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ROYAL AIRCRAFT ESTABLISHMENT

TECHNICAL REPORT No. 65124

# A BRIEF COST AND EFFECTIVENESS COMPARISON OF THE P1127 (KESTREL) WITH DIFFERENT NAVIGATION SYSTEMS [S]

by

Staff of Weapons and I.E.E. Departments



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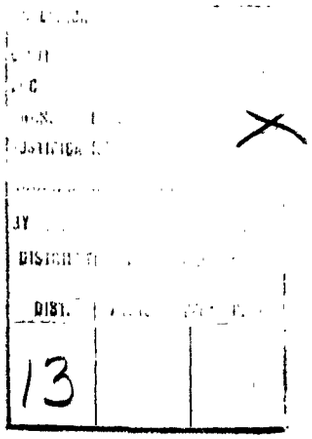


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SUMMARY

A brief comparison is given of the cost and effectiveness of the 1127 (Kestrel) with simple and inertial navigation/attack systems using retarded bombs, 1000 lb bombs, cluster weapons and rockets and guns against tanks, parked aircraft and personnel. On this basis, recommendations are made on the navigation/attack system fit for the aircraft.





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CONTENTS

## 1 INTRODUCTION

This Report discusses briefly the cost and effectiveness of the P1127 (Kestrel) fitted with various navigation/attack systems

Four navigation/attack systems have been considered for the 1127. These consist of

(i) Gyro compass, air data computer
PH15 roller maps
ISIS weapon aiming computer
Light fighter sight

(ii) IN platform, navigation computer
Topographic display
ISIS weapon aiming computer
Light fighter sight

(iii) IN platform, navigation computer
Topographic display
ISIS weapon aiming computer
Head-up display

(iv) IN platform, navigation computer
Topographic display
P1154 weapon aiming system
Head-up display

There is also a proposal for a forward looking J-band radar.

## 2 SCENARIO

The basis of the scenario for this comparison is in the army support role where targets are identified by Forward Air Controllers (FAC).

Briefly the technique is as follows:

(i) The FAC is positioned with the forward troops and calls for air strikes against a target.

(ii) The aircraft takes off from an airfield up to 100 nm from the front and flies to an easily recognised and prominent landmark known as an IP about 10 miles behind the battle area.

(iii) At this point, contact is made by two-way radio between the FAC and the pilot and the attack aircraft is given a course to steer and time to fly to the target.

(iv) During this period the FAC describes the position of the target and talks the pilot on to it rather like a GCA landing procedure.

(v) The pilot attacks the target and returns to base.

3 NAVIGATION CAPABILITY

It is always difficult to quantify the increased capability arising from better navigation accuracy but a brief examination of the probability of finding a prominent and medium prominent IP is given in Table 3. This is based on a 100 nm run between base and the IP without the use of any intermediate fix to up-date the aircraft position. This condition is likely to arise only when the countryside is featureless or when the transit to the IP involves flying blind, but when it does occur there is a marked increase in the probability of finding the IP.

4 WEAPON AIMING CAPABILITY

As the proposed navigation/attack systems represent small increments in capability the detailed assessment of aiming accuracy has been limited to systems (i) and (iv) with some comment on the other two. System (iv) has been considered both with and without a J-band radar for ranging purposes. In the absence of the radar, a kinematic ranging procedure has been assumed, in which the rate of rotation of the sight line is used to deduce the range to the target. This system is proposed by Ferranti but it has not yet been proved.

The accuracy of the weapon aiming systems are compared by evaluating attacks on a selection of targets, under various attack modes.

The specific targets chosen are:

(i) a Tank as representative of a small hard target

(ii) a Parked aircraft representative of a large soft target

(iii) Personnel, a small group of personnel either standing or prone in the open on average terrain.

The chosen attack modes are:

1000 lb retarded bomb in low level attack at 200 ft, at 450 and at 600 knots.

1000 lb free fall bomb in a 10° dive attack at 450 knots with depressed sight line.

A single cluster weapon to NAST 1197, in low level attack at 200 ft, 450 knots.

