

Air Historical Branch (RAF) Narrative

**THE ROYAL AIR FORCE IN
OPERATION GRANBY, THE FIRST
GULF WAR, 1990-1991**

JAGUAR

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The Royal Air Force in Operation Granby, The First Gulf War, 1990-1991:

Jaguar

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1. General Introduction

The first offensive support aircraft to be dispatched by the UK to the Gulf during Operation Granby were twelve Jaguar GR1As from RAF Coltishall. Although initially based at Thumrait, in Oman, the Jaguars were moved to Muharraq, Bahrain, during the build-up of coalition forces that preceded the launch of Operation Desert Storm. During Desert Storm, the detachment was chiefly engaged in air interdiction (AI) operations against ground targets in Kuwait and Iraq; secondary roles included reconnaissance and anti-surface unit warfare (ASUW) against Iraqi naval vessels.

The Jaguar entered service with the RAF in October 1973; in little more than three years, eight Jaguar squadrons and a large OCU comprising 156 aircraft had been established. The first three squadrons were located at RAF Coltishall; the others were based at RAF stations in West Germany, where they served for more than a decade until replaced by the Tornado GR1.

In August 1990, the Coltishall wing comprised Nos. 6, 41, and 54 Squadrons, each with a complement of twelve Jaguar GR1As and one T-2 trainer. Two squadrons, 6 and 54, operated exclusively in the ground attack role, but 41 Squadron had a dual role in which ground attack was subordinated to reconnaissance. The aircraft used by all three squadrons were virtually identical, but only 41 Squadron's were wired to carry the Vinten reconnaissance pod. These aircraft were, however, fully capable in the ground attack role and could thus be used by any of the squadrons. First and second-line engineering support was provided within each squadron organisation, which included two Engineering Officers and roughly 100 groundcrew. The Officer Commanding 41 Squadron also commanded the Reconnaissance Intelligence Centre (RIC), numbering about 60 additional personnel.

The decision to send Jaguars to the Gulf was determined more by their NATO role than detailed consideration of their potential military contribution. The RAF's Jaguar squadrons formed an integral part of the UK's Specialist Reinforcement Forces – mobile forces based in the UK but assigned a rapid reinforcement role in the NATO area. This required the three squadrons to deploy to Bardufoss in Norway and Tirstrup in Denmark in support of the ACE Mobile Force. By 1990, these deployments had been practised many times, and the Jaguar wing had successfully demonstrated its ability to move quickly overseas and conduct sustained operations,

albeit from prepared sites. At the time, no other aircraft in the RAF's inventory was so well prepared for immediate deployment. As for their destination, this was inevitably influenced by both political and military arguments, the former favouring Oman, the latter Bahrain. The deliberations that surrounded the Jaguar detachment's location and the demands made by the deployment on participating aircraft and personnel are considered in the first section of this study.

In the northern European theatre, the Jaguar's primary capability in daytime operations involved penetrating enemy defences at high speed and ultra low-level to deliver conventional weapons, including free-fall 1,000lb GP bombs, retarded 1,000lb bombs, and BL-755 cluster bombs. The Jaguar detachment arrived in the Gulf expecting to operate in precisely the same way. Almost immediately, however, a new anti-shipping role was proposed for the Jaguar, and a new weapon, the CRV-7 rocket, was procured for this purpose. At the same time, the assumption that the Jaguars could perform their principal AI role at low altitude was challenged in some quarters on the basis that they would be vulnerable to Iraqi air defences at low level; medium-altitude tactics appeared to offer a safer alternative. Although this debate was not resolved until the outbreak of hostilities, the possibility of medium-level operations was being actively considered as early as October 1990, when a search for suitable weapons began. The development of new tactics and weapons for the Jaguar detachment, and their employment during Operation Desert Storm, provide the focus for the Section 2 of this narrative. Section 3 describes the conduct of operations – planning, execution, problems encountered, solutions adopted, and results achieved.

Although possessing an excellent reputation for reliability and maintainability, the Jaguar was very far from the forefront of military aircraft technology when the Gulf crisis erupted in 1990. Its small size and low thrust-to-weight ratio imposed limitations on the available combinations for under-wing carriage of fuel, weapons, ECM, and self-defence equipment, and heavy, high-drag configurations significantly reduced its performance. The RAF were under no illusions regarding the potential hazards involved in the deployment of such an old aircraft into a combat environment against an opponent possessing modern fighters and Ground-Based Air Defences (GBAD). The Jaguar therefore received a range of enhancements intended to

improve its offensive and defensive capabilities and optimise its performance in the Gulf environment. These upgrades provide the focus of Section 4.

2. Jaguar Deployment and Basing

Deployment to Thumrait

The proposal to send a detachment of Jaguars to the Gulf emerged from the deliberations of the Defence Staff in the immediate aftermath of Iraq's invasion of Kuwait on 2 August 1990. If intervention was sanctioned by the government, the principal objective would be to deter Iraq from any further advance; British forces should therefore be prepared to support Saudi Arabia in the event of an attack. This called in the first instance for a defensive response (soon provided by a detachment of Tornado F-3s), but a truly effective deterrent would not exist until offensive support aircraft were deployed in theatre at fully operational status. Speed was of the essence. It was assessed that Iraq might be capable of invading Saudi Arabia from 7-8 August and of securing her eastern oil fields from Kuwait southward to Dhahran within two days.

