 1980s reportedly damaged the structure, and sometime later (perhaps in the later 1990s) the external surface was painted in green camouflage colours. In c.2000-1, a programme of groundworks resulted in the ground surrounding the dome, and especially to the south and south-east of it, being raised to form a helicopter landing area. Google Earth imagery shows that by April 2007 the fuselage of a light aircraft had been dumped to the immediate north-west of the structure.

3. DESCRIPTION OF THE STRUCTURE

3.1.1. A cylindrical wall forms the base of the dome (see Figs 2 and 3 and Appendix 2, Fig 4). This has an external diameter of 12.65m and rises to a height of 1.6m before the dome roof begins (Plate 1). The vertical wall allowed the mirror and gunners to be placed at the base of the curved ceiling, thus giving a more realistic 'sky' surface for the film image to be reflected onto. The apex of the dome rises to 7.74m from floor level. An Air Ministry drawing (see Appendix 2 Fig 6) indicates that the depth of concrete beneath the walls is likely to be 300mm, while the main floor should be formed of 100mm of concrete over 100mm of hardcore. Cement render is present over the entire dome exterior (giving a total wall thickness of just 130-140mm).

3.1.2. A rainwater gully formed from pre-formed segments of 0.88m length skirts the base of the dome (Plate 2; Appendix 2 Fig 4). Two vertical pipes (not visible here but marked on Air Ministry plans) transferred water to a sump or into the nearby ditch and stream. The gully terminates at either side of the entrance, and the projecting concrete door frame has a rainwater lip on its top edge, to allow water to flow down the sides of the entrance into the gully (Plate 3).

3.1.3. The entrance measures 2.1m in width and 2.07m in height and originally housed a recessed double door. The width of the door is the only noticeable divergence from the original Air Ministry plan, which gives a width of 4.6 feet (1.4m). A concrete ramp leads up to the entrance, two-thirds of which is now covered with a thick bituminous substance. This is possibly the remains of the original roof covering, which consisted of a bituminous emulsion followed by a coat of hot bitumen, into which camouflage material (chopped heather or stone chippings was recommended) was pressed. A fire in the structure in the 1980s may have caused the bitumen to liquefy, run off the roof and solidify here. The original recessed doors have been replaced by a heavy duty sliding external door mechanism, presumably during F G Miles' tenure. Although this later door is no longer present, two rails to guide it remain *in situ* at the top and base of the entrance (Plate 1; Appendix 2 Fig 4). The lower of these was inserted into a slot cut through the ramp and the rainwater gully.

3.1.4. Further post-war modifications to the structure include the addition of nine steel-shuttered windows of 1.25m height and 0.56m width, added at irregular intervals around the circumference, all approximately 0.9m from the ground (Plates 4 and 5). As built, the only openings into the dome were the entrance, a small ventilation hole 2.8m up from the floor in the dome (Plate 6) and a 0.29m by 0.54m rectangular slot in the western side used to exhaust the ventilating plant. This was later bricked up (Plate 7). Two small steel hooks and a connection point, possibly for a telephone connection, are visible on the western area of the roof (Plate 8), although whether these date from the original construction is not clear. There is no sign of the external power supply or the earthenware pipe in which it was laid.

3.1.5. The entrance is constructed from a concrete frame covered with a cement render. It sits within the maximum space available between two radial lattice reinforcement boxes. The cement render is spread around the concrete frame, over the Hy-Rib and up to walls and a ceiling which is no longer present (Plate 9), demonstrating the ceiling level of the small lobby (see Appendix 2 Fig 4). The lobby as indicated on the Air Ministry plan (see Appendix 2 Fig 6) consisted of a breeze block wall with a timber joist ceiling.

3.1.6. The interior of the dome has been gutted. All original fittings have been removed, including the steel-frame partition wall. This has opened up the dome into a single space (Plates 10 - 13). The plasterboard, originally fitted to the dome ceiling and walls, has been removed in its entirety, exposing the Hy-Rib mesh and, in a number of places where the mesh has rusted and failed, the steel construction behind it. Sixteen radial steel lattice reinforcement box cages emanate from a crown ring near the top of the dome (approximately 1.5m in diameter; see Appendix 2 Fig 5), and provide the structural integrity of the dome (Plate 13). The radial steel lattice reinforcement box cages are square in section, with four steel bars one in each corner, running the full length of the cage. Connecting these together are steel bar laces, welded to each face of the girder, to provide internal reinforcement which resists cracking and tensile forces (Fig 2).

3.1.7. The reinforcement at the apex of the dome would appear to be formed solely from Hy-Rib mesh. A further eight tiers of horizontal rings of increasing diameter are placed at regular intervals beneath the crown ring and all of these are formed of steel lattice reinforcement box cages, bolted in sections to the radial reinforcement box cages (Plates 14 and 15). As the radial reinforcement box cages near ground level they naturally become increasingly further apart and to maintain consistent spacing, intermediate reinforcing bars have been added between them, to join the second and fourth horizontal rings, and two bars to join the fourth ring to the footings at ground level. These bars were noted at the dome trainer at Langham Airfield in Norfolk to be made of two parallel bars welded to cross bars, forming a ladder-like construction (Morton Partnership Ltd, 1998 and 2005).

3.1.8. The Hy-Rib has been fixed horizontally around the lower part of the dome, but after a height of approximately 2m, the curved sheets can no longer be laid in this fashion, due to the difficulties of coating a convex surface with a rectangular sheet. The method employed was to tilt the sheets at a 45° angle and line one third of the dome ceiling, with the opposite one third lined in a similar but opposite fashion. The remaining central section was lined with the sheets approximately aligned north to south (Plate 16).

3.1.9. Set within the wall and fixed to horizontal steel bars (fitted between the radial girders) are a large number of small wooden blocks which measure 140mm by 150mm on the interior face (Plates 17-19). In section they are trapezoidal in shape, with the widest side fitted to the steel frame. It would seem they were either fixed with staples or nails subsequently bent around the tensioned bars. The Hy-Rib mesh was applied around their locations and the concrete, when poured, held the blocks in place due to their wedged shape. The section detail provided in Air Ministry drawing 73/42 (Appendix 2 Fig 6) suggests there was an intention to apply a half-inch thick render to the inside face of the structure, which would also have helped to fix the blocks. It is not clear whether this render was ever applied to the Shoreham Airfield example.

3.1.10. The first tier of timber blocks occurs at 0.9m from ground level, with each block being set approximately 1m from its neighbour (although their placement is dependent on not being coincident with a radial box girder). There are eleven tiers, and a further single block is placed in the apex of the dome. There are 24 blocks on the lowest tier, all of which are situated between either end of the former partition wall, and sixteen in the highest tier, which, because it is higher than the former partition, form a full circle. There are in excess of 200 blocks in total. The fibrous plasterboard that covered the interior was nailed to these blocks and the 3" nails are still present, despite the absence of the plaster. There are no blocks fitted within the cloakroom and plant room beyond the partition wall, confirming the detail on the Air Ministry plan that where plaster boarding was not a necessary finish, the wall surfaces were left bare.

3.1.11. The partition wall appears to have been added after the completion of the dome's concrete formation but prior to the addition of plaster. A fragment of the partition remains on the eastern side; this comprises a truncated 200mm high segment of steel lattice reinforcement box cage (Plate 20). The line of the partition is clearly visible as a lighter-coloured arc on the ceiling and walls of the dome (Plate 21). Within this arc are a number of steel bolts and rectangular plates onto which the steel frame of the partition was fastened (Plates 18 and 20). There are no visible scars in the floor along the line of the partition.

3.1.12. In the floor, although covered in silt from recent flooding episodes and coated in a thick paint, are 14 post holes of 120mm by 150mm dimension. These supported the steel guard rail which surrounded the technical equipment (Plate 22, see Appendix 2 Fig 6). A further post hole, located in the centre of the dome, and measuring 100mm square, took a timber post onto which the mirror arrangement was secured. Behind the mirror, the sighting unit, fitted with casters, could be wheeled into the guard rail area and then bolted into holes in the concrete floor. The rear guard rail featured a top bar that could be raised, allowing access for the other machinery, in the form of sighting units for alternate 'weapons' or a predictor unit. The service ducting, which brought electrical cables to the equipment, was covered by wooden planks and ran from the ventilating plant room (where there was probably a master switch and fuse set) underneath the technical equipment in a general southerly direction, with an eastern spur.

4. CONDITION SURVEY

4.1.1. The structure is situated in an area which is surrounded on the northern and western sides by access tracks and on the two other sides by an area of ground which was raised in the early 2000s to form a helicopter landing area (Figs 2 and 3, Plate 1; Appendix 2 Figs 2 and 3). This had led to water pooling around and inside the dome during periods of heavy rain (Plate 4).

4.1.2. Vegetation has been allowed to develop around the structure (Plate 23). By March 2020 this had grown to include relatively mature trees.

4.1.3. The external surface coating to the dome comprises impermeable green paint over-painted in places with a brown paint for camouflage purposes. Beneath this there is a tar or bituminous layer with grit embedded in it (Plate 3). It is understood that the dome was repainted in the 1990s and this paint is now cracking and debonding; the tar/bituminous layer is likely to be original. Water can become trapped beneath the damaged paint and percolate into cracks in the render. Where the over-painted bitumen on the exterior surface has cracked, seedlings have taken root in the pockets created (Plate 24). Their roots will exacerbate any cracks or other damage.

4.1.4. The external render has a regular pattern of at least eleven vertical cracks, each approximately 2-3mm wide (Plate 27). These correspond approximately to the position of the pre-welded radial lattice reinforcement cages. This suggests that these cages may be corroding, with the expansion causing cracking in the concrete and render. There is no evidence of differential settlement or spreading of the dome.

4.1.5. There are local patches where the external render has spalled, often adjacent to a crack. The loss of render has exposed patches of the Hy-Rib which it has corroded (Plates 27 and 29).

4.1.6. The external perimeter drainage gully has become blocked with vegetation (Plates 1 and 2).

4.1.7. The door frame, window frames and window shutters have surface corrosion (Plastes 5 and 14). The window and door openings allow water ingress.

4.1.8. The structure has been used to store discarded objects, including large timber cases and tractor wheels and tyres (Plates 25 and 26). In addition, the fuselage of a light aircraft has been dumped close to the structure (Plate 30).

4.1.9. Internally the Hy-Rib is exposed and corroded . In a number of places it has corroded away and exposed the reinforcement bars within the concrete: this is particularly evident in the south-west of the dome.

4.1.10. Where the reinforcement box cages and ladders are exposed, they are corroded (*ie* Plate 14). In some areas where reinforcement has been exposed the concrete is spalling.

4.1.11. No concrete testing has been undertaken. However, based on the fact that where the concrete of the dome at Langham in Norfolk was tested, it was found to have carbonated, the concrete in the Shoreham Airfield example may also have carbonated, perhaps to a

depth of up to 20mm externally (where coatings still offer some protection) and up to 50mm internally. Concrete is alkaline and this protects the steel from corrosion. Carbonation is the process whereby atmospheric carbon dioxide penetrates the concrete and reacts with calcium oxide to form calcium carbonate which is not alkaline. If the depth of carbonation reaches the steel reinforcement is can cause corrosion. Given the coastal location, there is also a risk of chloride ingress, which will also cause corrosion.

4.1.12. Whilst many of the wooden blocks for fixing the plaster board remain, some have decayed and some have been lost.

4.1.13. The ground slab was difficult to inspect because of overlying silt, and the foundations were not inspected. However, there was no evidence of settlement.

5. STATEMENT OF SIGNIFICANCE

5.1.1. Historic England (2017, 4) identifies that the starting point for effective conservation of a heritage asset is to understand its significance. The significance (or heritage value) of Shoreham Airfield dome trainer is derived from its historic and architectural interest.

5.1.2. Rigorous training is paramount for the efficient and successful application of military force and anti-aircraft defence is no exception to this, being at the front line in the early years of WWII. The high importance of mitigating against air attack led to anti-aircraft positions being built before the war began, well before any of the more common anti-invasion defences (pillboxes, anti-tank blocks *etc*) were constructed. The investment put into inventing, creating and developing dome trainers is a manifestation of this thought process.

5.1.3. The concept of a synthetic training method which combined cinematography with hi-tech electrical equipment was an innovative one which pre-empted much of the modern industry of virtual reality by many decades. The dome provides enduring physical evidence of the concept and its combination of a range of disparate technologies to help solve an immediate problem. Despite its relatively short period of use, the structure therefore has a place in the history of WWII defence and the technological revolutions which accompanied it.

5.1.4. The structure's unusual form makes is aesthetically pleasing and invites curiosity. This, together with the combination of surviving design drawings and physical evidence, enhances the architectural interest of the structure, as does the innovative use of lightweight, pre-fabricated materials.

5.1.5. The important elements of the dome trainer's setting are Shoreham Airfield, the airport's original terminal buildings and hangar, and the various WWII structures related to defence of the airfield. This setting contributes positively to the historic interest of the asset.

