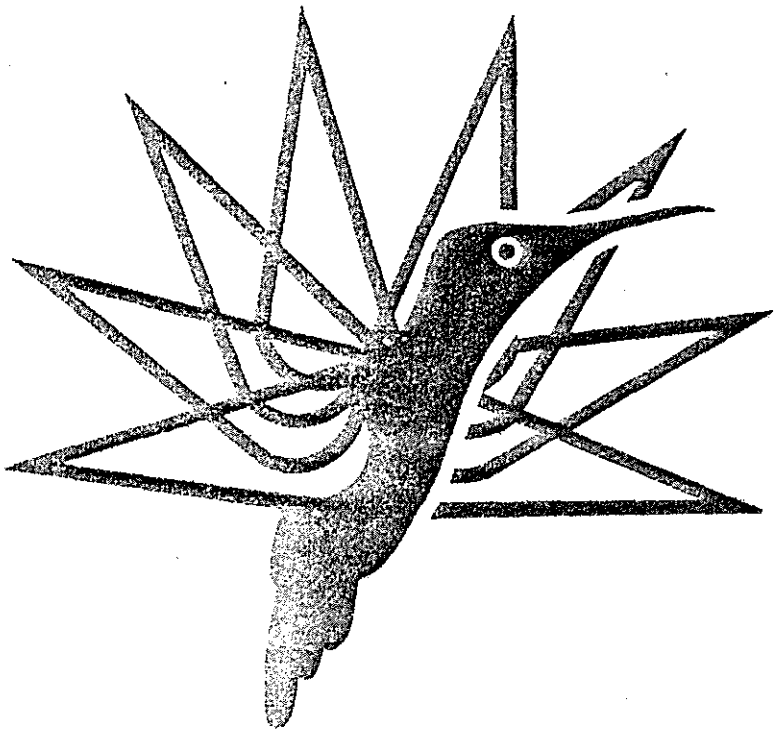

THE MADGE HELICOPTER APPROACH AID OPERATION ON MOBIL'S BERYL 'A' PLATFORM

by

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ABSTRACT

The MADGE helicopter approach aid is being purchased by Mobil for use at their Beryl 'A' Platform in the North Sea. Offset approach paths in both azimuth and elevation are employed to enhance safety and lower current operating limits at Beryl 'A'.

A U.K. C.A.A. programme is underway which has the aim of certificating MADGE to limits of 150 ft. amsl (or helipad height whichever is greater) minimum descent altitude and 300 metres decision range.

This paper outlines the flight trials by the Royal Aircraft Establishment which lead to the choice of offset approach paths, describes the system supplied to Mobil and Bristow Helicopters and gives the offshore flight trials programme leading to certification.

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Dr. R.W.G. Clarke - M.E.L.

1. Introduction

The MADGE* aircraft approach aid has recently been fitted to Mobil's Beryl 'A' Platform in the North Sea and application made to the United Kingdom Civil Aviation Authority for approach limits of 150 ft. (200 for Beryl 'A') minimum descent altitude and 300 metres RVR equivalent.

MADGE was originally designed to meet a NATO requirement for a tactical aircraft approach aid which can be carried by two men and set up in 15 minutes to give guidance to approach limits equivalent to ICAO Category II.

Technical descriptions of MADGE are readily available (see References 1 - 4).

For the purposes of this paper it is sufficient to know that MADGE operates in the microwave region and measures the precise position of an aircraft. This position together with the identity of the aircraft can be made available on the ground as well as in the aircraft over a horizontal sector of greater than 90^{o} and out to 30 nautical miles. This means that, by suitable computation on the ground or in the air, virtually any form of flight path can be provided.

The problem thus becomes the fascinating one of determining the ideal approach profile for a particular aircraft type and operation.

* MADGE is an acronym for Microwave Aircraft Digital Guidance Equipment.

One important standard feature of MADGE is that the guidance, displayed on a conventional ILS zero reader, is beam softened in the last mile to touchdown. This means the pilot receives guidance of a constant sensitivity right up close to the MADGE ground station. This is in contrast to ILS which provides guidance which becomes progressively more sensitive so that close to the ILS ground equipment, the guidance cannot be followed by the pilot.

This feature is vital offshore as the helicopter is to be guided to a position close to the ground station.

The offshore MADGE system is a modular extension of the tactical system and utilises standard MADGE airborne and ground equipment supplemented by special offshore platform computation monitoring and recording modules.

The MADGE offshore station consists of an Azimuth Interferometer Array, which measures the angle of azimuth of an aircraft, a Transponder Set which is the ground element of the data link, and Near Field Monitor Antennas, all mounted on a turntable assembly. This is sited so as to give a good line of site along the desired helicopter approach paths.