The RAF considered the Tornado GR1 to be the best offensive aircraft for the task, but it could not be deployed and brought to operational readiness immediately. The Harrier and Jaguar squadrons were capable of a rapid response and were holding readiness states of 72 hours' notice to move: both had designated rapid reinforcement roles within the NATO area, and they also practised out-of-area deployments. For these purposes, they were trained and equipped to operate with less host nation support (HNS) than the Tornado squadrons required. Yet only the most recent variant of the Harrier, the GR5, possessed the necessary capability in terms of range and self-defence, and it was a relative newcomer to the front line. Its weapons were still awaiting a number of CA clearances, and the necessary level of spares support was by no means assured. By contrast, the Jaguar was fully operational, and the force was provided with Fly Away Packs (FAPs) of essential spares to support basing overseas. On this basis, it became the preferred choice for deployment to the Gulf.

There were sound military arguments favouring the deployment of offensive aircraft to the Gulf and the selection of the Jaguar, rather than the Harrier, for the task.

Nevertheless, in the discussions that preceded the Jaguars' departure, military considerations were soon outweighed by political ones, with profound operational consequences. If collective action in the Gulf was to be effective, the government believed that it should involve as many Arab countries as possible, and there was deep disquiet when not only Yemen but Jordan refused to support UN resolutions condemning the invasion of Kuwait and imposing mandatory sanctions on Iraq. The defence of Saudi Arabia was clearly the top priority, but the presence of RAF detachments in other Gulf states, such as Bahrain and Oman, would reassure them of western resolve and encourage them to take a robust line with Saddam Hussein.

The Jaguar's limited range made the more northerly Bahrain the obvious choice from a purely military standpoint, but the political arguments favoured Oman. The UK was not formally committed to the provision of military support to Oman in the event of any threat to her territorial integrity, but relations between the two countries were historically close, and the Sultan had received more wide-ranging assurances of defence assistance (including specific references to ships, combat aircraft, one to two army battalions and one SAS squadron) than any other leader in the region. Additionally, the Royal Air Force of Oman (RAFO) operated Jaguars from both Thumrait and Masirah, and sales to the Omani armed forces were of great importance to the UK's defence industry. In 1982, the Prime Minister had assured the Sultan in writing that the UK was 'fully committed to the security of Oman'. On 6 August 1990, Mrs Thatcher again wrote to him stating 'that Oman continues to enjoy the United Kingdom's fullest support' and asking him to 'let us know if there is any particular way in which . . . we can do more to help.'

The UK was no less supportive of Bahrain. In the event of any threat to her security, Bahrain could request assistance from the UK under the 1971 Treaty of Friendship and, by 7 August, she had accordingly sought consultations to determine the precise form that British military assistance might take. On 8 August, the Prime Minister personally notified the Emir that the UK might deploy Tornado F3s and Jaguars to the Gulf and asked if some of these aircraft could be stationed in Bahrain. But there were doubts about the strategic implications of basing offensive aircraft so close to Kuwait. Such a deployment could well have been considered provocative and would have come close to committing the UK to offensive action in the event of a war with Iraq, whereas the government hoped to establish a British presence in the Gulf

without becoming embroiled in actual hostilities. The first reaction of the Secretary of State for Defence, Tom King, to the crisis was that 'We are not going to get our arm caught in this mangle.' CDS duly conveyed the same message to the Joint Commander.

From this perspective, a deployment to the more southerly Oman seemed far more attractive. The Jaguars' location there would impose physical limitations on their ability to intervene if hostilities broke out on Saudi Arabia's northern frontier; UK assets would remain firmly under UK control. Oman therefore became the preferred destination. In the words of DCDS(C), 'It wasn't the idea to fight from there. It was tokenism.'

On 8 August, the Cabinet Overseas and Defence Committee took the formal decision to dispatch British forces to the Gulf, and the Secretary of State for Defence subsequently approved the preparation of a detachment of twelve Jaguars for deployment to Oman. Following the Sultan's agreement and a ministerial meeting the next day, Mr King formally sanctioned the deployment, which was to commence as soon as possible after the departure of the Tornado F-3s for Saudi Arabia. The aircraft were to be based at Thumrait.

At RAF Coltishall, the month of August 1990 began like any other with routine squadron flying and participation in recurring exercises. Of these, the chief commitment was the 'Reconnaissance Air Meet '90' at Bergstrom Air Force Base, Texas, in the middle of the month. The routine was interrupted on the evening of 8 August, when the Jaguar force was warned of an increase in readiness state from 1200 on the following day, and directed to prepare for deployment, probably to Thumrait, with a night stop at Akrotiri. In the event, the final destination was only confirmed to the first Jaguar detachment when it reached Cyprus. JHQ issued a formal Warning Order the following evening, calling for 12 aircraft (eight standard GR1As and four reconnaissance) to be held at 24 hours' notice to move. Weapon stocks sufficient for five days' operation at intensive rates were to accompany the detachment, which was also to comprise 24 pilots, nearly 300 ground personnel, and supporting equipment. The initial aircrew/aircraft ratio of 2:1 was later reduced to 1.5:1.

Normal flying training was promptly suspended as the squadrons commenced preparations for the move. Combat-ready pilots began operational low flying (i.e., flying down to 100ft instead of the normal limit of 250ft), and aircraft were hastily adapted for a combined Ferry/War fit. Desert camouflage painting was accomplished overnight on 10/11 August by a team of five Coltishall tradesmen, eight others lent by Abingdon, Brampton, Lyneham and West Raynham, and a party of Air Cadets, girls included, who were then at Coltishall on summer camp.