5.1.6. Shoreham Airfield dome trainer is recognised as being of national importance and is accordingly a scheduled monument. Dome trainers were never common structures in the landscape and this example is now one of only six to survive (examples at Langham,

Limavady, Mildenhall, Pembrey and Wyton being the others). It is the only one remaining in southern England.

6. GENERAL CONSERVATION PRINCIPLES

6.1.1. Historic England (2017, 4-5) emphasise that successful conservation is about managing change to a heritage asset and its setting in ways that will best sustain its significance. At the same time, opportunities should be taken to better reveal or enhance that significance for present and future generations (Conservation Principle 4).

6.1.2. General conservation 'best-practice' principles for built heritage assets include:

- basing all conservation on a good understanding of an asset's history and significance;
- regular monitoring of an asset to inform continual improvement of planned maintenance and identify the need for periodic repair or renewal at an early stage;
- ensuring that any repair and/or consolidation works do not jeopardize the future integrity of an asset;
- ensuring that materials and methods of repair are the best currently available, are compatible with those already used, have proven durability and are honestly, but subtly, distinguishable from original fabric or previous interventions;
- keeping intervention to a minimum; and
- seeking opportunities to foster the appreciation of heritage assets.

6.1.3. Conservation is founded on appropriate management and routine maintenance. The basic principle underpinning this CMP is therefore that Shoreham Airfield dome trainer would benefit from a long-term programme of management and conservation.

6.1.4. Deterioration of fabric is inevitable without regular maintenance. Generally, conservation works should in the first instance aim to safeguard the structural integrity of historic fabric and ensure weatherproofing. Thereafter, conservation should be directed in a priority order based upon a combination of significance and vulnerability.

6.1.5. It is appropriate to consider a quinquennial review to ensure that the momentum of any such programme is sustained. This should include examination of structural and maintenance issues, stewardship, and the effects of use.

7. VULNERABILITIES, OPPORTUNITIES AND RECOMMENDED ACTIONS

7.1.1. In the following section of the report, vulnerabilities and opportunities are identified in the left-hand column and the corresponding recommended action is provided in the right-hand column. These are then grouped in the Action Plan, to be found at the rear of this plan.

Vulnerabilities	Recommended actions
Dumped refuse in the structure obscures access and assessment / monitoring of its condition.	1 Remove waste from inside and around the structure.
Vegetation growth around the structure will lead to root penetration of its foundations. Eventually, if left unchecked, trees will develop which could cause structural damage.	2 Remove vegetation from around the structure. Thereafter, undertake regular ground maintenance to prevent overgrowth returning.
Lack of security allows the possibility of vandalism.	3 Install secure, vented doors to the structure.
Flooding around the exterior and in the interior of the building means that from time to time the building sits with its feet in water. This will percolate into the concrete and cause corrosion of the Hy-Rib and reinforcement. Freeze-thaw action can also exacerbate the growth of cracks and cause spalling of the concrete.	4 Engineer a means of groundwater egress from the area surrounding the structure. This could be achieved by, for example, creating gaps in the bunds around the dome, emovng parts of te bund or by laying one or more drainage pipes to drain groundwater away from the dome. 5 Clear the vegetation from the drainage channel around the perimeter of the building. Thereafter, keep this clear by undertaking regular maintenance.
Vegetation growth on the structure will lead to widening of cracks.	6 Carefully remove vegetation from the structure, taking care to minimise damage to the structure. Thereafter undertake regular maintenance to prevent vegetation growth returning.
Corrosion of the structure's steel and consequential spalling of the concrete will continue due to carbonation of the concrete and the ingress of chlorides and water.	7 Undertake a detailed concrete investigation including: hammer testing to check the bond of the render to the external surface; exploratory cutting out of concrete to measure the cover and check the continuity of the reinforcement; carbonation testing; chloride testing and sulphate testing.
Water ingress to the external face will continue leading to an increase in corrosion.	8 Cut back and repair the cracking to the external render. If the render has debonded from the concrete locally cut out, clean off corrosion from Hy Rib and

	reinforcement, apply primer that improves bonding between the steel and concrete repair material and then repair material.
The external paint system is failing. This allows water to penetrate the render, in turn increasing the risk of corrosion of the Hy-Rib mesh and reinforcement.	9 Clean off the external paint and apply an agreed coating. This should have a degree of elasticity (to bridge cracks in the render) and be breathable. An anti-carbonations coating may be required.
Spalling concrete is a risk to the safety of those entering the dome, and ultimately will threaten its structural integrity.	10 Gently clean all loose concrete and corrosion from dome intrados using agreed method; high level access and inspection will be required. The results of the concrete investigation may mean that more concrete, for example carbonated concrete, should be removed. Where significant loss of section has occurred patch repair of the concrete may be required with an appropriately specified material to match the existing concrete.
Corrosion of the Hy-Rib mesh and steel reinforcement will cause spalling of the concrete.	11 Install a cathodic protection system to protect the steel from further corrosion by installing a sacrificial anode and restoring the alkaline passive concrete around the steel. This will require a detailed concrete investigation and specialist advice so that an effective system is specified, in accordance with BS EN 1504 Products and Systems for the repair and protection of concrete structures and BS EN ISO 12696:2016 Cathodic protection of steel in concrete. Consider companies such as Martech Technical Services (who undertook similar work at Langham trainer dome), or Concrete Repairs Ltd (CRL).
Opportunities	**Recommended actions**
Encourage community interest in the dome trainer by facilitating external public access.	12 Incorporate public access to the dome trainer into the country park detailed design.

Foster educational opportunities.	13 Prepare and install a heritage interpretation panel close to the structure.
Provide occasional public viewings of the interior, perhaps on Heritage Open weekends or via online content.	14 Organise public viewings of the interior of the dome, once it is safe to do so. Until then, consider preparing video content of the interior for sharing online.
Create a community space such as a chapel, community hall or hall for a youth organisation.	15 Create a safe, dry and ventilated environment within the dome by installing a new plaster ceiling on metal lath on the underside of the dome, ensuring a ventilated gap between the Hy-Rib mesh and ceiling.

8. SHOREHAM AIRFIELD DOME TRAINER ACTION PLAN

8.1.1. In this section of the report, the series of actions identified in Section 7 are prioritised. All the recommended actions are, of course, entirely dependent on funding being available.

8.1.2. A scheduled monument is protected against ground disturbance or unlicensed metal detecting. Written consent from the Department for Digital, Culture, Media and Sport must be obtained before any work on a scheduled monument can begin. Most of the works recommended in this section will require scheduled monument consent from DCMS (see Scheduled Monument Consent | Historic England). Details of the extent and specification of the works intended would need to be submitted to Historic England as part of the consent application process.

8.1.3. The tables are divided into Priority 1 works (the most urgent) and Priority 2 works.

8.1.4. Works begun and not completed should be carried over into the following year.

8.1.5. Regular inspections of the structure should be undertaken. Based on these observations, the actions set out below should be reviewed on a regular basis to ensure they remain appropriate.

2020-2022		
Priority	**Action or Repair No.**	**Summary description of action**
1	1	Remove waste from inside and around the structure.
1	2	Remove vegetation from around the structure (repeat annually).
1	3	Install secure, vented doors to the structure.
1	4	Engineer a means of groundwater egress from the area surrounding the structure.
1	5	Clear the vegetation from the drainage channel around the perimeter of the building (repeat annually).
1	6	Carefully remove vegetation from the structure, taking care to minimise damage to the structure (repeat annually).
1	12	Incorporate external public access to the dome trainer into the country park detailed design.
2	13	Prepare and install a heritage interpretation panel close to the structure.
2023-2024		
Priority	**Action or Repair No.**	**Summary description of action**
2	14	Provide occasional public viewings of the interior, perhaps on Heritage Open weekends or via online content.
2	7	Undertake a detailed concrete investigation including: hammer testing to check the bond of the render to the external surface; exploratory cutting out of concrete to measure the cover and check the continuity of the reinforcement; carbonation testing; chloride testing and sulphate testing.
2	8	Cut back and repair the cracking to the external render. If the render has debonded from the concrete locally cut out, clean off corrosion from Hy Rib and reinforcement, apply primer that improves bonding between the steel and concrete repair material and then repair material.
2	9	Clean off the external paint and apply an agreed coating. This should have a degree of elasticity (to bridge cracks in the render) and be breathable. An anti-carbonations coating may be required.

2	10	Gently clean all loose concrete and corrosion from dome intrados using agreed method; high level access and inspection will be required. The results of the concrete investigation may mean that more concrete, for example carbonated concrete, should be removed. Where significant loss of section has occurred patch repair of the concrete may be required with an appropriately specified material to match the existing concrete.
2	11	Install a cathodic protection system to protect the steel from further corrosion by installing a sacrificial anode and restoring the alkaline passive concrete around the steel. This will require a detailed concrete investigation and specialist advice so that an effective system is specified, in accordance with BS EN 1504 Products and Systems for the repair and protection of concrete structures and BS EN ISO 12696:2016 Cathodic protection of steel in concrete.

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10. APPENDIX 1 PLATES



Plate 1: The dome trainer's entrance, showing the later door rail. The camouflage paint was also a later addition



Plate 2: A segmental concrete gully skirts the perimeter of the structure



Plate 3: Rainwater gully cast in concrete over entrance



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Plate 19: Front and rear of two wooden blocks. The nails on the left block are for attaching the plasterboard. The right-hand block shows the 'staples' for attaching the block to the steel cable



Plate 20: Location of the partition wall, showing the remnant stub of box girder, steel plates and the limit of the wooden blocks (therefore also the extent of the plasterboard)



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Plate 30: The dome trainer from the south-east. The aircraft fuselage was cleared away by The Community Stadium Ltd in 2020.