SNEB 68 mm rocket battery
30 mm Aden gun
} in 10° dive attacks at 450 knots.

The basic assumption in assessing the delivery errors are similar to those used in R.A.E. Technical Note 64044 and the Buccaneer 2/2* assessment. The chosen targets are assumed to be radar complex targets in all cases.

An operational degradation factor of two in the pilots tracking error, the speed error and the dive angle error has been included, together with an error in knowledge of target height above sea level, so that the accuracies and kill chances quoted are considered to be representative of operational sorties over unfamiliar terrain. The ISIS computer includes some compensation for dive angles and speed errors and only very approximate estimates for this are currently possible. The results, as presented, may be over-optimistic by up to 25% in aiming accuracy for this case.

4.1 Bomb and cluster weapons

The accuracies of the attacks with bombs and cluster weapons, Appendix A, are listed in Table 1 in the form of standard deviations in range $S_R$ and in line $S_X$. The table covers systems (i) and (iv) the latter for both normal alignment and rapid alignment of the IN platform. Both radar and kinematic ranging are considered for case (iv).

The corresponding kill chances against the three targets are listed in Table 1 for single bombs, a stick of two bombs and a single cluster weapon. Against personnel the 'kill chance' is defined as the chance of getting at least 50 per cent casualties in a group of personnel within an area of some 50 ft diameter.

The results show:

(i) The kill chance is increased by a factor of between two and three with the IN system (iv) compared with the simplest system (i), for both low level and dive attacks.

(ii) The inclusion of a F.L.R. has only a very small advantage (about 10% on kill chance) over the kinematic ranging system in low level attacks. This arises because the radar beam is at a grazing angle giving poor ranging accuracy against non discrete targets whereas the kinematic ranging system works with higher accuracy because of the greater rate of sight line spin in this type of attack.

(iii) The degradation between normal alignment and rapid alignment with the IN system is only some 10 to 20 per cent in kill chance.

4.2 Rockets and guns

The accuracy figures and kill chances are listed in Table 2 for systems (i) and (iv) with and without radar. The estimates for rocket attacks with system (i) without forward looking radar are similar to current experience on Hunter aircraft.

In evaluating the kill chance it has been assumed that all the rockets (two batteries of nineteen spaced 12·5 ft apart on the aircraft) are fired against a single target.

Hotchkiss-Brandt claim a ballistic dispersion of 1·5 mils S.D. for the SNEB rocket and this is supported to a limited extent by firings at A & A.E.E. This is far below the optimum and therefore three kill chance values are quoted in Table 2 for each case, namely those for the existing or claimed 1·5 mils S.D., for the optimum dispersion against each target and for a compromise optimum of 10 mils S.D. (which is already available on the 2" rocket launcher when firing banks of 4).

The conclusions from this assessment of rockets and guns are:-

(i) Radar ranging gives little improvement in kill chance at a given range. It may however encourage the pilot to withhold his fire until the best range is reached.

(ii) The present claimed ballistic dispersion of 1·5 mils S.D. for the SNEB rocket is far below the optimum - a good compromise appears to be 10 mils S.D.

(iii) With the present ballistic dispersion the 2 x 19 rocket installation has roughly the same effectiveness as a stick of 2 retarded 1000 lb bombs against a tank and as a single retarded 1000 lb bomb against a parked aircraft: in both cases the effectiveness could be increased to that of the single cluster weapon by increasing the ballistic dispersion to 10 mils S.D.

(iv) Against personnel the present rocket installation is again equivalent in effectiveness to a single 1000 lb retarded bomb but even with a ballistic dispersion of 10 mils S.D. it is only about half as effective as the cluster weapon.

(v) The gun is highly effective against large soft targets such as parked aircraft. It has zero effectiveness against a tank and only 10 per cent effectiveness against personnel.

## 5 COSTS

Authenticated cost data is not yet available but the estimates below are probably adequate to indicate the order of cost of the aircraft and its system.

| Aircraft or system | R & D | Tooling | Production |
|---|---|---|---|
| Aircraft and engine | £35 to 60M | | £0·5 to 0·7M |
| Navigation attack systems | | | |
| Simple systems (i) | £3·0M | £65K | £5K |
| Advanced IN systems (iv) and H.U.D. | £4·5M | £320K | £45K |

No costs of the forward looking radar are available but as it gives little operational improvement and is unlikely to be ready in time this is not important.