The inclusion of reconnaissance aircraft in the package dictated that 41 Squadron would participate in the detachment, but the extent of their contribution was limited by their prior commitment to the Bergstrom exercise. None of the other squadrons could provide the requisite number of experienced pilots from within its own complement. The detachment had therefore to be assembled from the resources of all three squadrons and the Jaguar OCU. Selected aircrew were told to relinquish their squadron affiliations and view themselves as part of a single cohesive unit for the duration of their deployment.

The Jaguar detachment was placed under the command of the OC 6 Squadron, Wing Commander Jerry Connolly; as Acting Station Commander, Connolly was intimately involved in all preparations for the deployment. In selecting the pilots, he was guided by the AOC 1 Group, Air Vice-Marshal Wilson, who himself became UK Air Commander for Operation Granby. Wilson had to consider the possibility that the detachment's personnel might very shortly participate in live operations. Moreover, they would have to adapt immediately to a totally unfamiliar environment, perhaps while hostilities were in progress. Connolly was therefore told to pick the most experienced team that could be assembled.

The deployment began on 11 August. Observed by a large press contingent, the Jaguars took off in three waves of four aircraft at 30-minute intervals, reaching Akrotiri less than six hours later after refuelling from Victor tankers. They proceeded to Thumrait on 13 August, refuelling from VC-10s. Groundcrew, equipment, and the remaining aircrew followed in C-130s, the airlift being completed by 14 August. On the following day, in response to the first tasking order, four aircraft were placed on Quick Reaction Alert (QRA) in the CBU/gun fit at 60 minutes readiness, supported by

a VC-10 tanker. By then, four days' worth of weapon stocks were in place and stocks for another two weeks were being moved to Akrotiri.

During the first few days in theatre, the Detachment Commander worked closely with the Omanis to develop a co-ordinated flying programme. Meanwhile, all efforts were devoted to establishing the detachment – to providing the necessary domestic, operational, administrative and engineering infrastructure and facilities. In such an unfamiliar environment, this was a demanding task. The original plan envisaged that many personnel would be accommodated in tents, but the heavy British-pattern canvas tents sent out from Coltishall were more suited to an arctic climate than the Omani desert, where high winds and daytime temperatures of 35°C were common. Solid bedrock just below the thin layer of surface sand hampered efforts to peg the tents down. No fewer than 60 were erected in just two days, but the problems with the 'tent city' were such that numerous groundcrew were housed in RAFO barrack accommodation, which was basic but functional. The pilots were billeted in portacabins, which were fortunately air-conditioned. The RAF Mobile Catering Support Unit rapidly erected a field kitchen and began to source produce from local suppliers.

Command and control was straightforward where operational matters were concerned: the detachment naturally reported to the UK Air Commander in Riyadh. RAFO command channels were more problematic. For local issues, the detachment's sole route to the higher RAFO authorities lay via the one-star Station Commander, and this arrangement sometimes had far-reaching implications. For example, by controlling the rate of flying from Thumrait and the use of ranges, the RAFO exerted a direct influence on the detachment's training programme. The Station Commander readily provided all the essential facilities required to support the Jaguar detachment but sometimes proved reluctant to enhance or augment the established arrangements. Moreover, as he was the only point of contact for the Detachment Commander, it was impossible to determine whether he was acting on his own initiative or in response to orders from RAFO headquarters at Seeb. Either way, careful negotiations were required to resolve such differences as periodically arose.

By contrast, the resident RAFO Jaguar squadron (8 Squadron, then commanded by an ex-RAF Jaguar pilot, Squadron Leader Ian Ord) could not have been more supportive. They provided accommodation for flying and engineering operations rooms, an administration office, intelligence and GLO offices, and officers' and airmens' crew-rooms, all of which were air-conditioned. The squadron also offered useful guidance on aspects of airmanship and tactics peculiar to desert operations. There was already a USAF detachment at Thumrait comprising 20 F-15Es and 16 C-130s, and the senior USAF officer, Colonel Hal M. Hornburg, likewise supplied invaluable support in both material and morale terms. A very close working relationship was soon established, extending across the operational and administrative spheres. There was also a close emotional bond, which was particularly evident when one of the USAF F-15s crashed during a joint exercise with the Jaguars and both crew members were killed.

By the end of August, the Jaguar detachment numbered 44 officers and 274 airmen. It was supported by personnel from 30 Signals Regiment, Blandford, the Intelligence Cells of Wittering, Honington, Brampton and Kinloss, an Administration/Imprest Officer from Waddington, and a Ministry of Defence Public Relations representative.

There was to be one further change to the domestic accommodation. Although the barrack blocks provided a useful temporary solution, their sanitary arrangements left much to be desired, and several groundcrew began to suffer from dysentery. The Detachment Commander had no wish to appear unappreciative of the Omanis' generosity in offering the barrack rooms, but a move was clearly essential. Privately, he established that hotel accommodation was available in the nearby town of Salalah and managed to negotiate favourable out-of-season rates. However, the Station Commander steadfastly refused to allow coalition personnel off-base.

Fortunately, the Detachment Commander found an opportunity to raise the issue at a high level when the Secretary of State for Defence visited Oman at the end of the month. Mr King then tactfully mentioned off-base movement to the Omani Chief of Defence Staff and was immediately assured that there was no problem. The Station Commander subsequently acquiesced, and the matter was resolved. Financial and other details were sanctioned by the UK Air Headquarters on 22 September, and 140 airmen then moved out of the barrack blocks and into the hotel in Salalah. The

hotel was about an hour's drive from Thumrait, so a small cadre of groundcrew always remained at the station in case a mission was ordered at short notice.