11. APPENDIX 2 LEVEL 3 HISTORIC BUILDING SURVEY

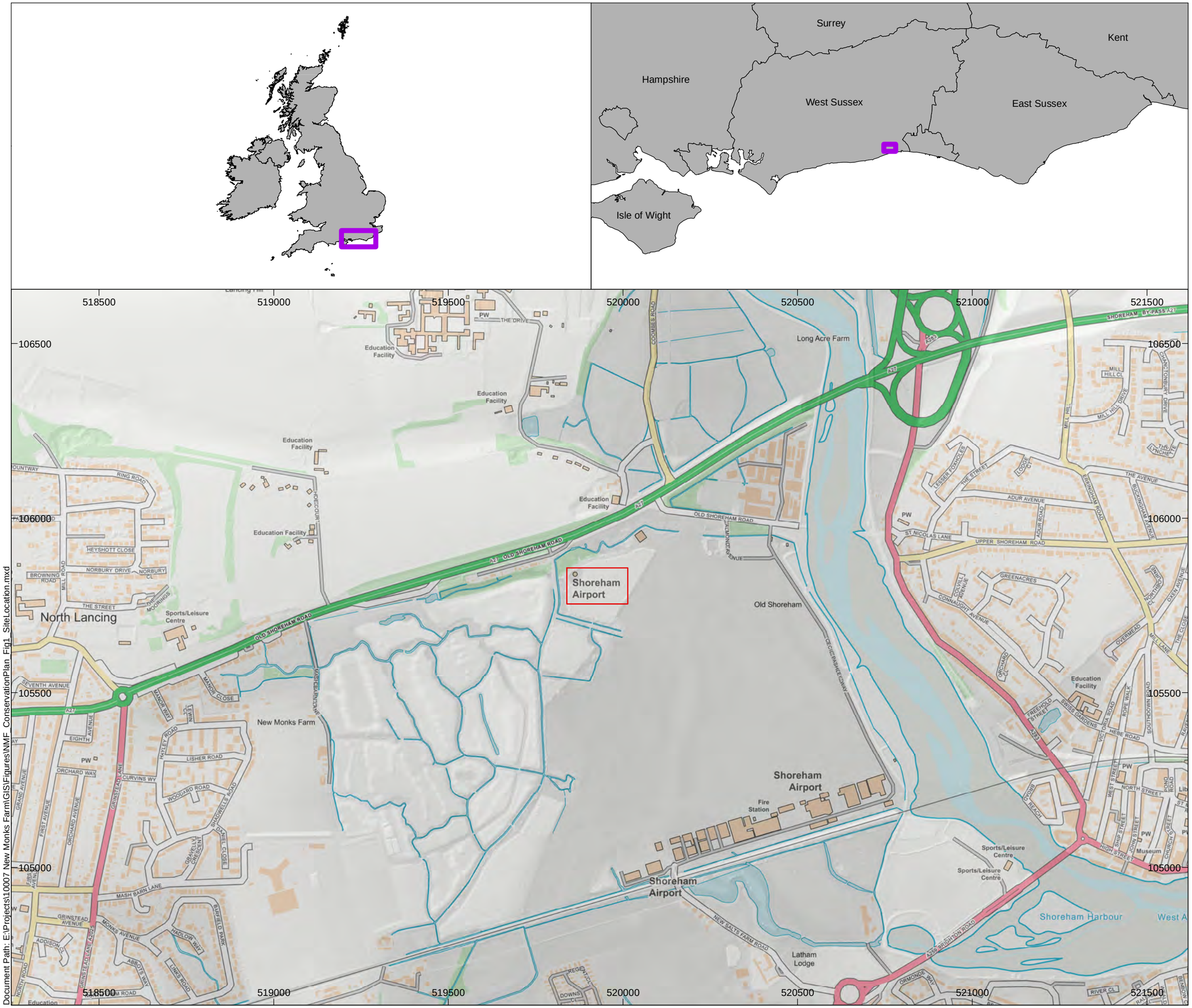

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Fig 1 Site location
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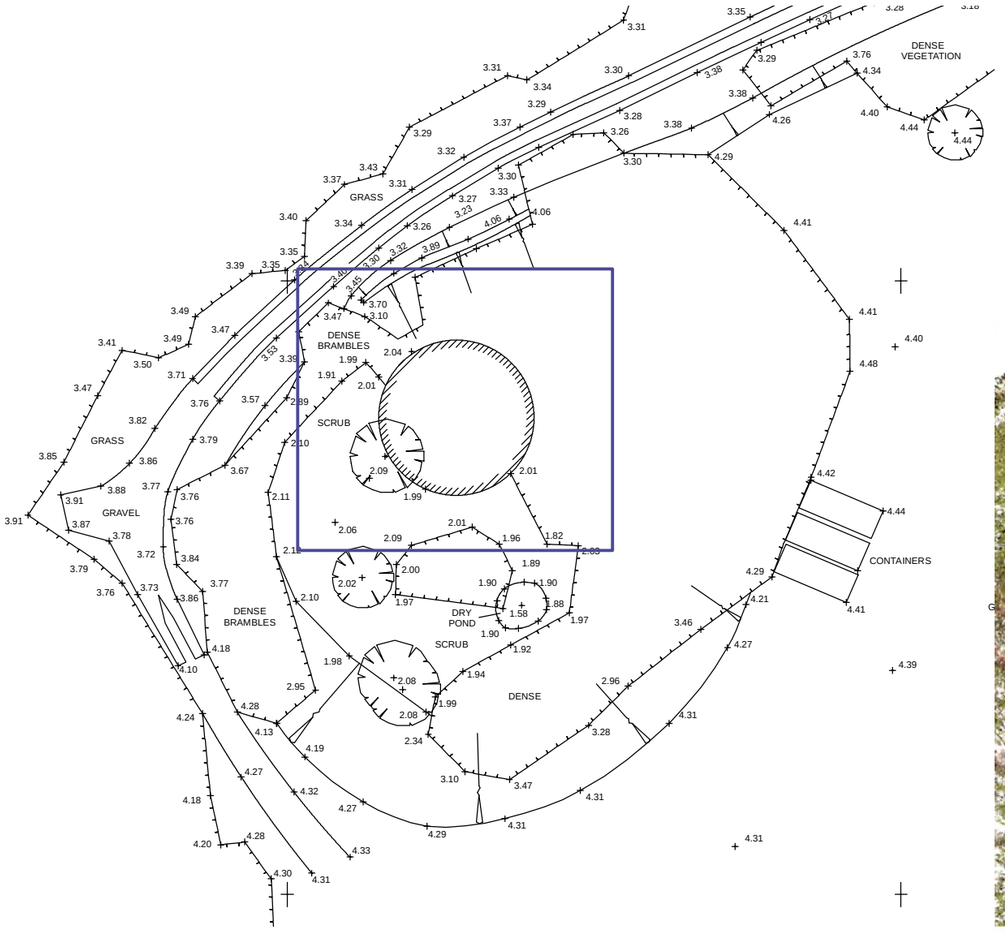

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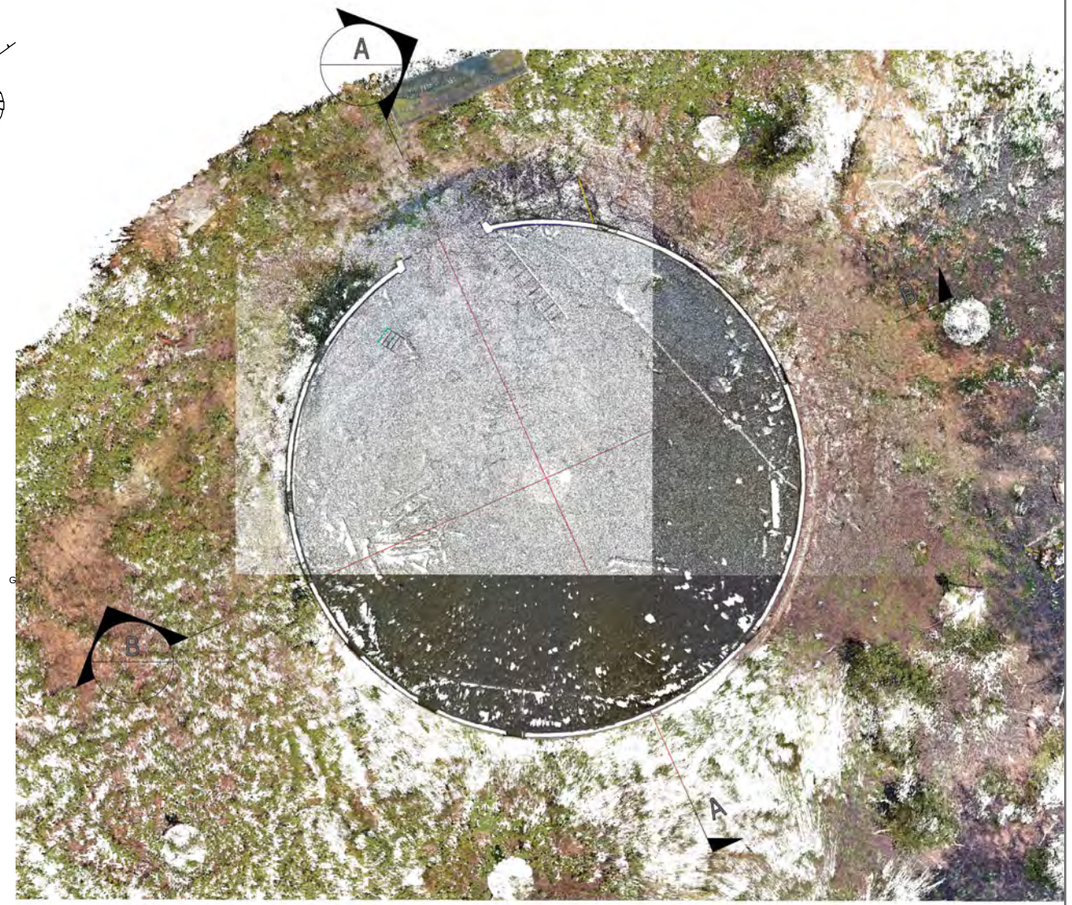

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Conservation Management Plan
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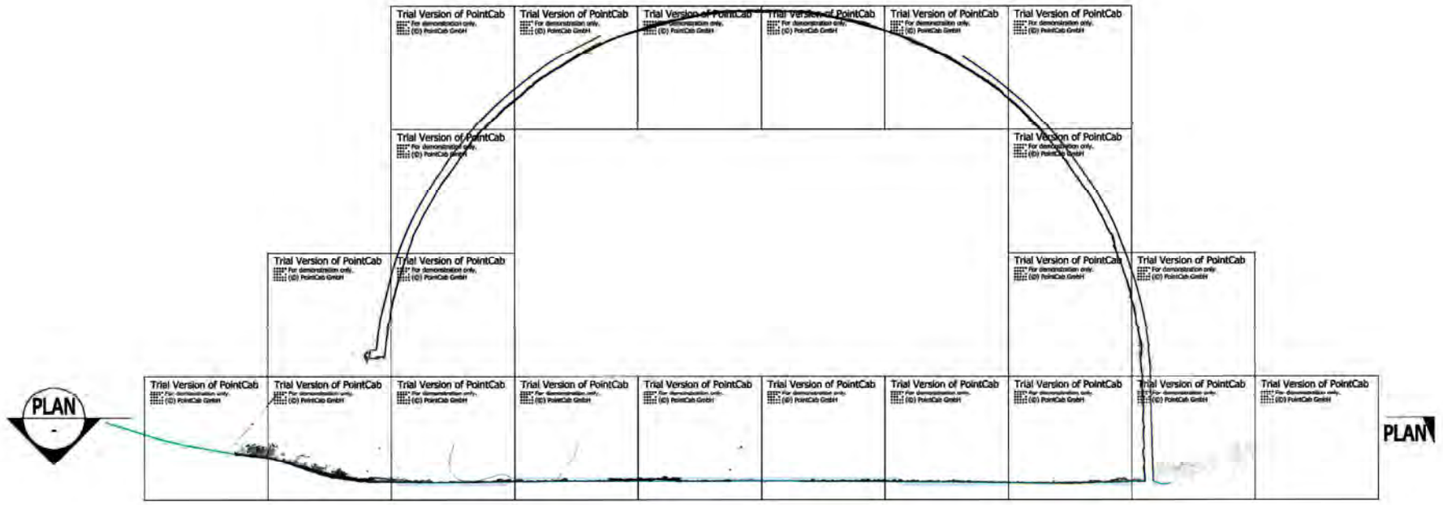

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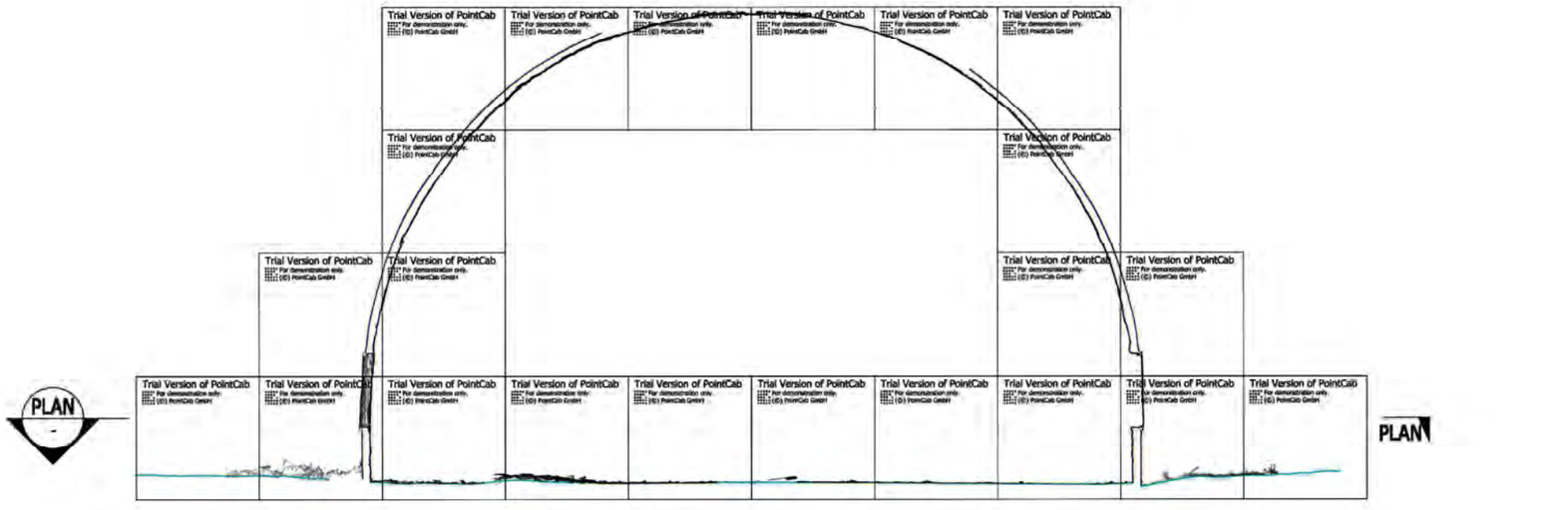

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11. APPENDIX 2 LEVEL 3 HISTORIC BUILDING SURVEY

Archaeology South-East

ASE

DOME TRAINER, NEW MONKS FARM, LANCING, WEST SUSSEX

Historic Buildings Record

NGR: 519863, 105838

Planning Refs: AWDM/0961/17

ASE Project No: 190585
Site Code: NMO18

ASE Report No: 2020157
OASIS id: archaeol6- 400557



By
Justin Russell

DOME TRAINER, NEW MONKS FARM
LANCING, WEST SUSSEX

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SUMMARY

In July 2020 Archaeology South-East carried out a historic buildings record (Historic England Level 3) of a Second World War dome trainer associated with Shoreham Airport prior to the redevelopment of New Monks Farm, Lancing, West Sussex (NGR: 519384 105392; Figures 1-2)*. The building, used for training in ground-based anti-aircraft fire, is a Scheduled Monument. The work was commissioned by PCA Heritage.*

Dome trainers were built as part of the emerging development of synthetic training, putting recruits through a realistic experience to encompass all forms of aerial attack, without the need for real weapons, ammunition or aircraft. Six of the recorded 44 dome trainers that were built survive to this day. The Shoreham dome trainer, built in 1943, has had many alterations made to it since its decommissioning and has suffered from many years of neglect, which has resulted in its current poor state of preservation.