Associated with this and situated in any convenient place on the platform, is the MADGE Offshore Control Unit which comprises:-

Processor Offset Approach

Controller Turntable (Offshore)

Data Recorder Offshore

The aircraft equipment consists of a Transmitter Receiver, a Logic Unit, a Pilots Control Unit, two Microwave Antennas and associated pilot displays.

2. The Beryl 'A' Platform

Mobil's Beryl 'A' Platform is situated approximately 95 miles South East of Sumburgh Airport at the southern tip of the Shetland Islands and 210 miles North East of Aberdeen Airport, the two airports from which it is served by three Mobil dedicated S61N helicopters of the Bristow fleet.

The concrete platform is surmounted by a steel deck measuring 71 x 60 metres with the helipad on top at a height of 178 ft. amsl. There is a flare stack separated from the main platform by a 200 metre long walkway.

The platforms' design capacity is 300,000 barrels of oil per day. Oil is loaded into tankers via a single point loading buoy situated 1 nautical mile from the platform.

Mobil have recently announced their intention to build a second platform on the field. This platform, the Beryl 'B' will be about 5 miles to the North of Beryl 'A'.

The helipad has recently been extended to provide a helicopter parking area and this has given us an ideal site for the turntable assembly with a good unobstructed view of some 280°.

The obstructed 80° are of no importance since approaches in this sector are not liked due to the flare stack.

The Offshore Control Unit is situated in the radio communications room where radio contact with aircraft in the vicinity of the platform is maintained.

The existing approved limits at the platform are:-

200 ft. decision height and
800 metres RVR equivalent
both day and night.

The limits applied for using MADGE are 200 ft. above sea level and 300 metres. Due to the height of the helipad, 178 ft. amsl, no reduction of decision height can be made at the Beryl 'A', however a marked reduction in RVR equivalent is expected.

No accurate cloud and visibility statistics exist for the North Sea. However it is estimated that with the MADGE limits it will become a rare event for the Beryl Platform to be unattainable by helicopter for visibility reasons - a marked contrast to present operating experience.

3. RAE Offshore Trials

The present helicopter daytime offshore approach visibility limits compare very respectably with those of ILS Category I and use only basic aids such as NDB's (non directional beacons) or weather radars.

To improve significantly on these limits is quite difficult and the reason lies in the capabilities of the current helicopter types used offshore. It should be noted that the following comments apply to many other platforms as well as Beryl 'A'.

In general the S61N arrives at the Beryl platform with sufficient fuel for a diversion to a land base (at least 95 n miles away) plus normal reserves. The all up weight thus gives an engine out safety speed of 30 to 40 knots and pilots are therefore naturally reluctant to fly at an airspeed of less than 50 knots until landing.

Another factor is that below about 50 knots the helicopter becomes increasingly difficult to fly on instruments. Hence the usual Bristow approach air speed is in the region of 60 knots.

Now all the present approach techniques direct the helicopter straight towards the platform. Precision distance to go is not available, neither is precision directional guidance hence the U.K. C.A.A. have set RVR equivalent limits of about $\frac{1}{2}$ nautical mile.

It is tempting to think that with precision guidance to the platform and precision distance to go data, the limits can be significantly reduced.

However the Royal Aircraft Establishment (Bedford) conducted a series of helicopter approach trials at Shell's D Platform on the Leman Bank using MADGE and other aids (Ref. 5) and concluded that, due to the high approach speed and the need for a safe missed approach procedure, very little reduction of limits could be justified using a straight-in approach path.

R.A.E. then investigated a variety of approach paths. They determined that the key to reducing limits significantly is to guide the helicopter along a missed approach path where a safe engine-out and a good IFR flying speed can be maintained, and where the pilot is given the optimum chance of visually acquiring the platform and achieving a successful landing.