Training, both in the air and on the ground, began while the detachment was still establishing itself. Ground training was designed to prepare personnel for the possibility of conventional, biological or chemical weapons attack. Flying training started on 18 August at a rate of 12 sorties per day, using the area to the east of Thumrait to avoid any suggestion of provocation towards Yemen, to the west. The training comprised four and six-aircraft attack missions against RAF and RAFO opposition, air-to-ground work with first-run attacks on the ranges at Aqzayl and Rubcut, and daily AAR training with the VC-10s. Flying in operational configurations, the Jaguars had the opportunity to practise strafing with HE ammunition, and laser-ranging.

After the first week, the sortie rate was raised to 16 per day and then to 24. By September, the training pattern involved night AAR and multi-national packages similar to those flown during the RED FLAG and MAPLE FLAG exercises in the USA and Canada. These comprised four Jaguars supported by AAR, with F-111, F-16 and F-4G Wild Weasel aircraft. The profile included a medium-level transit to rendezvous (RV) with a tanker, low-level penetration to a target in a Saudi low-flying area, and medium-level return to Thumrait with a second tanker RV *en route*. In addition to the Wild Weasel SAM suppression and coalition fighter cover, AWACS provided threat information, and there were defensive Combat Air Patrols (CAPs) in the target area. Although low-level weapon delivery profiles were predominantly employed, sorties were also flown to investigate medium-level bombing options, and the Jaguars practised free-fall dive-bombing as a form of attack that would permit weapon release and aircraft recovery beyond the range of small-arms fire.

The Move to Bahrain

The UK's first deployments of the Gulf crisis served both a political and a military purpose, but political considerations were initially paramount, as we have seen. There was no war, the coalition had no aspirations to start one, and it seemed possible that hostilities might be avoided altogether if the weight of international opinion, economic sanctions and the massive deployment of multi-national forces into the Gulf persuaded Iraq to withdraw from Kuwait. It is within this context that the

Jaguars' initial deployment to Oman must be considered. They were sent there not because the UK was prepared to engage in offensive operations against Iraq, but, initially at least, to ensure that such engagement was avoided. Their dispatch to Thumrait also reflected long-standing political and economic links between the UK and Oman and emphasised the Sultanate's alignment with the coalition's cause.

Yet the possibility of open hostilities had to be considered seriously, and it soon became clear that the Jaguars could not realistically go to war from such a southerly location. Thumrait was nearly 1,000 miles from Kuwait. Given the Jaguar's limited range, operations from there would demand extravagant AAR support, and the sortie duration of up to six hours would ensure that the flying rate remained low, reducing the quantity of weapons delivered.

The first few days of the crisis were inevitably a period of uncertainty and, for that reason, considerable tension. On 13 August, the day the Jaguars arrived, the Joint Commander spelled out the drawbacks of operating from Thumrait to CDS, adding that he had asked the UK Air Commander to see whether there might be a suitable forward operating base in Saudi Arabia or perhaps Bahrain. A week later he signalled CDS in more urgent terms, referring to his 'growing concern that we could be moving quite rapidly towards major hostilities'.

If the fighting does start, UK forces are currently not well postured to contribute effectively. If HMG agrees that early military conflict now looks increasingly likely and that we should become more involved from the outset, then we ought to consider moving the Jaguars forward from Oman (probably to Bahrain).

It will be recalled that, during the first week of August, the Bahraini government had sought consultations with the UK about the provision of military assistance under the terms of the 1971 Treaty of Friendship. The consultations took place on 10 August, when it emerged that their government was interested in obtaining an increased British naval presence in Bahraini waters, troops for seaward defence, and a variety of military equipment; ground troops were the top priority. However, a few days later, British representatives in Bahrain met the Emir and the Crown Prince, and both expressed deep disappointment at the decision not to deploy Jaguars to their country. Although grateful for British offers of equipment and training, they stressed

that, as a higher priority, they were looking to the UK not merely to participate in the defence of the Gulf region but also to contribute directly to the protection of Bahrain. For this purpose, a visible British presence was essential.

On 17 August, the Defence Procurement Minister and VCDS visited Bahrain and managed to clarify the situation. While the Bahrainis had hoped for support from UK surface forces for defence against a possible helicopter or seaborne attack, they would nevertheless welcome the presence of RAF combat aircraft at Muharraq air base, both for protection and to provide a tangible demonstration of Bahrain's commitment to the coalition cause.

On 21 August, the Chiefs of Staff acknowledged both the clear operational advantages to be gained from deploying the Jaguars forward and the importance of protecting Bahrain and her government. But the Jaguars were not originally sent to the Gulf to be actively employed in offensive operations; if operational considerations were now paramount, the Chiefs favoured the deployment of the Tornado GR1 – a much more modern and capable aircraft. CDS therefore ruled that 'Whilst redeployment of Jaguar could be coupled with the deployment of GR1, it was nevertheless of a lower priority.' Ultimately, the Chiefs recommended moving the GR1s to Bahrain first, together with ground defence and GBAD units, and the government accepted their advice; the GR1s flew out to Muharraq on 27 August.

Consideration of the Jaguars' forward deployment subsequently continued, but the pressure for precipitate action eased somewhat. This provided Wing Commander Connolly with an opportunity to visit Bahrain to ascertain its suitability as a Jaguar base, and he also inspected Minhad in the UAE and Doha in Qatar. The UK Air Commander likewise examined the various Jaguar basing options. With the amount of vacant ramp space in the Gulf shrinking by the day, he concluded that the only realistic solution lay in co-locating them with the GR1s at Bahrain.