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1.0 INTRODUCTION

1.1 In July 2020 Archaeology South-East carried out a historic buildings record (Historic England Level 3) of a Second World War dome trainer associated with Shoreham Airport prior to the redevelopment of New Monks Farm, Lancing, West Sussex (NGR: 519384 105392; Figures 1-2).

1.2 The work was commissioned by PCA Heritage, who prior to the redevelopment of the site consulted with Historic England and West Sussex County Council (WSCC), the archaeological advisors to Adur District Council (ADC). The archaeological consultation resulted in the following condition being recommended:

Within one calendar year from commencement of the development a written Conservation Management Plan for the Shoreham Airfield dome trainer shall be submitted to and approved in writing by the Local Planning Authority. Thereafter works shall be carried out in full accordance with the approved details.

2.0 SCOPE & METHODOLOGY

2.1 The recording involved the survey of the building to Level 3 as defined by Historic England (2016). The methodology follows that set out in the written scheme of investigation produced for the adjacent Archaeological Works Package 5 (ASE 2019).

2.2 A visit to the dome trainer (Heritage Asset 001 in the gazetteer of heritage assets included in the ES, with ES ref) was made by Justin Russell and Amy Williamson on 9th July 2020. A photographic record was made of the exterior and interior of the building and its immediate environs including general external and internal elevations, setting, surviving architectural detail, fixtures and fittings. An index of the digital photography, together with location plans are included as an appendix to this report.

2.3 The written description and photographic record is supplemented by a drawn record of the site. Plans and elevations of the site were produced from a laser scan by Ramboll, for use by ASE.

2.4 A number of adjacent Second World War structures (HA058, HA060, HA061, HA088) have been recorded as part of Archaeological Works Package 5 as defined by PCA Heritage. This work has been reported on separately.

3.0 SITE LOCATION

3.1 Shoreham Airfield is located on the West Sussex coastal plain (placed centrally between the towns of Brighton to the east and Worthing to the west), on the western edge of the River Adur (Fig. 1). The dome trainer lies in the north-western corner of the airfield, close to the A27 (TQ 19863,05838). The English Channel lies approximately 1.5km to the south and the South Downs lie approximately 1km to the north.

3.2 According to the British Geological Survey 1:50,000 scale geological mapping available online[1], the natural geology in the vicinity of the site comprises Raised Beach deposits tapering out to the east, over 4m to 10m of head over chalk.

4.0 STATUTORY DESIGNATIONS

4.1 The Shoreham Airfield dome trainer is a Scheduled Monument (List Entry Number: 1005818). Other nearby structures associated with the airfield are listed buildings, namely the Shoreham Airport terminal building (Grade II* listed) and adjoining municipal hangar (Grade II listed). Immediately north-east of the site is the Grade II* listed Old Shoreham Bridge, a footbridge which originally served as a toll bridge.

5.0 HISTORIC BACKGROUND AND CARTOGRAPHIC EVIDENCE

5.1 The Brighton and Shoreham Aerodrome was officially opened in 1911, the land having been used for the two years prior to this as a site for aircraft development. In 1914 the airfield was requisitioned for the Royal Flying Corps and used for flying instruction but by 1920 was abandoned and returned to pasture.

5.2 Activity returned to the site from 1926 and in 1936 the Brighton, Hove and Worthing Municipal Airport was opened, with the (now iconic and Grade II* Listed) terminal building as its centrepiece.

5.3 The advent of the Second World War meant that once again Shoreham Airport was requisitioned for military use and in June 1940 it was reopened as an advanced airfield in the Kenley sector (Kenley Airfield, Surrey) of No 11 Group, Fighter Command. Advanced airfields, in this context, were used as emergency refuelling and arming sites for fighter squadrons that were engaged in operations. Throughout the war, Shoreham's ownership changed hands a number of times, and its roles included air-sea rescue, participation in the Dieppe Raid, as a base for the Free-French during D-Day and as an anti-aircraft training facility. The airfield boundary was enlarged in 1941 by expanding west and flattening the embankment on which the New Salts Farm Road had been located as well as the demolition of Lees Barn. In 1945 and 1946 the airfield became a satellite of RAF Nether Wallop (Hampshire) until being handed back to the Ministry of Civil Aviation in March of 1946.

5.4 Shoreham airfield had a number of light anti-aircraft positions built around its perimeter from 1940 (up to eight by 1941), as well as pillboxes, trenches and breastworks to counter land-based attack. The light anti-aircraft positions in 1941 were intended to fire Lewis Guns (.303 calibre) in single, double or triple mounts, to combat low flying aircraft strafing or dive-bombing. Later on in the war, as supply became available, .30 calibre Brownings and 40mm Bofors Guns arrived at the airfield. Large calibre anti-aircraft weapons (3.7" and 4.5") were suited to combat aircraft at high altitude and were not stationed at airfields for defence.

5.5 Training in the techniques of light anti-aircraft fire began in a classroom, before moving out to a target practice area (generally looking out over the sea) where the personnel could fire at a target towed by a Lysander (using light or medium machine guns). Though a useful introduction, this did not incorporate any of the high speed manoeuvres that might be employed by the Luftwaffe in a real attack, such as dive

bombing or attacks by multiple aircraft. A practical solution, which involved a significant level of realism, was needed before the transition to a genuine ground defence role could take place. The recruits needed to acclimatise themselves not only to the brevity of an attack (30 seconds was an approximate maximum duration) but also to the psychological effects, so that they might be fully mentally prepared in battle. That solution came in the form of the dome trainer.

5.6 Wooden domes were in use from 1926 using lamps projecting images of handheld aircraft, but it was Henry Stephens who came up with an idea which was developed extensively from 1939 (Francis, 1996). Two main types of dome were introduced: the Apparatus, Dome, A.A. Training, No. 1, Mk. 1 with a 20ft radius and the Apparatus, Dome, A.A. Training, No. 2, Mk. 1 and No. 3 Mk. 1, each with 10ft radii. The difference between the No. 2 and No. 3 being that the latter was designed for tropical climates (War Office, 1944). The basic concept involved a film projector throwing footage of aircraft onto a mirror, which could be manoeuvred to reflect the aircraft onto the ceiling of the dome. A dummy gun (the 'sighting unit') and operator could then follow the image and practice taking aim and shooting. With aircraft speeds in excess of 300mph, aiming and shooting at the aircraft itself, in a real attack, would have meant the projectiles would arrive in the space the aircraft had previously occupied and do no damage. The dome trainer taught gunners to predict the flight path of an aircraft and to aim in front of it (to 'aim off'), so that projectile and aircraft arrive at the same location simultaneously. To achieve this as a practical exercise, the film footage was manually marked with a yellow dot, frame by frame, the dot representing the aircraft's future position. The sighting unit shone a graticule (cross hair and concentric circle aiming mark) onto the dome ceiling to show where the gun was pointing and when the two coincided a 'hit' was recorded. When gunners had practised this initial version of the simulation, they could then don yellow coloured glass spectacles, rendering the yellow dot invisible to them, and practise hitting the aircraft without any aid.

5.7 All the footage shown in the dome (there were 14 films referenced in the 1944 training manual, each comprising two attacks) was made using models and stop frame animation by Technicolour. Recordings of aircraft engines in flight were played through speakers and the dummy weapon featured a representative gun noise amplifier. To power all of this, an external electricity supply was fed into the dome via an earthenware pipe, beneath the floor at the entrance and distributed to the various pieces of equipment. A large partition wall cut off approximately one quarter of the dome interior to provide two extra rooms. These rooms, accessible from the entrance lobby were the ventilating plant room and the cloak room.

5.8 The ventilating plant was necessary to extract air out of the main room (the arc lamps used for illumination produced a significant amount of heat) via two fans set in the partition wall, while fresh air could freely enter through other vents. The partition wall was fitted with acoustically treated soundproofing quilts (Cabot's Quilt) to deaden the impressive echo that was generated by the domed roof when all loudspeakers were in operation.

5.9 Construction of dome trainers involved the prefabrication of the steel framework by the Trussed Concrete Steel Co (a US based company with a facility in South Kensington), in their factory, before being shipped to, and assembled, on site. A steel mesh called Hy-Rib, a commercial product of the Trussed Concrete Steel Co., was then fixed to the frame, on internal and external surfaces (Air Ministry 73/42). The thin lath mesh, which came in strips that were ribbed to provide strength, could be rolled to accommodate curved surfaces and would retain the concrete when

poured. The external Hy-Rib extended only up to 2.74m (9ft) on the outer frame, above which the concrete would be kept in place by gravity. After the concrete had cured, the entire external surface was cement rendered. The interior was covered in pre-formed fibrous plaster sheets, to create a regular and smooth surface, with a void between the plaster and the concrete. The interface between the floor and walls were then fitted with coving of the same material and vents in the coving allowed air to circulate behind the plaster boards. The internal partition wall did not have the fibrous plaster board as per the dome interior surface, merely a 'wire mesh' on which the quilts were attached, to form the finished coating.

5.10 Attempts were made to simplify the manufacturing process of dome trainers and in 1942 Charles Bell undertook tests to see if concrete could be poured over inflatable balloons, thereby removing the complicated steel framework. During the initial stages it became clear that the balloon alone might be used, alleviating the necessity of the permanent and costly concrete dome. Thereafter, the Portobell dome became the dome trainer of choice until the war ended, although it seems domes of wood or concrete were still constructed in theatres of war up until 1945. Approximately 44 concrete domes were built during the war in the UK, of which there are 6 surviving.

5.11 In 1942 construction began on the Shoreham dome trainer (officially an 'Apparatus, Dome, A.A. Training, No. 1, Mk. 1'), located in the north-west corner of the airfield, close to the Old Shoreham Road/A27. A photograph from 15th October 1942 (GX 11990 SG0047) though not showing the dome, does appear to show signs that the ground is being prepared and a track leading from the site to the south-east is visible, intersecting with the truncated New Salts Farm Road. The accommodation huts to the west of the dome trainer first appear on aerial photographs from November 1941 (S653 H9 1407/11/41), but most likely were built in late 1940 along with the pillbox guarding the northern airfield entrance. Two over blister hangers to the east were constructed between November 1941 and February 1942 (Fig. 2). Aerial photographs of the site in from 16th March 1943 (GX12066 SD0049) show an unfinished dome with the track very much in use and by 20th May 1943 (GX11971 SG0277) the dome looks externally complete.

5.12 An entry in the RAF file from 12/5/1943 (Shoreham Airport Archive) states 'No 7 AA Practice camp almost complete first course on twin Brownings commenced today with approx. 100 trainees. Dome trainer steadily advanced and hopes to complete near future'. The trainees would have been practising using the towed target attached to a Lysander, in preparation for progression to the dome, once it was complete. They were most likely accommodated or at least given instruction in the huts to the west of the site. After the war the dome was used as a training hall for 1440 Air Training Corps (ACTA, 2016), followed as a storage facility for the Miles Aircraft Company who are likely to have made a number of alterations to the structure. The Scheduled Monument listing refers to a fire within the structure in 1980 and a subsequent restoration effort in 1995.

5.13 In 2001 a helicopter landing area was constructed 50m to the immediate south of the dome, requiring raising of the ground level by 2m (Fig. 3). The dome was left in a pocket of land at the original construction level, while everything surrounding it was raised, with the result that the dome sits in an artificial hollow.

6.0 DESCRIPTION OF THE BUILDING

6.1 A cylindrical wall forms the basis of the dome structure, externally 12.65m (41.5ft) wide, rising to a height of 1.6m (approximately 5ft) and thereafter the dome roof begins (Fig. 4, Plates 1-4). The elevation in height to the start of the dome curve is to place the mirror and gunners (using the sighting equipment) at the base of the curved ceiling, thus giving a more realistic 'sky' surface for the film image to be reflected onto. The apex of the dome rises to 7.74m from the floor level. While footings for the structure were not visible, the Air Ministry drawing (Fig. 6) indicates the depth of concrete beneath the walls is 300mm (12"), while the main floor has 101mm (4") of concrete with another 101mm (4") of hardcore beneath that. Cement render is present over the entire dome exterior (giving a total wall thickness of just 130mm), though some notable cracks are present.

6.2 Surrounding most of the structure is a rainwater gully, 0.88m in width at ground level, currently choked with vegetation (Plate 5). The extensive surface area of the dome would catch significant amount of rainwater so the gully provided effective dispersion of this and two vertical pipes (not visible in the survey but marked on the Air Ministry plans) transferred water to a sump or into the nearby ditch and stream. The gully terminates at either side of the entrance (Plates 6 and 7), although the projecting concrete door frame has a rainwater lip on its top edge, thereby allowing water to flow down the sides of the entrance, into the ground gully (Plate 8).