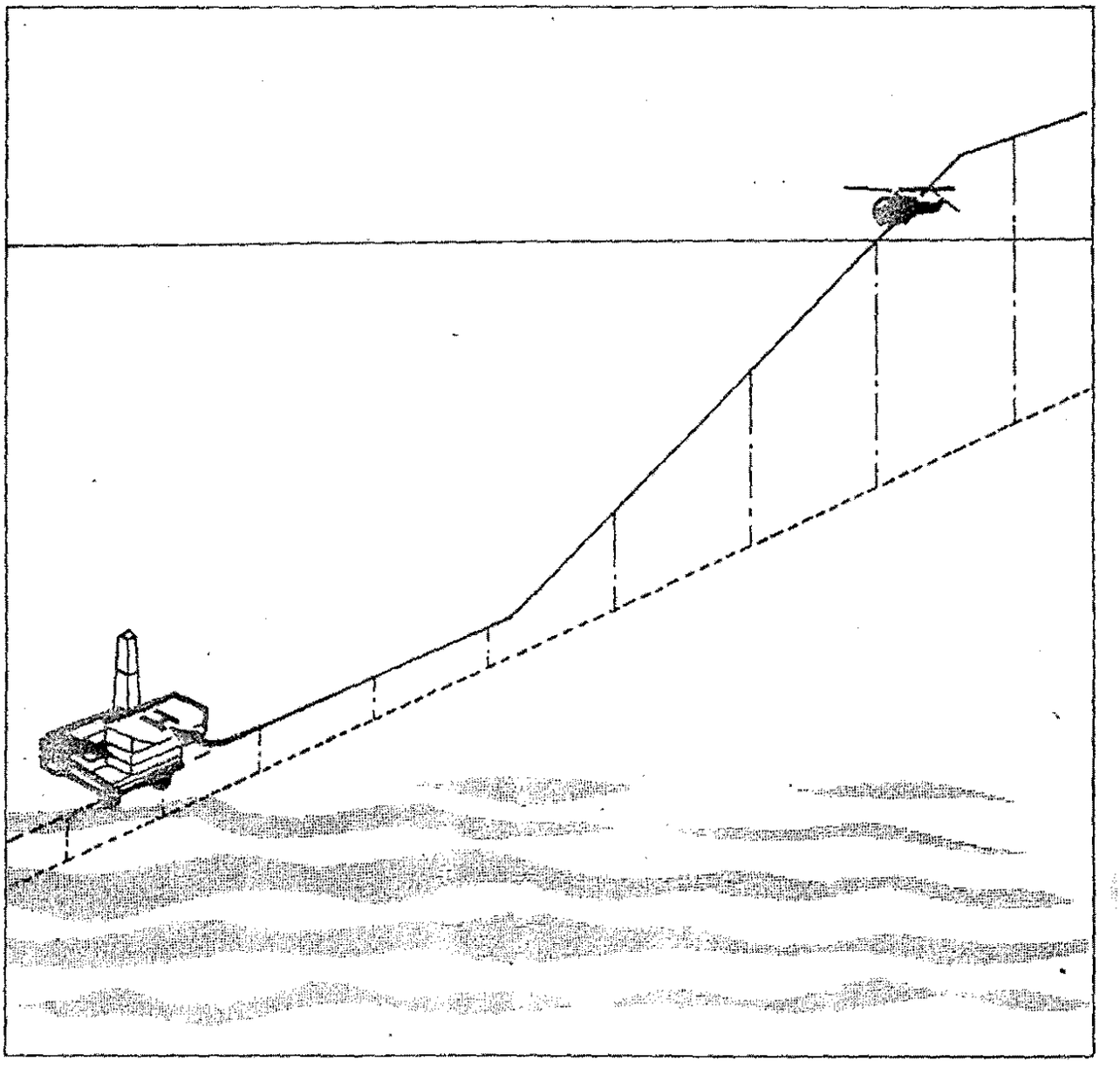
The optimum approach path was found to be offset from the platform in both azimuth and elevation and is shown schematically in Fig. 1.

Here the helicopter is guided along a straight horizontally displaced track by passing the platform by 200 metres.

If adequate visual contact is made, the pilot can leave the guided approach path in order to land; if this is not made before a range of 300 metres from the nearest part of the platform is reached, a missed approach procedure is initiated.

An airspeed of 50/60 knots is suitable and means this approach path can be flown in IMC with a good engine out performance.

Various vertical approach profiles were also tried out. A 3° descent angle was found satisfactory and has the advantage of commonality with the usual ILS glide slope. However a pilot operating to absolute limits would be quite busy at decision height visually acquiring the platform whilst arresting his descent and turning in to land.



The MADGE Offset Approach to an Offshore Helipad

Fig. 1

The approach is over the sea and hence it is feasible to descend at 3° to the minimum descent altitude some distance from the platform and fly level at that height on the horizontally offset approach path.

A level segment of ½ nautical mile was found to be a good compromise between giving the pilot enough time to settle into level flight before reaching decision range and avoiding flying for long periods at low level.

The height of the minimum descent altitude should be above the helipad height in order to give the pilot a good perspective view of the helipad and to avoid having to climb in the last stages of the approach.