By the first week of September 1990, the Defence Staff were developing plans to reinforce the UK military presence in the Gulf. The forces dispatched in August had fulfilled their short-term objectives, but any longer-term commitment might well involve overt hostilities and would certainly require enhanced operational capabilities. As well as considering the deployment of more Tornado F3s and GR1s, the Defence Staff again noted that the Jaguar detachment was positioned too far

from Kuwait. As the Director of Air Force Operations wrote in the 3rd, 'It should be deployed further forward ... if it is to have any meaningful deterrent value.'

Planning proceeded along these lines, and the advantages of basing at Muharraq were soon reconfirmed. The availability of ramp space apart, Bahrain emerged as the preferred choice partly to limit the number of RAF bases in theatre. Moreover, many logistical advantages would be gained from co-locating the Jaguar detachment with the Tornado GR1s and other RAF elements already there. But the Jaguar detachment's move could not be considered in isolation; it was intimately linked to decisions about the second Tornado GR1 deployment, for which Bahrain or Tabuk (in north-west Saudi Arabia) were possible destinations, and several other coalition air forces were also hoping to use the base. Space at Muharraq was therefore at a premium. Whatever decision was taken, there remained problems of order, timing, and transport. It was also important to co-ordinate diplomatic arrangements carefully to avoid giving offence to Oman or appearing to take Bahrain's agreement for granted.

Tabuk was eventually selected for the second Tornado GR1 deployment for during the third week of September. As the base was not quite ready, the first six additional GR1s deployed to Bahrain to start their work-up, relocating to Tabuk a week later. Meanwhile, planning continued to move the Jaguars to Bahrain as soon as the six GR1s left. A party of five officers from the Jaguar detachment conducted a three-day pre-deployment visit to Muharraq to determine preliminary basing arrangements there. Air transport emerged as a potential problem. There was stiff competition for the available UK airlift, and the Jaguars' move from Thumrait might have been drawn out interminably had Colonel Hornburg not offered the assistance of the resident USAF C-130 wing. He and Wing Commander Connolly devised all the details of the lift themselves before passing their proposals to Riyadh, where they were promptly accepted.

The USAF provided 60 C-130 sorties along with key movements personnel to assist with loading and unloading. On 7 October, the first six Jaguars flew into Muharraq, where they were allocated space under sunshades in the Bahrain Defence Force (BDF) compound; the remaining six followed three days later. The majority of personnel arrived over a period of four days, and the relocation was complete by the

15th. Members of the detachment were deeply impressed by the professionalism of the American airmen who helped them. In a message of thanks to CINCCENTCOM, General Schwarzkopf, the Joint Commander wrote that the episode had been an excellent example of co-operation and flexibility on the part of the USAF, which had been much appreciated at all levels in the RAF.

The Jaguar detachment established itself at Muharraq with remarkable speed and the minimum of disruption to its flying programme. Flying training resumed on 10 October at up to 24 sorties per day to familiarise pilots with the area. The rate was reduced to 18 per day as training became more complex. Exercising with multinational packages continued, and the detachment took advantage of the proximity of the Tornado F3s at Dhahran to practise fighter evasion at low level. The RSAF King Fahd range was available on Fridays, when the host nation did not fly, and was used for freefall and retarded bombing from low and high angles, and for tactical strafe attacks. The programme also included simulated airfield attacks against Sheikh Isa airfield in the south of Bahrain and exercises with Special Forces in the UAE. The training areas were further from Bahrain than from Thumrait, and the Jaguars therefore required more AAR; access to ranges was also more restricted owing to the demands of other coalition forces. After a visit to the Gulf at the end of October, the Strike Command Flight Safety Officer reported that training opportunities from Muharraq were very limited, and that transit and tanking accounted for a disproportionate amount of the Jaguars' time in the air.

At the end of October, the detachment's aircraft were replaced by Jaguars enhanced to 'Stage 2' standard (see below). The roulement did not run smoothly. The first wave of seven aircraft left Coltishall bound for Akrotiri on 23 October with Victor AAR support. However, the route support previously arranged had unfortunately been cancelled by JHQ because the necessary air transport was urgently needed elsewhere. On arrival at Akrotiri, five aircraft were serviceable and two unserviceable (including one with engine surging problems requiring an ECU change). On the morning of 24 October, three further aircraft were declared unserviceable with weeping drop tank pylon seals.

The remaining two aircraft left for Muharraq that day with Tristar AAR support, but one Jaguar failed to accept fuel during its first AAR bracket, and both eventually

returned to Akrotiri. A team of eight support personnel had to be flown out from Coltishall (together with a replacement ECU) to remedy the various defects. Four aircraft then proceeded to Muharraq, while the final three completed the journey without incident on the 26th. A brief prepared for JHQ subsequently warned that the second part of the roulement, involving five Stage 2 Jaguars, was scheduled to commence on 2 November. It finished laconically: 'Route support is again recommended.'

The complete roulement of pilots and groundcrew took place over about four weeks, starting in early November. At the very beginning of the crisis, personnel sent to the Gulf had been told that they would be replaced after three months, and, having given this undertaking, the Joint Commander felt he should abide by it. Yet some of those involved were not so sure. The first aircrew to deploy were a hand-picked team comprising the more experienced members of the Coltishall wing. Three months of intensive training in theatre then brought them to a peak of operational readiness. The case for returning them to the UK and losing their hard-won expertise seemed questionable, especially since they would be replaced by relatively inexperienced pilots, none of whom was familiar with conditions in the Gulf or the corpus of operating procedures that had developed there. In the event, while the majority of deployed pilots were replaced during the roulement, a few expressed a preference to remain at Muharraq and were allowed to do so. The new Detachment Commander, taking over from Wing Commander Connolly, was Wing Commander GW Pixton, the OC 41 Squadron.