6.3 The entrance itself is a square opening 2.1m wide and 2.07m high, originally housing a recessed double door. The width of the door is the only noticeable divergence with the original Air Ministry plan (Fig. 6), which gives a width of 4.6 feet (1.4m). A concrete ramp leads up to the entrance although two-thirds of this is now covered with a thick bituminous substance (Plate 1). This is possibly the remains of original roof covering, which consisted of a bituminous emulsion followed by a coat of hot bitumen, into which camouflage material (chopped heather or stone chipping were suggested) is pressed. The fire in the 1980s may have heated the bitumen and caused it to liquefy, run off the roof and solidify here. The original recessed doors have been replaced by a heavy duty sliding external door mechanism. Though the door is no longer present, there remain two rails to guide it, at the top and base of the entrance (Plate 1). The lower of these was inserted into a slot, cut for the purpose, in the ramp. The lower rail continuing to the east of the entrance, also truncates the rainwater gully terminus on that side.

6.4 Further modifications to the structure involve the addition of nine steel shuttered windows 1.25m tall and 0.56m wide, added at irregular intervals around the circumference, all approximately 0.9m from the ground (Plates 1-4). As built, the dome had only one entrance, one small ventilation hole 2.8m up on the roof (Plate 4) and a 0.54m by 0.29m rectangular slot in the western side serving as an exhaust pipe for the ventilating plant (Plate 9). The latter of these has been bricked up, post decommissioning. Two small steel hooks and a connection point, possibly for a telephone connection are visible on the western roof (Plate 10), though whether these date from the original construction is not clear. There is no sign of the external power supply or the earthenware pipe in which it was laid, near the entrance.

6.5 The entrance to the dome is constructed of a concrete frame covered with a cement render and sits within the maximum space available between two of the radial box girders – whether there is a pre-cast lintel or if the concrete was entirely formed in situ is unclear. The cement render is spread around the concrete frame, over the Hy-Rib and up to walls and a ceiling no longer present, indicating the ceiling level of

the small lobby (Plate 11). The lobby as indicated on the Air Ministry plan consisted of a breeze block wall with a timber joist ceiling.

6.6 The interior of the dome has been gutted with the removal of all original fittings, including the steel frame partition wall, which opens up the entire dome as a single room 12.38m wide (approximately 40ft) (Plates 12-15). The plasterboard, which was fitted to the dome ceiling and walls, has been removed in its entirety, exposing the Hy-Rib mesh and, in a number of places where the mesh has rusted and failed, the steel construction behind it. Sixteen steel radial box girders emanate from a crown ring, near the top of the dome (approximately 1.5m in diameter), providing the structural integrity of the dome (Plate 16). The radial box girders are square in plan, with four steel bars in each corner, running the full length of the girder. Connecting these together are steel bar laces, welded to each face of the girder, to provide internal reinforced bracing (Fig. 5).

6.7 The metalwork for the apex of the dome would appear somewhat superficial above the crown ring, formed only from Hy-Rib mesh to continue the curved shape. A further eight tiers of longitudinal rings of increasing diameter are placed at regular intervals beneath the crown ring and all of these are formed of box girder, bolted in sections to the radial girders (Plates 17 and 18). As the radial box girders reach ground level, they naturally become increasingly further apart and to mitigate interruption of the frame strength, intermediate reinforcing bars have been added between box girders, to join the second and fourth longitudinal rings and two bars to join the fourth ring to the footings at ground level (Plate 18). These bars were noted at the dome trainer at Langham Airfield in Norfolk to be made of two parallel bars welded to cross bars, forming a ladder-like construction (Morton Partnership Ltd, 1998 and 2005).

6.8 The Hy-Rib has been fixed longitudinally around the lower part of the dome, but after a height of approximately 2m, the curved sheets can no longer be laid in this fashion, due to the difficulties of coating a domed surface with a rectangular sheet. The method employed was to tilt the sheets at a 45 degree angle and line one third of the dome ceiling, with the opposite one third lined in a similar but opposite fashion. The remaining central section was lined with the sheets approximately aligned north to south (Plate 19).

6.9 Set within the wall and fixed to horizontal steel cables (fitted between the radial girders) are a large number of small wooden blocks, measuring 140mm by 150mm on the face exposed to the interior (Plates 20-22) . In plan, however, they are an isosceles trapezoid in shape, with the widest platform fitted to the steel frame. It would seem they were either fitted with staples or nails subsequently bent around the tensioned cables. The Hy-Rib mesh was applied with respect to their locations and the concrete, when poured firmly encased the blocks in place, due to their wedge-shaped nature. The first level of blocks starts at 0.9m from ground level and are approximately 1m apart, (although their placement is dependent on not being coincident with a radial box girder) and they continue upwards with eleven tiers in total, with a final block in the apex of the dome. There are 24 blocks on the lowest tier, between either end of the partition wall and sixteen in the highest (higher than the partition extends, so therefore forming a full circle), giving in excess of 200 blocks in total. The fibrous plaster board that covered the interior was nailed to these blocks and the 3” nails are still present, despite the absence of the plaster. There is not a single block fitted within the cloak room and plant room beyond the partition wall, confirming information on the Air Ministry plan that where plastering was not a necessary finish, the wall surfaces were left bare.

6.10 The partition wall appears to have been added after the completion of the main dome concrete formation but prior to the addition of plaster. A fragment of the partition remains, on the eastern side, a 200mm high truncated segment of box girder (Plates 23 and 24). The line of the partition is clearly visible continuing above the box girder fragment, over the ceiling of the dome (Plate 25) and down onto the western floor (Plate 15). Along this partition scar are a number of steel bolts and rectangular plates onto which the steel frame of the partition was attached (Plates 20 and 24). There are no visible scars in the floor along the line of the partition.

6.11 In the floor, though covered in silt from recent flooding episodes and coated in a thick paint, 14 post holes (120mm by 150mm) were visible, that supported the steel guard rail surrounding the technical equipment (Plates 26 and 27). A further post hole, located in the centre of the dome, measuring 101mm square (4”), took a timber post onto which the mirror arrangement was secured. Behind the mirror, the sighting unit, fitted with casters, could be wheeled into the guard rail area and then bolted into holes in the concrete floor. The rear guard rail featured a top bar that could be raised, allowing access for the other machinery, in the form of sighting units for alternate ‘weapons’ or a predictor unit. The nature of the current silt and paint across the floor surface meant it was not possible to locate these bolt holes. The service ducting, bringing electric cables to the equipment was covered by wooden planks and ran from the ventilating plant room (where there was probably a master switch and fuse set) underneath the technical equipment in a general southerly direction, with an eastern spur. The ducting retained either its wooden covering or had been filled with concrete to stabilise the floor – the covering of thick paint prevented full inspection of the duct, though its trace was visible (Plates 26 and 27).

6.12 The bricked up exhaust port is visible in the ventilating plant room, approximately 2.5m from the partition wall (Plate 28). The small ventilation hole high in the southern wall is visible internally and unobstructed (Plate 29). The nine windows cut into the wall are all bolted closed with steel shutters, with the exception of one shutter that has become unfastened (Plate 30).

7.0 DISCUSSION

7.1 Rigorous training is paramount for the efficient and successful application of military force in wartime and anti-aircraft defence is no exception to this, being at the front line in the early years of the war. The battle of Britain, Blitz and other air raids required significant amounts of man and woman power (the auxiliary Territorial Service playing a key role in A.A. strategy) to form an effective defence. The high importance for the need to mitigate against air attack led to anti-aircraft positions being built before the war began, well before any of the more common anti-invasion defences (pillboxes, anti-tank blocks etc) were constructed. The investment put into inventing, creating and developing the dome trainer is integral to this thought process. The Langham dome trainer archive material suggests that a staggering 1.5 million people, of many nationalities, were trained in domes of various types throughout the course of the war and in numerous countries. It is likely that many of the domes used in other countries were of Plywood construction or the Portobell type.

7.2 Dome trainers are rare buildings, six remaining in the UK of the estimated 44 that were originally built. The other five examples are located at:

- Langham, Norfolk
- Limivady, County Londonderry
- Mildenhall, Suffolk
- Pembrey, Carmarthenshire
- Wyton, Cambridgeshire

7.3 Their concept and design based on synthetic training pre-empts much of the modern industry of virtual reality by decades and the use of domes in military training is ongoing, albeit in a different form. Despite its relatively short period of use, its place in the history of the Second World War and the technological revolution in the second half of the 20th century that followed in its wake, is assured.

8.0 DEPOSITION OF THE ARCHIVE

8.1 The project archive will be deposited with Worthing Museum under the site code NMO18. The archive will comprise all survey material collected and produced in undertaking the project.

9.0 ACKNOWLEDGEMENTS

Archaeology South-East would like to thank PCA Heritage for commissioning the work and Ramboll for providing the laser scan outlines for the dome. We would also like to thank Mackley for providing access and welfare while on the site. Special thanks go to Patrick Allen, Chairman of the Friends of Langham Dome, in Norfolk, who was extremely generous with information and supplied not only the Air Ministry plan but many other unique documents relating to dome use and conservation.

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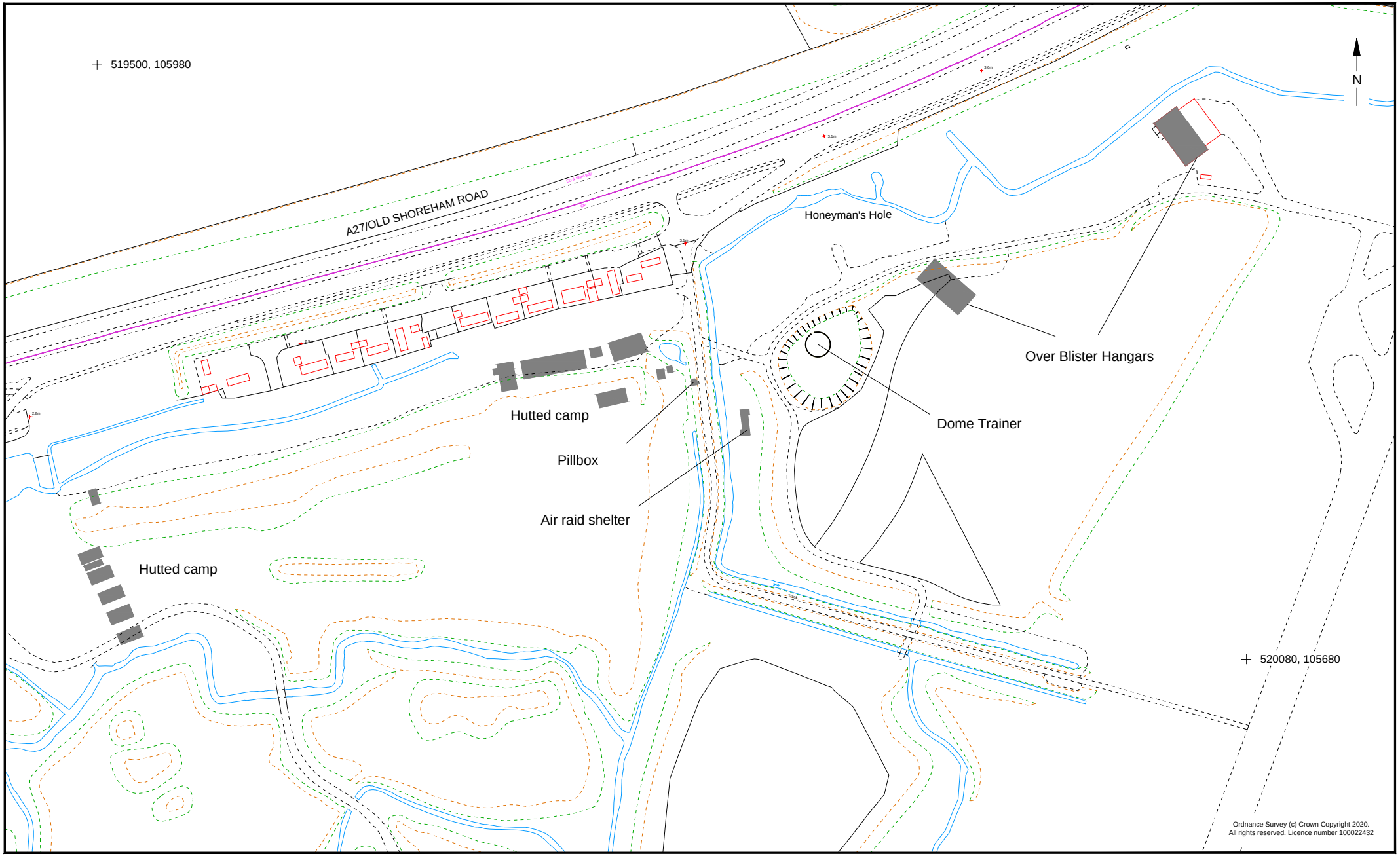
National Collection of Aerial Photography