From the above figures it can be seen that the increase in R and D and production cost entailed by including the advanced IN system is between 5 and 10 per cent for an improvement in capability by a factor of between 2 and 3 indicated in the earlier sections.

## 6 CONCLUSIONS

A brief comparison of the capability of the P1127 (Kestrel) navigation and attack capability with unguided weapons with the simple (i) and advanced (iv) Ferranti navigation/attack systems has shown that system (iv) gives a kill capability (bombs and clusters) between two and three times that obtained with the simple system (i) at an increased cost of between 5 and 10 per cent. In addition there is an increased probability of finding an IP or target in some conditions.

With Ferranti system (iv) there is a small increase in accuracy (10 per cent) obtained from the forward looking radar which does not increase the capability significantly in low level attacks but in dive attacks the accuracy is almost doubled.

The ballistic dispersion of the SNEB rocket is far below the optimum and the capability with this weapon could be more than doubled if the dispersion can be increased to about 10 mils.

## 7 RECOMMENDATIONS

From this brief study of effectiveness and cost it is shown that there is a considerable improvement in kill chance for a small increase in cost when the Ferranti Advanced (iv) Navigation Attack system is fitted. This fit is therefore recommended.

It is also recommended that action be taken to increase the ballistic dispersion of the SNEB socket to about 10 mils.

## ACKNOWLEDGEMENTS

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## Appendix A

## CLUSTER WEAPON

The cluster weapon to NAST 1197 is assumed to be a low drag type of 1000 lb all up weight, carrying 250 bomblets which are ejected radially after a free fall of 50 ft.

The anti-tank bomblet is a shaped charge of $2\frac{1}{2}$ inches effective diameter. The casing of the anti-personnel bomblets consist of 1/8th inch steel spheres embedded in an aluminium matrix.

When released from level flight at 200 ft, 450 knots the bomblets are assumed to be uniformly distributed over an ellipse whose major and minor axes are

| | |
|---|---|
| Anti-tank version | 600 ft x 170 ft |
| Anti-personnel version | 700 ft x 180 ft |

Table 1

P1127 EFFECTIVENESS OF BOMBS AND CLU

| System | Weapon type | Speed | Release height | Dive angle | Strike angle | Accuracy | | | Ta |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $S_R$ | $S_Y$ | $S_X$ | |
| | | Knots | Feet | Degrees | Degrees | Feet | Feet | Feet | 1 Bomb |
| (i) (Simple system) | Retarded bomb | 450 | 200 | 0 | 27 | 333 | | 42 | 2 |
| | Retarded bomb | 600 | 200 | 0 | 26 | 438 | | 53 | 1 |
| | 1000 lb bomb | 450 | 1540 | 10 | 25 | 193 | 80 | 83 | 2 |
| | Cluster bomb | 450 | 200 | 0 | 14 | 390 | | 41 | 13 |
| (iv) Radar (normal alignment) | Retarded bomb | 450 | 200 | 0 | 27 | 127 | | 33 | 6 |
| | Retarded bomb | 600 | 200 | 0 | 26 | 172 | | 54 | 3 |
| | 1000 lb bomb | 450 | 1540 | 10 | 25 | 105 | 44 | 55 | 5 |
| | Cluster bomb | 450 | 200 | 0 | 14 | 168 | | 34 | 24 |
| (iv) Kinematic (normal alignment) | Retarded bomb | 450 | 200 | 0 | 27 | 148 | | 33 | 5 |
| | Retarded bomb | 600 | 200 | 0 | 26 | 209 | | 54 | 2 |
| | 1000 lb bomb | 450 | 1540 | 10 | 25 | 181 | 75 | 55 | 3 |
| | Cluster bomb | 450 | 200 | 0 | 14 | 215 | | 34 | 22 |
| (iv) Radar (rapid alignment) | Retarded bomb | 450 | 200 | 0 | 27 | 130 | | 44 | 5 |
| | Retarded bomb | 600 | 200 | 0 | 26 | 175 | | 63 | 2 |
| | 1000 lb bomb | 450 | 1540 | 10 | 25 | 117 | 49 | 72 | 3 |
| | Cluster bomb | 450 | 200 | 0 | 14 | 170 | | 45 | 23 |
| (iv) Kinematic (rapid alignment) | Retarded bomb | 450 | 200 | 0 | 27 | 150 | | 44 | 4 |
| | Retarded bomb | 600 | 200 | 0 | 26 | 212 | | 63 | 2 |
| | 1000 lb bomb | 450 | 1540 | 10 | 25 | 191 | 79 | 72 | 2 |
| | Cluster bomb | 450 | 200 | 0 | 14 | 217 | | 45 | 20 |