The move to Bahrain provided scope for substantial personnel reductions: as some RAF support elements were already located there, the detachment no longer needed to be completely autonomous. In September 1990, the Jaguar detachment had consisted of 39 officers and 238 airmen; after relocation, the headcount was ultimately reduced to 23 officers and 141 airmen.

The detachment's training regime evolved during November to encompass anti-shipping attacks and strikes on splash targets. Additionally, as the countdown to war continued, training and operational flying overlapped when the Jaguars flew close air support missions with the US Marines during a major amphibious landing exercise in northern Saudi Arabia. The aim was to reinforce coalition deception activity by

confronting Iraq with the possibility of an amphibious assault on the Kuwaiti coast, thereby holding Iraqi troops in the east while the coalition prepared to launch its main ground assault in the west.

On 13 November, the Jaguar detachment suffered its only flying casualty of Operation Granby. Flight Lieutenant Keith Collister sadly died when his aircraft crashed during a training sortie, accidentally flying into gently rising ground. The other members of his six-aircraft formation were at an altitude of about 100ft at the time of the accident; the minimum permitted altitude was 50ft. Collister was an experienced pilot – a member of the original Thumrait detachment, with one month of training flying from Muharraq to his credit. He was, of course, new to the Stage 2 Jaguar, which had only recently arrived in theatre, but the subsequent Board of Inquiry did not consider that this contributed to the accident. Weather and visibility were good, and the sun was behind the aircraft, so it was unlikely that he was dazzled, but the desert below was nearly featureless and the dune into which he flew was of smooth white sand. These conditions might have created an optical illusion so that if, at the critical instant, he had been scanning across the formation, he might not have identified the elevation in front of him. In advance of these findings, the UK Air Commander deemed it prudent to raise the minimum permitted altitude for training flying from 50ft to 100ft.

For their designated NATO role, Jaguar detachments had to be self-supporting. To this end, a highly mobile organisation had been developed at RAF Coltishall over many years and optimised to achieve the rapid deployment of aircraft and the necessary logistic support; detailed contingency plans for transport requirements and spares provisioning had been drawn up and paid handsome dividends at both Thumrait and Muharraq. Unit Movement Officers (UMOs) were thoroughly prepared for handling and loading all the equipment to be airlifted without relying on external assistance. The detachment received excellent spares support, and the Jaguar FAP worked well. The mobility plans extended to the provision of air portable avionics workshops (APAWs), air transportable reconnaissance exploitation laboratories (ATRELs) in support of the Jaguar's reconnaissance role, and to facilities for second-line bay servicing of armaments. As a result, components could be serviced and repaired in theatre instead of being returned to Coltishall.

Nevertheless, although proving the efficacy of the Jaguar wing's deployment plans, the Gulf War also exposed a variety of shortcomings in the provision of logistical support for deployed operations. According to one subsequent report, pre-planned and routine deployments to bases like Bardufoss and Tirstrup had not prepared the RAF's Jaguar squadrons very well for spontaneous out-of-area operations such as Granby. Indeed, such deployments had degraded the wing's ability to operate from bare bases. Moreover, the strong spares support that the Jaguar detachment enjoyed resulted largely from reductions in the size of the RAF's Jaguar fleet since the 1980s and conspicuously did not extend to newly introduced equipment such as Havequick radios and Skyguardian Radar Warning Receivers (RWR). There was also considerable scope for simplifying logistical planning and introducing automated processes for handling logistical information for the FAP, and for the preparation and management of deployment establishments and nominal rolls. Such measures could in turn help identify airlift needs and ensure efficient and effective use of available airlift capacity.

3. New Tactics and Weapons

The Anti-Shipping Role

The Jaguar detachment's role, tactics and weaponry were all extensively revised during Operation Granby. An entirely new anti-shipping role was identified at an early stage of the operation, and medium-altitude tactics for AI missions were also actively considered. These capabilities were eventually acquired through the purchase and installation of two new weapons, but the process was by no means straightforward. Both initially suffered from varying degrees of inaccuracy, and one received only limited clearance for carriage by the Jaguar. Remedial action was partially but not fully implemented by the time hostilities with Iraq ceased.

The possibility of an anti-shipping role for the Jaguar detachment employing rocket projectiles (RP) was identified during the very first days of the Gulf crisis, but the Jaguar was not equipped with them at that time. The Harrier had formerly carried the only RP in the RAF's inventory, the SNEB, but the weapon was now obsolete. As a successor, the RAF had been considering the Canadian CRV-7 – a more accurate system with a much-improved slant range. However, financial constraints and various setbacks encountered during trials had delayed a decision to purchase. The

pressure of events in the Gulf now accelerated the decision-making process. On 11 August, the MOD asked MOD PE to hasten BAe investigations into the carriage and firing of CRV-7 by the Jaguar; the company was already working on a similar project for the RAFO. BAe duly submitted a feasibility study on the 28th.

The origins of the Jaguar's anti-shipping role are rather obscure. There appears to have been some concern in August 1990 about the threat posed by Iraqi fast patrol boats (FPBs) to coalition naval vessels, but the records do not contain any detailed discussion of this issue, and it seems unlikely that Iraqi FPBs would have ventured so far south as Oman. Some contemporary papers described Yemeni FPBs as the principal danger. Whatever the truth is, the Jaguar was identified as the only air asset 'in that part of Arabia' capable of performing in an anti-FPB role. Anti-FPB missions employing the BL-755 cluster bomb or 30mm cannon would have involved direct over-flight of the target at low level, potentially exposing the Jaguar to anti-aircraft fire. By contrast, CRV-7 was expected to 'allow attacking aircraft the ability to stand off from the shorter-range defences, and thus greatly improve survivability'. It was on this basis that an Urgent Operational Requirement (UOR) submission for CRV-7 was originally prepared.