NCAP GX 11990 SG0047
NCAP S653 H9 1407/11/41
NCAP GX12066 SD0049
NCAP GX11971 SG0277

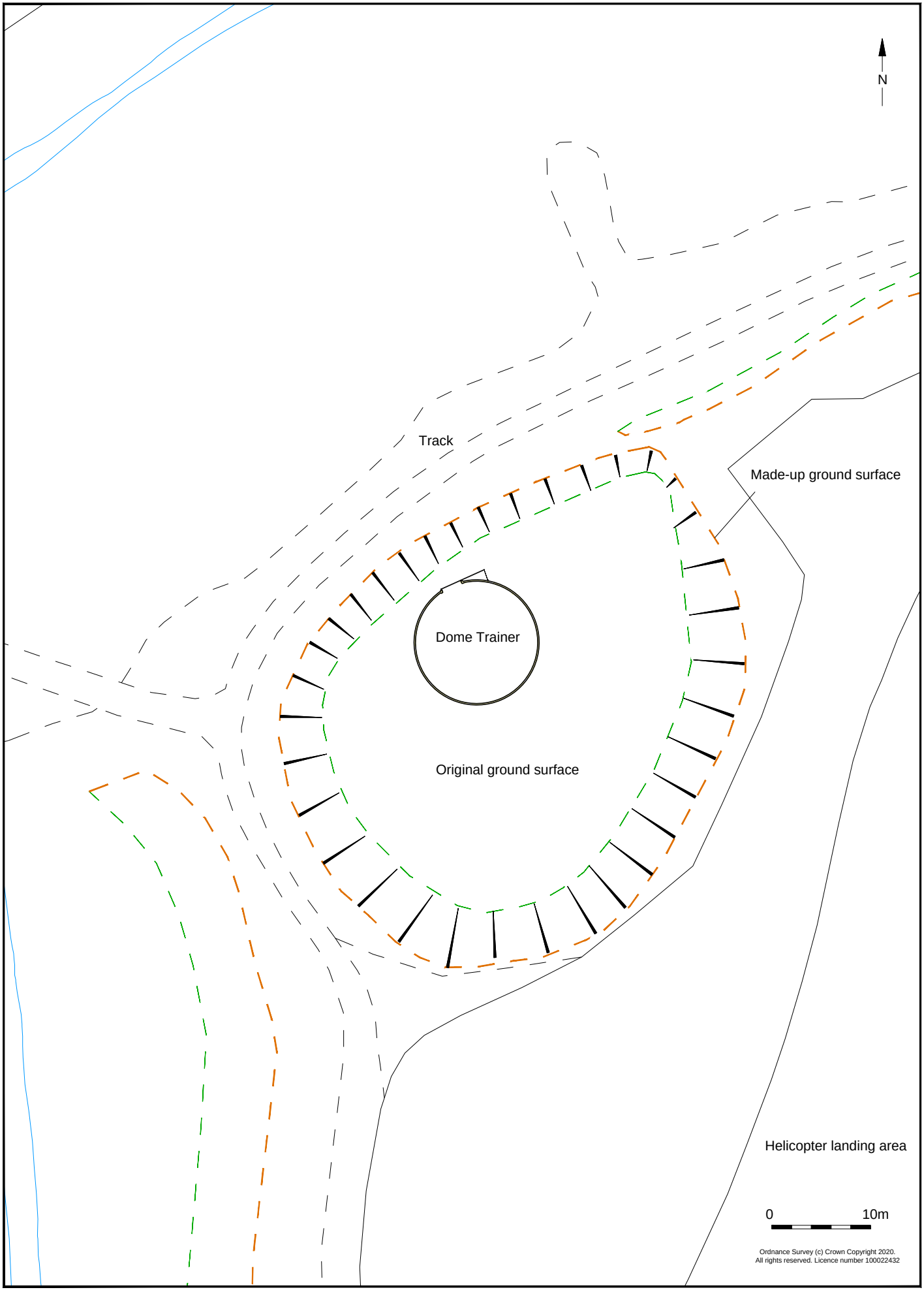
Shoreham Airport Archive
RAF Regiment Gunnery Training School file



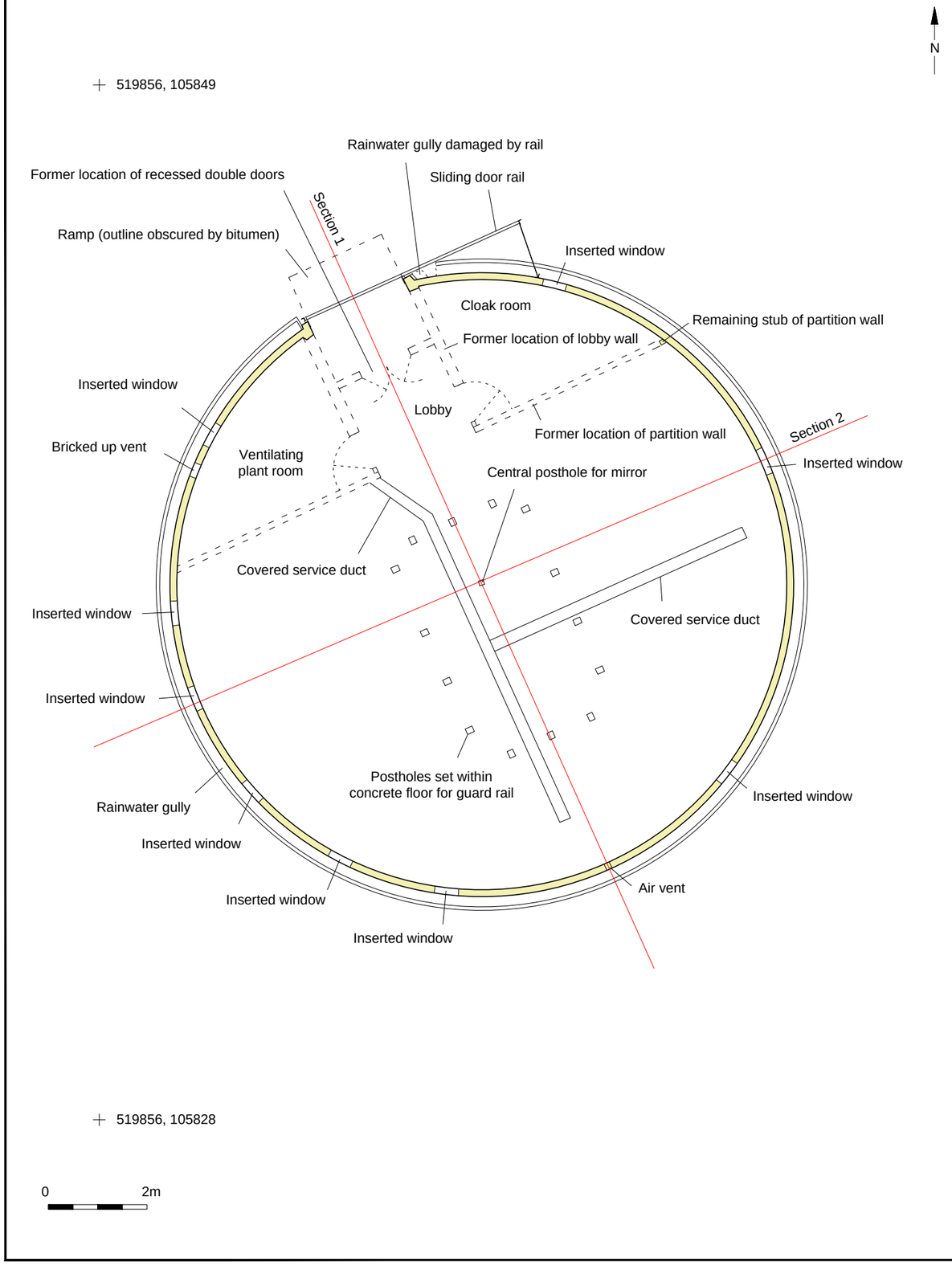
© **Archaeology South-East**		Dome Trainer, New Monks Farm, Lancing	Fig. 1
Project Ref: 190585	July 2020	Site location	
Report Ref: 2020157	Drawn by: JR		

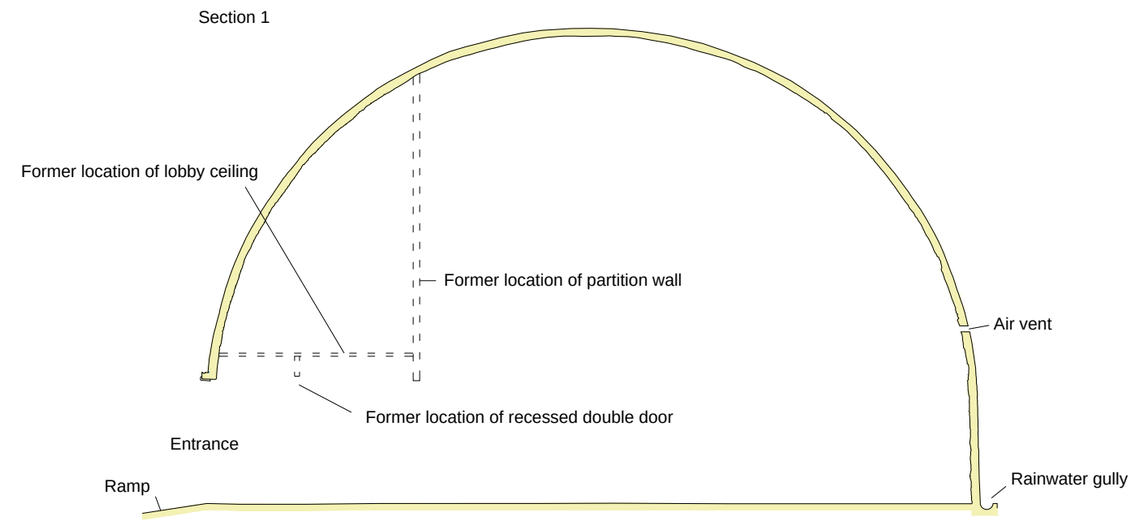


© **Archaeology South-East**		Dome Trainer, New Monks Farm, Lancing	Fig. 2
Project Ref: 190585	July 2020	Dome Trainer and associated buildings (from RAF 3G TUD UK 15960 5048 1946)	
Report Ref: 2020157	Drawn by: JR		



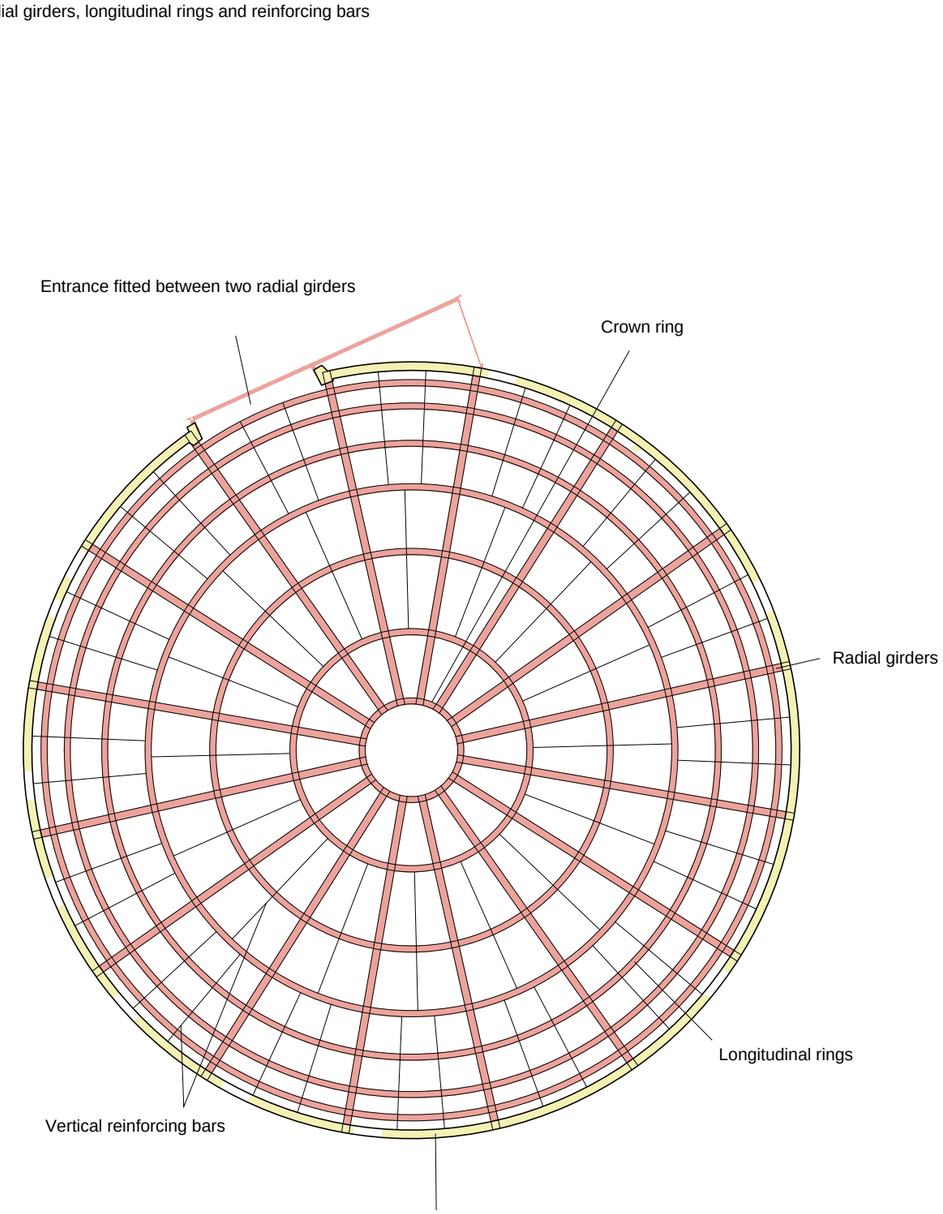
© **Archaeology South-East**		Dome Trainer, New Monks Farm, Lancing	Fig. 3
Project Ref: 190585	July 2020	Detailed site location	
Report Ref: 2020157	Drawn by: JR		