$S_R$ = Standard deviation in range

$S_Y$ = Standard deviation in elevation

$S_X$ = Standard deviation in line

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Table 1

P1127 EFFECTIVENESS OF BOMBS AND CLUSTER WEAPONS

| ase ght t | Dive angle Degrees | Strike angle Degrees | Accuracy $S_R$ Feet | $S_Y$ Feet | $S_X$ Feet | Percentage kill chance: Tank 1 Bomb | Tank Stick of 2 | Parked aircraft 1 Bomb | Parked aircraft Stick of 2 | Personnel Standing 1 Bomb | Personnel Standing Stick of 2 | Personnel Prone 1 Bomb | Personnel Prone Stick of 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 27 | 333 | | 42 | 2 | 4 | 18 | 35 | 15 | 30 | 5 | 10 |
| 0 | 0 | 26 | 438 | | 53 | 1 | 2 | 14 | 27 | 10 | 20 | 3 | 6 |
| 0 | 10 | 25 | 193 | 80 | 83 | 2 | 3 | 30 | 55 | 17 | 32 | 5 | 9 |
| 0 | 0 | 14 | 390 | | 41 | 13 | - | 52 | - | 57 | - | 43 | - |
| 0 | 0 | 27 | 127 | | 33 | 6 | 12 | 45 | 77 | 40 | 71 | 16 | 30 |
| 0 | 0 | 26 | 172 | | 54 | 3 | 6 | 34 | 63 | 25 | 47 | 8 | 15 |
| 0 | 10 | 25 | 105 | 44 | 55 | 5 | 9 | 53 | 85 | 40 | 65 | 13 | 24 |
| 0 | 0 | 14 | 168 | | 34 | 24 | - | 88 | - | 94 | - | 80 | - |
| 0 | 0 | 27 | 148 | | 33 | 5 | 10 | 40 | 70 | 35 | 63 | 13 | 26 |
| 0 | 0 | 26 | 209 | | 54 | 2 | 5 | 29 | 54 | 21 | 40 | 7 | 13 |
| 0 | 10 | 25 | 181 | 75 | 55 | 3 | 5 | 33 | 60 | 24 | 45 | 7 | 14 |
| 0 | 0 | 14 | 215 | | 34 | 22 | - | 80 | - | 85 | - | 72 | - |
| 0 | 0 | 27 | 130 | | 44 | 5 | 9 | 44 | 76 | 36 | 64 | 12 | 24 |
| 0 | 0 | 26 | 175 | | 63 | 2 | 5 | 34 | 62 | 23 | 42 | 7 | 13 |
| 0 | 10 | 25 | 117 | 49 | 72 | 3 | 6 | 48 | 80 | 30 | 52 | 9 | 17 |
| 0 | 0 | 14 | 170 | | 45 | 23 | - | 83 | - | 93 | - | 68 | - |
| 0 | 0 | 27 | 150 | | 44 | 4 | 8 | 39 | 69 | 32 | 58 | 11 | 21 |
| 0 | 0 | 26 | 212 | | 63 | 2 | 4 | 28 | 53 | 19 | 36 | 66 | 11 |
| 0 | 10 | 25 | 191 | 79 | 72 | 2 | 4 | 31 | 57 | 19 | 36 | 5 | 11 |
| 0 | 0 | 14 | 217 | | 45 | 20 | - | 75 | - | 85 | - | 61 | - |