By the beginning of October, the Aeroplane and Armament Experimental Establishment (A&AEE) had been tasked to undertake carriage and firing trials of CRV-7 from training and operational launchers. Anticipating that these would be successful, the Head of RP(Air) approved the procurement of the missile on 19 October. Although the outcome of the trials was as yet uncertain, no problems were anticipated as the RAFO had successfully fitted CRV-7 to their Jaguars.

The first CRV-7s were delivered to the RAF at the end of October, and by 7 November an in-service date of 'mid-November' was anticipated. This proved optimistic: unspecified obstacles presumably encountered during trials delayed its deployment for two weeks. On 3 December, Strike Command authorised a Special Trial Fit (STF) for CRV-7. One week later, the A&AEE's Superintendent of Performance and Trials Management recommended giving Operational Emergency Clearance to the aimed firing of CRV-7 from the Jaguar but recorded serious doubts about its accuracy. As hit-or-miss weapons, RP must be aimed with great precision, but the Jaguar's weapon-aiming system was not programmed for CRV-7. During

trials, pilots had therefore used the reversionary mode on the Head-Up Display (HUD), which gave them a fixed sight:

The CRV-7 was fired from Jaguar GR Mk 1A XZ385, using the reversionary sight in the Head-Up Display (HUD) WPN Mode to provide an aiming mark. Sight depressions were calculated using aircraft incidence tables and CRV-7 manufacturer's ballistic tables. The aiming solution produced using this method tended to result in the rockets falling short of the target.

Correction figures could be supplied by the manufacturers, but they took time to produce and were specific to launch profiles, meaning they would not be applicable in all tactical circumstances.

On 21 December, 1 Group received Operational Emergency Clearance (OEC) for CRV-7; the weapons were delivered to the Gulf over Christmas, and the Jaguar detachment first tested the rocket at the Fahad range on 8 January 1991. However, they were not authorised to train with CRV-7 until the 14th, just two days before the start of the air campaign.

RAF Jaguars equipped with CRV-7 mounted their first Surface Combat Air Patrol (SUCAP) on 22 January; it was uneventful, as was a second mission on the 24th. On the 25th, the SUCAP was vectored on to an Iraqi naval barge and cleared to engage. Their cannon fire struck the vessel but, in accordance with the A&AEE's findings nearly two months before, the two CRV-7s launched by the Jaguars fell slightly short of their target. The experience of a second mission against the same target was identical. 'CTTO¹ have been asked for revised weapon release figures as all pods appear to be hitting short,' Wing Commander Pixton recorded. The following morning, the detachment formally requested that computed weapon aiming for CRV-7 be introduced 'as soon as possible'.

CRV-7 was next employed operationally on 29 January, when two Jaguars participated in an engagement with no fewer than 16 Iraqi FPBs. The pair attacked, using two CRV-7s each, and made a follow-up strafing pass with their cannon; the FPBs were also engaged by coalition naval forces. Four enemy craft were destroyed

1. CTTO – The Central Trials and Tactics Organisation at Boscombe Down

and twelve more sustained damaged, but it was impossible to confirm that CRV-7 contributed to this achievement in any way. The final action in which the rocket was employed operationally in its intended role occurred the following day, when two Jaguars attacked an Iraqi Polnochny naval tanker. On this occasion, CRV-7 hits were confirmed (although cannon again proved more accurate), and the vessel was left on fire from end to end. Despite this success, the Detachment Commander concluded that the low-level cluster bomb, BL-755 would probably be more effective than CRV-7 against maritime targets. On 4 February, the Jaguars flew their last, uneventful, SUCAP, and two days later a signal from the UK Air Headquarters to JHQ declared that 'Much of shipping threat has been dealt with.' CRV-7 was not used again operationally until computed weapon aiming became available.

On 20 February, the MOD formally cleared a new Operational Flight Programme (OFP) numbered 08-09, which provided computed weapon aiming for Jaguars equipped with CRV-7; software discs and ballistics tables arrived in theatre on the 22nd. As the threat from the Iraqi Navy was now minimal, CRV-7 was employed against ground targets, and it proved to be a most potent weapon. On first use with the new software programme (23 February), the Jaguar detachment achieved several direct hits on Iraqi artillery positions; they were equally successful the following day, when two separate missions recorded multiple accurate launches. Unfortunately, adverse weather and crowded airspace then conspired to prevent any further Jaguar strikes before the cease-fire. In all, thirty-two CRV-7 pods or 608 projectiles were launched by the Jaguar detachment during Operation Granby.

In summary, because no accurate weapon aiming provisions for CRV-7 were developed before the onset of hostilities, the Jaguar detachment was unable to employ the weapon to maximum effect until the very end of the campaign, and it may only have been launched successfully in the anti-shipping role for which it was procured on but one occasion. Yet only 25 days were required to produce the revised software that turned CRV-7 into the most effective weapon in the detachment's arsenal. As the rocket's earlier tendency to fall short of the target had been clearly identified by the end of November, a decision at that time to provide computed weapon aiming could have been fully implemented before Operation Desert Storm.