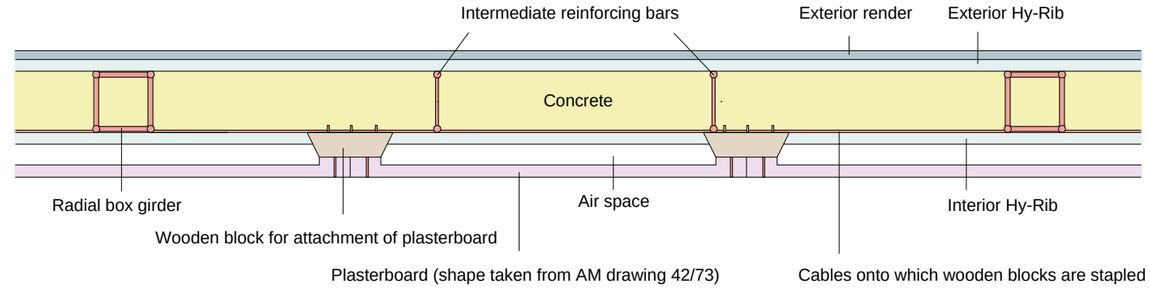


© Archaeology South-East		Dome Trainer, New Monks Farm, Lancing	Fig. 4
Project Ref: 190585	July 2020	Plan and sections	
Report Ref: 2020157	Drawn by: JR		

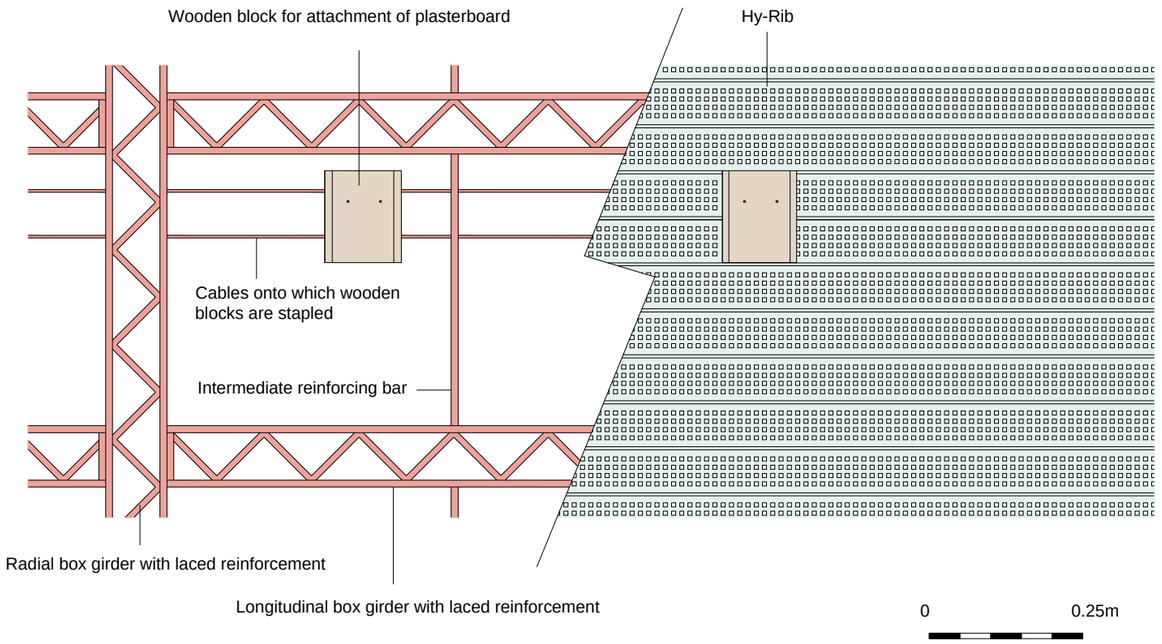
Plan showing radial girders, longitudinal rings and reinforcing bars

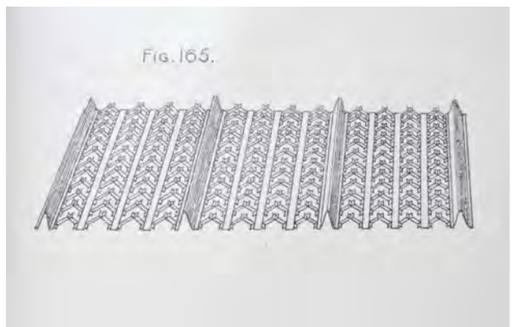


Schematic plan through section of dome wall (not accounting for curve of dome wall)



Schematic elevation of dome wall construction (not showing plasterboard)





An example of Hy-Rib (a slightly different pattern) from the 1922 Notes on Cement and Concrete: Reinforced Concrete

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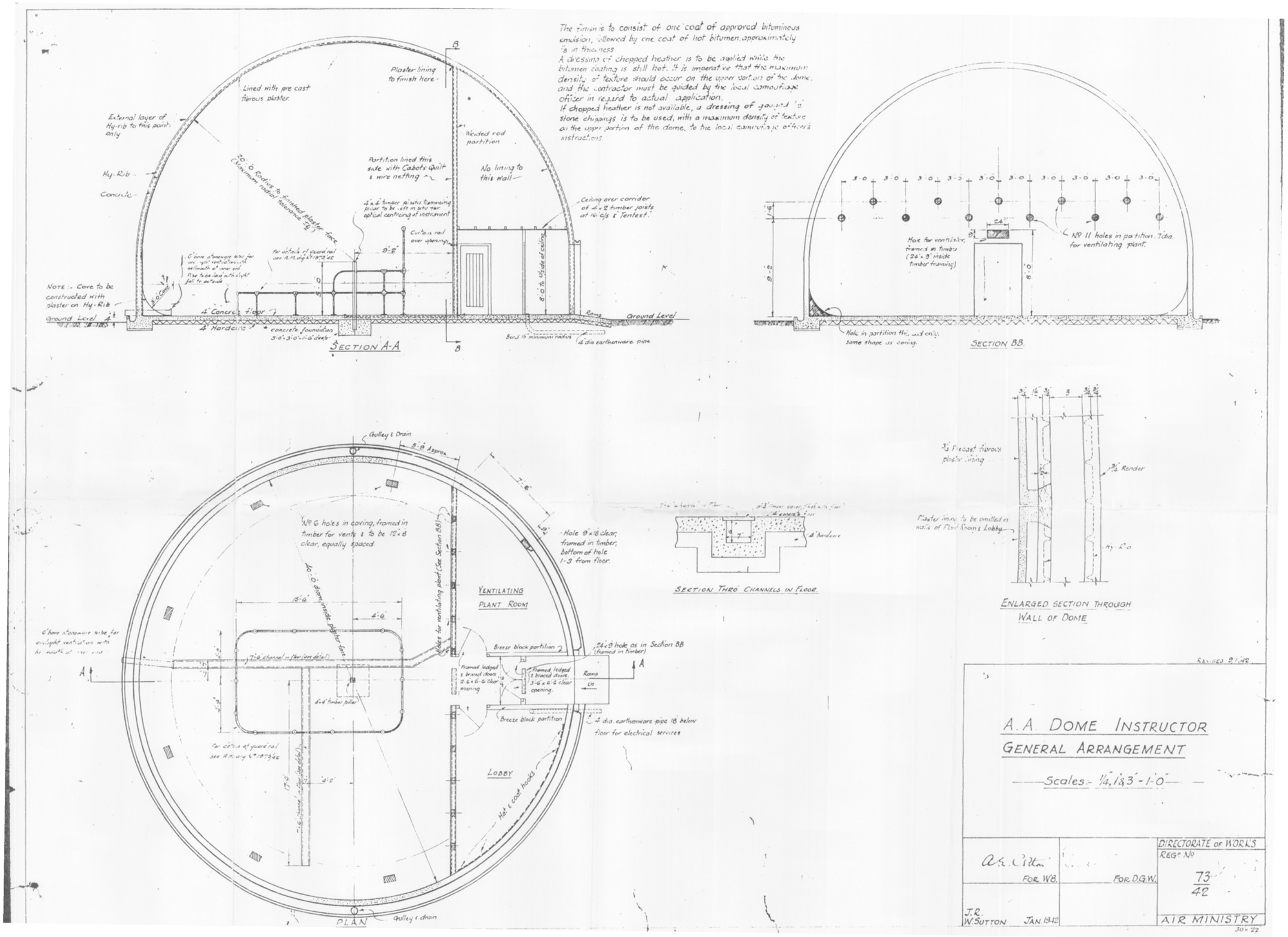
Project Ref: 190585	July 2020
Report Ref: 2020157	Drawn by: JR

Dome Trainer, New Monks Farm, Lancing

Construction plans and elevation

Fig. 5



© Archaeology South-East		Dome Trainer, New Monks Farm, Lancing	Fig. 6
Project Ref: 190585	July 2020	Air Ministry plan 73/42 A.A. Dome Instructor General Arrangement	
Report Ref: 2020157	Drawn by: JR		

Plates



Plate 1: Entrance to dome trainer, looking south-east, showing later sliding door mechanism and ramp where exposed (NMO18-0429)



Plate 2: Dome trainer looking east, showing inserted windows and steel shutters (NMO18-430).



Plate 3: Dome trainer, looking north-east (NMO18-0431)



Plate 4: Dome trainer, looking north-west, showing ventilation hole (NMO18-0436)



Plate 5: Rainwater gully, on the western side, excavated (NMO18-0442)



Plate 6: Rainwater gully terminus, western side of entrance (NMO18-0426)



Plate 7: Rainwater gully terminus, eastern side of entrance, truncated by sliding door rail (NMO18-0427)



Plate 8: Rainwater gully cast in concrete over entrance (NMO18-0440)



Plate 9: Inserted window and bricked up port for ventilating plant (NMO18-0433)



Plate 10: Telephone connection point and securing hooks (NMO18-435)



Plate 11: Entrance from the interior, showing the render extending up to the original timber ceiling (NMO18-0425)



Plate 12: Dome interior, looking north-west to entrance (NM18-0406)



Plate 13: Dome interior, looking north-east (NMO18-0403)



Plate 14: Dome interior, looking south-east (NMO18-0409)



Plate 15: Dome interior, looking south-west (NMO18-0407)



Plate 16: Dome ceiling, showing crown ring and sixteen radial box girders, interspersed reinforcing bars from the second longitudinal ring (NMO18-0410)



Plate 17: Longitudinal box girder detail, above an inserted window (NMO18-0423)



Plate 18: Radial box girders (vertical), interspersed with two reinforcing bars (vertical) and longitudinal box girders (horizontal) (NMO18-0412)



Plate 19: Formation of Hy-Rib to compensate for the curve of the domed roof (NMO18-0404)



Plate 20: In-situ wooden block for the securing of the plasterboard. Also shown is a steel plate for the partition wall (NMO18-0417)



Plate 21: Void for a former wooden block, shown the tensioned cables that the block was attached to (NMO18-0416)



Plate 22: Front and rear of two wooden blocks. The nails on the left block are for attaching the plasterboard. The right hand block shows the 'staples' for attaching the block to the steel cable (NMO18-0441)



Plate 23: Location of the partition wall, showing the remnant stub of box girder, steel plates and the limit of the wooden blocks (therefore also the extent of the plasterboard) (NMO18-0413)



Plate 24: Detail of the partition wall box girder stub and a steel plate (NMO18-0414)



Plate 25: The line of the former partition, arching over the ceiling (NMO18-0408)



Plate 26: Post holes for the guard rail in the concrete floor, looking south-east. Also visible is the service duct, running from the wall of the dome, to the bottom of the picture, where it turns to the north-west (NMO18-0438)