As the height of the Beryl helipad is 178 ft. amsl, the minimum descent altitude being applied for is 200 ft.

It is interesting to note that the approach path shown to be optimum in RAE's trials also recorded the remarkably low pilot workload of 1 on the Cooper-Harper scale (as modified by RAE), the lowest on that scale.

This contrasts markedly with the high work loads recorded by RAE using current offshore IFR procedures and leads to the conclusion that safety will be enhanced, as well as limits reduced, by adopting the precision offset approach path.

Indeed it was this double gain of enhanced safety as well as lower operating minima that lead Mobil to place the order for MADGE for their Beryl 'A' Platform.

The RAE trials also confirmed that as to be expected, significant tail wind components, particularly in the final phases of the approach, are to be avoided. As winds in the North Sea attack the platform from all points of the compass, at least four approach paths are required. These can be provided from the extension to the helideck chosen for the MADGE site.

During examination of the offset approach by the U.K. C.A.A. it was suggested that further enhancement of safety could be gained by the provision of a warning of an 'excess deviation' from localiser in the last mile of the approach.

Analysis of RAE MADGE helicopter pilotage data showed that the standard deviation of a helicopter, flown by pilots of widely varying experience, from a MADGE localiser (with beam softening) in the last mile to touchdown was 12 metres.

Statistically it would be an extremely rare event for a pilot, established on the offset localiser, to deviate by as much as 5 standard deviations. Hence an excess deviation indication, set at $\pm$ 60 metres from centre line has been provided to provide a warning in case of events such as pilot distraction.

4. Aircraft Installation

The three Mobil dedicated Bristow S61N helicopters have been fitted out with a MADGE installation.

The MADGE pilots display instruments are duplicated for each pilot and mounted on extensions to the cockpit instrument panel.

The instrument display consists of a standard ILS zero reader displaying localiser and glide path information in the normal way.

A Smiths MADGE Precision Range and Azimuth Indicator displays MADGE range in four digits from 29.99 to 0.01 nautical miles. Thus the range resolution is 18 metres, and is compatible with a decision range of 300 metres. This instrument also displays the localiser information expanded to $\pm$ 40° and is an important aid to beam joining as well as providing a useful statement of angular position. Finally this indicator has two arrows to indicate whether a left or a right offset track is being provided by the ground station.

The excess deviation warning, given by a cancellable flashing indicator, is also located on the extension to the cockpit instrument panel.

5. Flying Programme Offshore

At the time of writing the MADGE platform station had just been installed on the platform and, after final checks, the offshore flying programme leading to certification by the U.K. C.A.A. will begin.

The first stage is a period of 'shakedown' flying during which the four pre selected approach paths will be evaluated and alternatives tried out in order to establish the optimum set of approaches.

The initial approach path selections are shown in Fig. 2 together with the wind sectors thought to be suitable.

Note that these are all 'left' offset approaches with the co-pilot flying the aircraft on instruments and the Captain monitoring, visually acquiring the platform and taking over to land. All of these approach paths, with the exception of 010 have a decision range of 300 metres from the nearest part of the platform. Due to the position of the flare stack and its walkway, 010 has a decision range of 450 metres with a left offset.

Right offset approaches are possible, however they require the co-pilot to be a full captain if full minimums are to be achieved.

If a right offset is acceptable for approach 010, then the decision range will also be 300 metres for this approach.