range

elevation

line

Table 2

P1127 EFFECTIVENESS OF ROCKETS AND GUNS

| WEAPON | | 68 mm SNEB ROCKET | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of ROUNDS IN SALVO | | 38 (2 batteries of | | | | | | | | | |
| VULNERABLE AREAS at right angles to trajectory in 20° attack (sq ft) | TANK | (Hollow charge head) 67 sq ft (from | | | | | | | | | |
| | PARKED A/C | (Fragmenting 7 lb head) 470 sq ft ( 500 sq ft plan area and 3 ft thick tarmac, hits on tarmac count as kil | | | | | | | | | |
| | PRONE MAN | (Fragmenting 7 lb head) 330 sq ft ( scaled up directly with warhead wei | | | | | | | | | |
| NAV/ATTACK SYSTEM | | Simple Ferranti (System (i)) | | | | | | | | | |
| WITH OR WITHOUT RADAR Estimated S.D. mils (circular distribution) | | Without 15 | | | | | Without 10·5 | | | | |
| Firing range (ft) | | ← 2750 to 2400 | | | | | | | | | |
| | | Present | Optimum | | | Compromise | Present | Optimum | | | Co |
| Rocket ballistic dispersion (mils S.D.) | | 1·5 | 9 | 12 | 18 | 10 | 1·5 | 8 | 11 | 17 | |
| Kill chance (M or F) against single tank | % | 5 | 15 | - | - | 14 | 11 | 27 | - | - | |
| Kill chance (damage beyond unit repair) Single parked strike aircraft | % | 20 | - | 53 | - | 53 | 31 | - | 77 | - | |
| Average casualty rate in group of prone men distributed in Gaussian fashion over a circle of 100 ft rad (i.e. S.D. of 50 ft) | % | 5 | - | - | 30 | 22 | 6 | - | - | 33 | |

Table 2

27 EFFECTIVENESS OF ROCKETS AND GUNS

| 68 mm SNEB ROCKET | | | | | | | | | | | 30 mm ADEN GUN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 (2 batteries of 19) | | | | | | | | | | | 80 (2 sec fire with 2 guns) |
| (Hollow charge head) 67 sq ft (from O.B. Proc. Q.9027) | | | | | | | | | | | 0 |
| (Fragmenting 7 lb head) 470 sq ft (strike A/C, assumed 500 sq ft plan area and 3 ft thick standing 6 ft above tarmac, hits on tarmac count as kill) | | | | | | | | | | | 270 sq ft (direct hits only) |
| (Fragmenting 7 lb head) 330 sq ft (IDN.20 figure scaled up directly with warhead weight) | | | | | | | | | | | 33 sq ft |
| rranti (i)) | | Advanced Ferranti (System (iv)) | | | | | | | | | Either |
| ut | | Without 10·5 | | | | With 9·8 | | | | | Either 9·0 |
| 2750 to 2400 → | | | | | | | | | | | 3750 - 2400 |
| | Compromise | Present | Optimum | | | Compromise | Present | Optimum | | | Compromise | |
| 18 | 10 | 1·5 | 8 | 11 | 17 | 10 | 1·5 | 8 | 10 | 17 | 10 | |
| - | 14 | 11 | 27 | - | - | 25 | 12 | 29 | - | - | 27 | 0 |
| - | 53 | 31 | - | 77 | - | 77 | 34 | - | 80 | - | 80 | 85 |
| 30 | 22 | 6 | - | - | 33 | 25 | 6 | - | - | 33 | 25 | 10 |

Table 3

PROBABILITY OF IP ACQUISITION

(i.e. chance of detection on first pass 100 nm run without a fix)

| | Very prominent IP | Medium prominent IP |
|---|---|---|
| Simple system CEP 6 nm | 0·22 | 0·05 |
| Advanced system 2 min alignment CEP 0·75 nm | 0·85 | 0·50 |
| 12 min alignment CEP 0·4 nm | 0·95 | 0·68 |

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