Plate 27: Post holes for the guard rail in the concrete floor, looking south-east. Also visible is the service duct, running towards the entrance, before turning to the north-west (NMO18-0439)



Plate 28: Bricked up port for the ventilating plant (NMO18-0411)

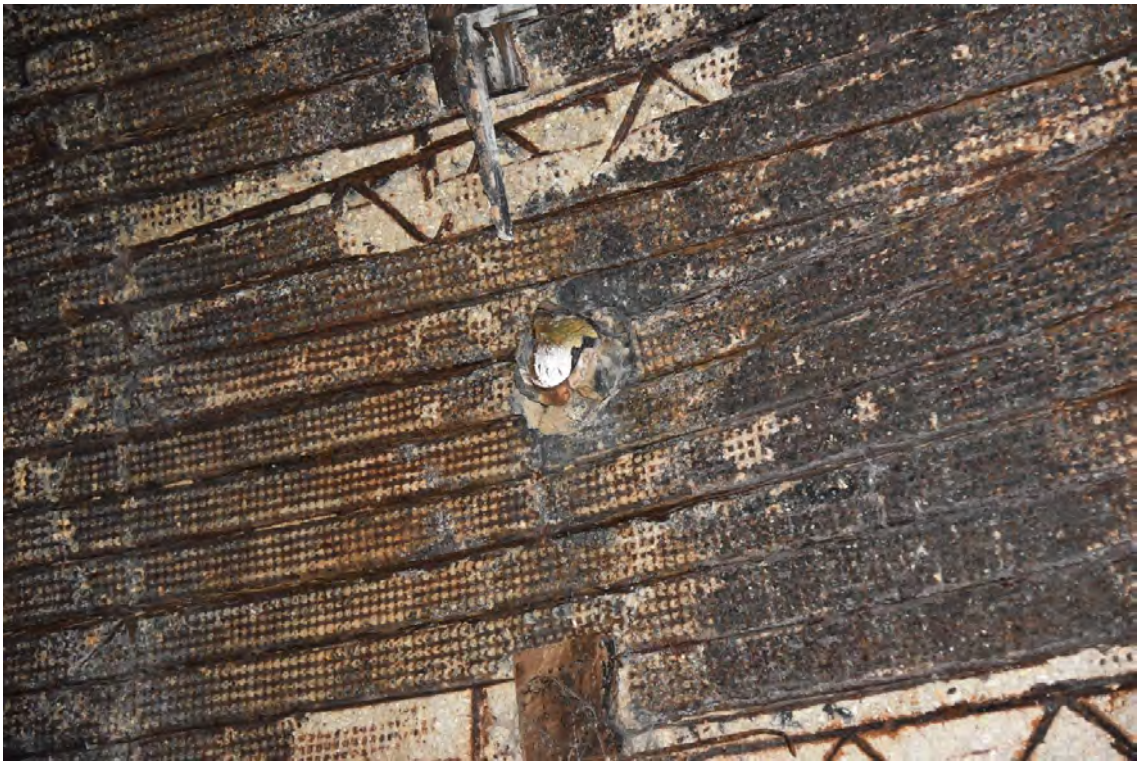


Plate 29: Air ventilation hole in the southern wall (NMO18-0421)



Plate 30: One of the inserted windows with partially open steel shutter (NMO18-419)

Appendix 1: Oasis Form

OASIS ID: archaeol6-400557

Project details

Project name	DOME TRAINER, NEW MONKS FARM, LANCING, WEST SUSSEX ARCHAEOLOGICAL WORKS PACKAGE 5
Short description of the project	In July 202 Archaeology South-East carried out an Historic Building Record of a Dome Trainer on Shoreham Airfield, West Sussex. Dome trainers were built as part of the emerging development of synthetic training, putting recruits through a realistic experience to encompass all forms of aerial attack, without the need for real weapons, ammunition or aircraft. Six of the recorded 44 that were built survive to this day. The Shoreham Dome Trainer, built in 1943 and has had numerous alterations made to it since being decommissioned. A full drawn and photographic record was made in July 2020. The work was commissioned by PCA Heritage.
Project dates	Start: 06-07-2020 End: 05-08-2020
Previous/future work	Yes / Yes
Any associated project reference codes	archaeol6- 384219 - OASIS form ID
Type of project	Building Recording
Site status	Scheduled Monument (SM)
Current Land use	Transport and Utilities 3 - Utilities
Monument type	DOME TRAINER Modern
Methods & techniques	"Laser Scanning","Measured Survey","Photographic Survey","Survey/Recording Of Fabric/Structure"
Prompt	Scheduled Monument Consent

Project location

Country	England
Site location	WEST SUSSEX ADUR SHOREHAM BY SEA Shoreham Airfield
Postcode	BN15 0RT
Study area	133 Square metres
Site coordinates	TQ 519800 105449 50.873812225019 0.160354339515 50 52 25 N 000 09 37 E Point
Height OD / Depth	Min: 3.1m Max: 3.1m

Project creators

Name of Organisation	Archaeology South-East
Project brief originator	PCA Heritage
Project design originator	PCA HERITAGE

Project director/manager	Ron Humphrey
Project supervisor	Justin Russell
Type of sponsor/funding body	Client

Project archives

Physical Archive Exists?	No
Digital Archive recipient	West Sussex County Council
Digital Contents	"Survey"
Digital Media available	"Images raster / digital photography","Survey"
Paper Archive recipient	West Sussex County Council
Paper Contents	"Survey"
Paper Media available	"Drawing","Plan"

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	DOME TRAINER, NEW MONKS FARM, LANCING, WEST SUSSEX ARCHAEOLOGICAL WORKS PACKAGE 5
Author(s)/Editor(s)	Justin Russell
Date	2020
Issuer or publisher	Archaeology South-East
Place of issue or publication	Portslade
Description	A4 bound book and PDF

Entered by	Justin Russell (justin.russell@ucl.ac.uk)
Entered on	5 August 2020

OASIS:

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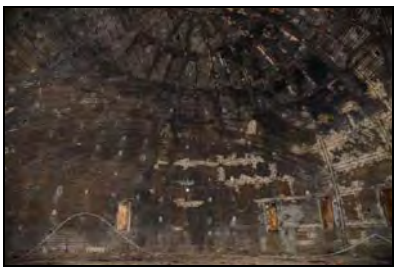
Appendix 2: Photographic record



NMO18-0398
Dome interior looking south-east



NMO18-0399
Dome ceiling, showing crown ring



NMO18-0400
Dome ceiling showing crown ring



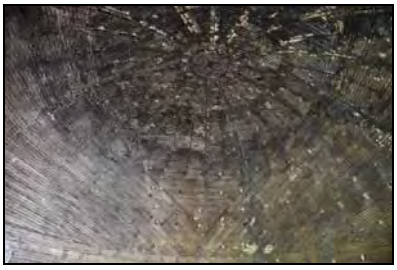
NMO18-0401
Dome interior looking north-east



NMO18-0402
Dome ceiling showing crown ring



NMO18-0403
Dome interior looking north-east



NMO18-0404
Dome ceiling showing Hy-Rib



NMO18-0405
Dome ceiling showing Hy-Rib



NMO18-0406
Dome interior looking north-west through entrance



NMO18-0407
Dome interior looking south-west



NMO18-0408
Dome ceiling showing partition mark



NMO18-0409
Dome interior looking south-east



NMO18-0410
Dome ceiling showing crown ring



NMO18-0411
Dome interior showing blocked ventilation port

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NMO18-0412
Dome interior looking west



NMO18-0413
Dome interior showing western end of partition



NMO18-0414
Dome interior showing partition stub



NMO18-0415
Dome interior showing wooden void for a wooden block



NMO18-0416
Dome interior showing void for a wooden block



NMO18-0417
Dome interior showing wooden block and partition plate



NMO18-0418
Dome interior showing box girder above inserted window



NMO18-0419
Dome interior showing inserted window



NMO18-0420
Dome interior showing section through wall cut by window



NMO18-0421
Dome interior showing ventilation pipe



NMO18-0422
Dome interior showing wall formation



NMO18-0423
Dome interior showing box girder above window



NMO18-0424
Dome interior showing longitudinal box girder



NMO18-0425
Dome interior showing entrance, looking north-west



NMO18-0426
Dome exterior, showing western rainwater gully terminus

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NMO18-0427
Dome exterior showing eastern rainwater gully terminus truncated by door mechanism



NMO18-0428
Dome exterior looking south



NMO18-0429
Dome exterior looking south-east



NMO18-0430
Dome exterior looking east



NMO18-0431
Dome exterior looking north-east



NMO18-0432
Dome exterior looking north



NMO18-0433
Dome exterior showing inserted window and shutter



NMO18-0434
Dome exterior showing rainwater gully



NMO18-0435
Dome exterior showing fitting to roof for telephone



NMO18-0436
Dome exterior looking north-west



NMO18-0437
Dome exterior showing window and shutter



NMO18-0438
Dome interior looking south-east showing postholes in floor



NMO18-0439
Dome interior looking north-west showing postholes in floor



NMO18-0440
Dome exterior showing rainwater gully above entrance



NMO18-0441
Wooden block fitting for plasterboard

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NMO18-0442
Dome exterior, rainwater gully

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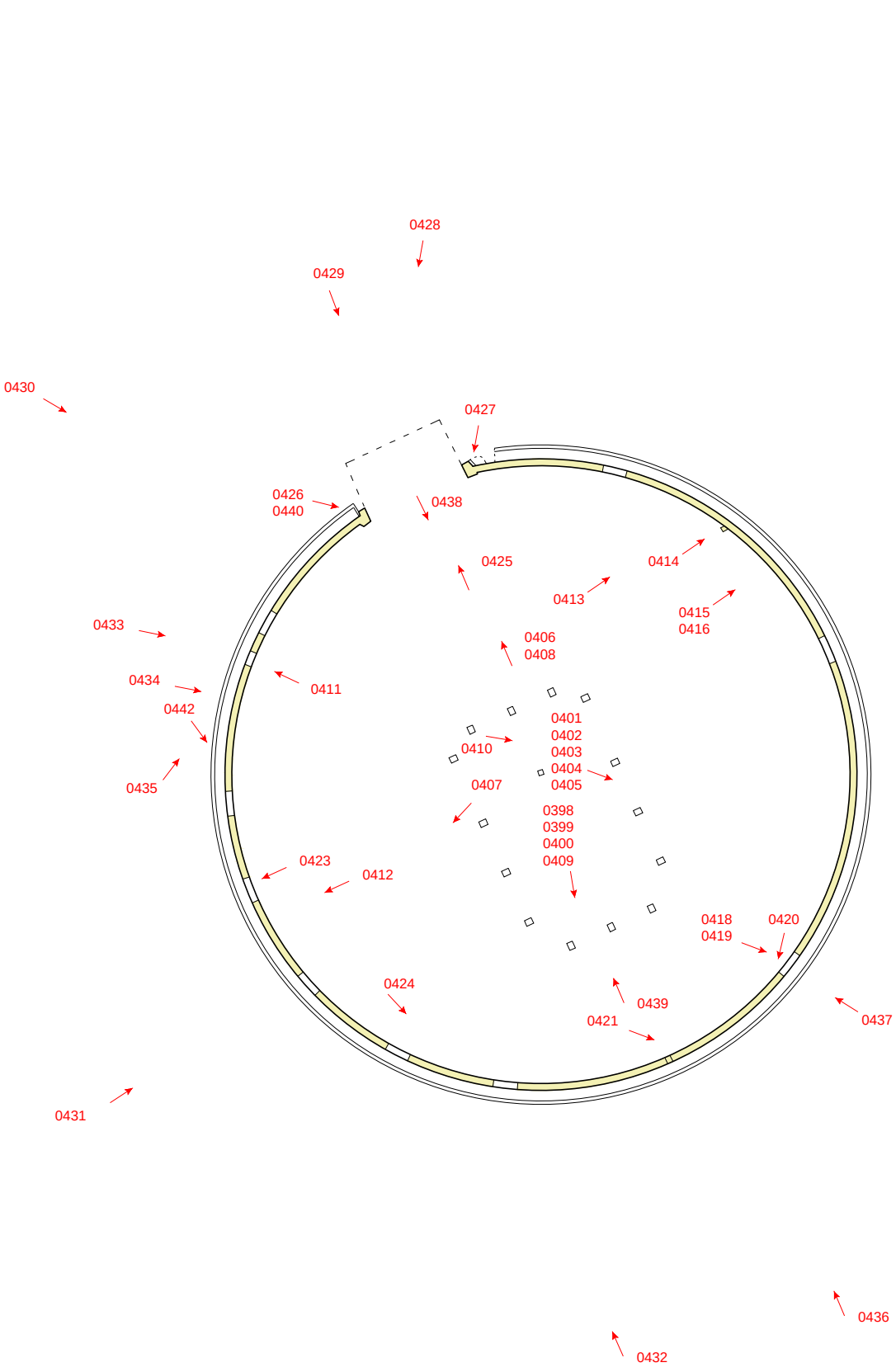

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