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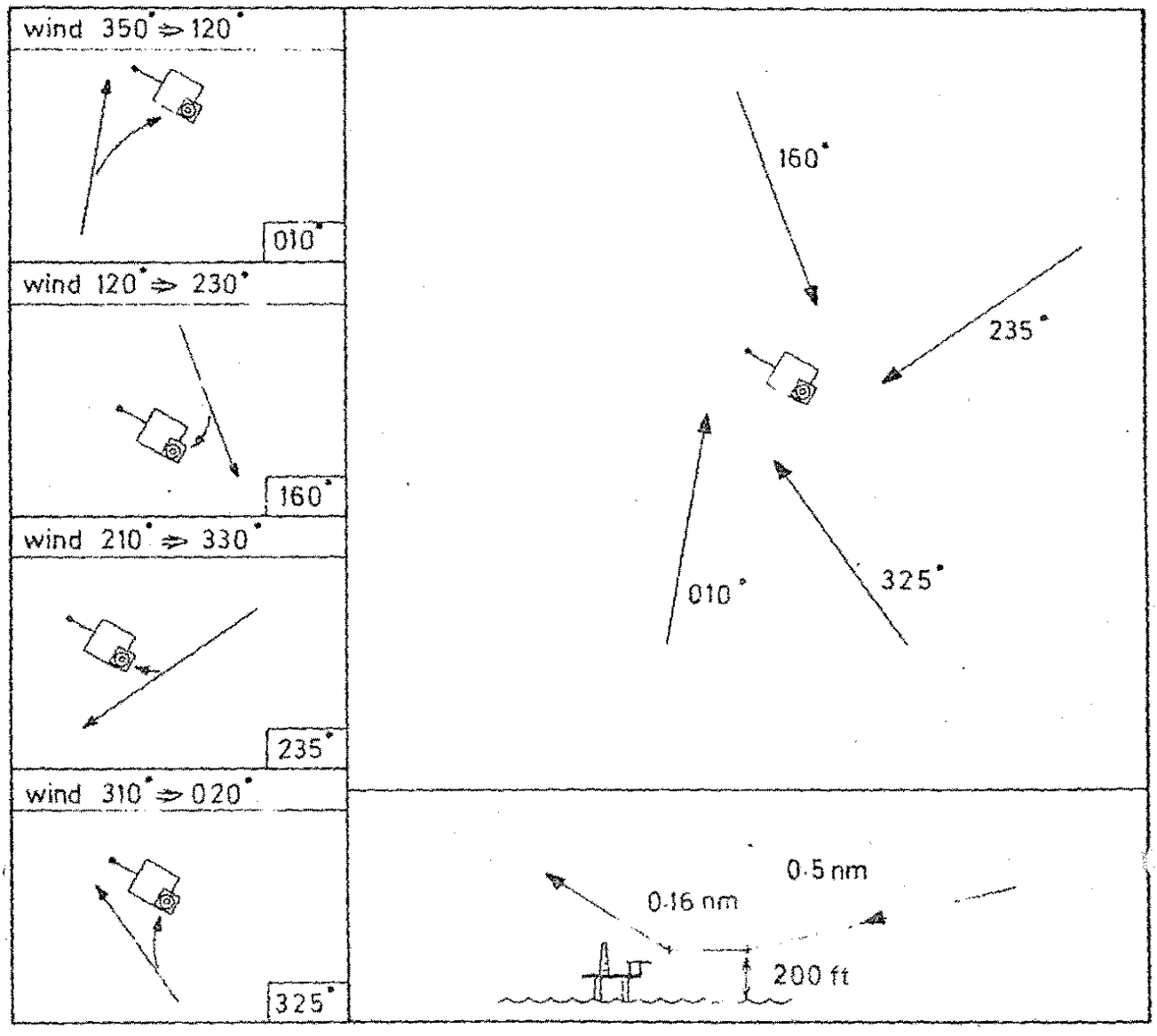

Four Suggested Localizer Approach Paths for BERYL A

Fig. 2

Until certification is achieved, all VMC flights will, when possible, terminate in a MADGE approach to the platform. On flights from Aberdeen (210 miles away) the approach will be flown by the co-pilot on instruments to decision range followed by the captain taking control for the visual segment and landing.

The overshoot procedure will be investigated on flights from Sumburgh (95 miles away), when the approach will be taken to decision range when overshoot action will be taken to 500 ft. followed by a visual circuit and landing. The overshoot procedures to be evaluated include maintaining the same heading, turning away from the platform at decision range by 15^{o}, climbing immediately, increasing air speed before climbing etc.

Approaches will also be made without passengers aboard and the co-pilot's screens fitted. Two approaches with overshoot will be followed by a third with a landing from decision range.

Some flights will be briefed to fly the localiser on about half scale deflection in order to verify the correct functioning of the excess deviation warning and the procedure to follow on an excess deviation warning occurring.

This shakedown period will be considered complete when the parameters of the four approach paths have been settled and the pilots familiarised with them.

The next phase is to gather statistics on the day to day performance of MADGE, the aircraft and the pilots. This will be accomplished by a combination of crew reporting and analysis of MADGE recordings - a data recorder has been supplied to record MADGE aircraft identity and position data for analysis by the U.K. C.A.A.

During this period, the C.A.A. will install a telegroscope (a portable aircraft tracking system used for checking and calibrating ILS systems), on the walkway to the flare stack and track the helicopter during a special series of guided offset approaches. In this way it is hoped to be able to correlate the performance of the system as measured on land with its performance offshore.

When sufficient flight data and crew reports have been collected, the U.K. C.A.A. plan to certificate MADGE approaches to the existing limits of 200 ft. and 800 metres. These limits will then be progressively reduced to 150/200 ft. and 300 metres as further satisfactory reports and data are amassed.

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