The reasons for this failure are unclear from the surviving documents. The Jaguar detachment's first commanding officer, Wing Commander Connolly, later recalled that he had asked for computed weapon aiming for CRV-7 while the detachment was still based at Thumrait; he had been warned of the aiming problem by the Omanis, who were also purchasing the rocket. However, the documents contain no mention of any such proposal before 29 January 1991. At the MOD, the staff of the Directorate of Air Force Operations were aware of the RAFO's difficulties, but apparently believed that complete accuracy could be achieved through a simple adjustment to the reversionary sight in the HUD. It may also have been supposed that the employment of standard attack patterns would facilitate sight handling and range assessment; in the event, this proved impracticable in the operational environment, where circumstances inevitably called for flexibility.

The Air Interdiction Role

The history of the Jaguar's role in Operation Granby, like that of the Tornado GR1, is dominated by two interrelated questions: first, should operations be conducted at low level or medium level? Second, if operations were to be conducted at medium level, what type of weapon should be employed? For their NATO role, the Jaguars were optimised for low-level operations and armed accordingly, but the Desert Shield phase of Operation Granby witnessed doubts about low-level tactics and weapons and a search for possible alternatives. Progress was initially slow. A workable alternative weapon for the Jaguar, an American cluster bomb known as CBU-87, was only located at the end of November 1990, and procurement was not sanctioned until the onset of hostilities in January 1991. CBU-87 ultimately proved very effective and rescued the Jaguar detachment from a shortage of 1,000lb bomb components, but the delay in its procurement had two adverse repercussions: it both limited the number of weapons that could be carried on any one sortie and caused a knock-on delay in the preparation of a suitable OFP.

In its role within NATO, the Jaguar was expected to fly at ultra-low level, making use of terrain masking. Depending on the intended target, mission loads comprised one or a combination of the following:

1,000lb GP free fall bombs

1,000lb retarded bombs

BL-755 cluster bombs

UK Paveway II Laser-Guided 1,000lb bombs (LGBs)

30mm cannon

BL-755 was designed purely for low-level delivery, while the other bombs were either to be dropped during a single pass at low level (or shallow 3^o-5^o dive) or, particularly in the case of the LGB, from a toss manoeuvre.

The first doubts concerning the viability of low-level tactics in the Gulf emerged at JHQ as early as October 1990, when a document prepared by ACOS (Air) warned:

AAA is to be found in abundance and is expected to be used extensively in defence of Iraqi armour. In the absence of good visual aiming opportunities, the free fire technique, or 'wall of lead' tactic, is likely to prevail. The direct overflight parameter required to deliver the current anti-armour munition, the BL 755, is likely to cause heavy attrition on the launch aircraft . . . Below 6,000ft . . . the risk is considerable, whereas above 10,000ft the risk is minimal.

The Chief of the Attack Cell at JHQ expressed identical sentiments in the following month:

We are concerned at possible attrition levels during low-level attacks as a result of Iraqi AAA and IR SAM. In certain circumstances . . . the medium-level option may be a means of defeating the AAA and IR SAM threat.

The employment of LGBs was considered but discounted. With Jaguars, Tornado GR1s and F3s already based in the Gulf, the RAF was understandably reluctant to accept the logistical challenges of sending out yet another fast jet, the Buccaneer, to act as designator. The 1,000lb bomb could have been delivered either from stand-off at low level or from medium level, but aiming errors from higher altitudes were

relatively large, making the weapon unsuitable for use against dug-in or dispersed targets.

There were two possible alternatives. The first was a modified BL-755. In its original form, BL-755 was designed as a low-level weapon to dispense numerous sub-munitions in a dense pattern over a large area. Medium-level delivery would cause the sub-munitions to become excessively dispersed. However, if the weapon was modified to delay sub-munition deployment, pattern density might be maintained. The second was the American Maverick anti-armour missile, which possessed a stand-off capability.

Although Maverick's integration into the Jaguar proved too difficult given the time available, consideration of the modified BL-755 continued into November. Both the Attack Cell at JHQ and the contractor, Hunting, believed the modification was feasible, but the Air Operations staff at the MOD argued that, even if it was, BL-755 could not be released accurately from medium level. This stance ultimately decided the issue, and the project was abandoned – at least for the duration of Operation Granby. The issue of offensive tactics and weapons for the Jaguar thereby reached an impasse less than two months before Desert Storm. On the one hand, the staff at JHQ were deeply concerned about the threat posed by Iraqi AAA to low-flying aircraft; on the other, the RAF did not contemplate operations at medium altitude with much confidence.

In the absence of a cluster bomb suitable for medium-level release, operational planning remained geared to low-level flying. Weapons provisioning assumed that the Jaguars would employ BL-755 on a significant scale. Flying training was largely conducted at low level. An OR study concerning one of the Jaguars' designated targets, the coastal Silkworm missile sites at Ras Al Qualayah, concluded at this time that lay-down deliveries of HE bombs or BL-755 from an altitude of 150ft would 'provide the most effective means of attacking', despite a possible threat from Iraqi AAA and man-portable SAMs. A medium-level capability now seemed desirable too, and concerns within the Jaguar detachment 'over weapon delivery accuracy if tactics dictate medium-level, steep dive attacks' were reported to both JHQ and the MOD. Nevertheless, the documents do not record any fundamental change in tactical assumptions.

Then, at the end of November, the Jaguar detachment's Qualified Weapons Instructors (QWIs) proposed the carriage of CBU-87. Their informal suggestion reached the UK Air Headquarters and JHQ on the 30th, stating simply 'that medium-level CBU delivery may well be a good option esp[ecially] if main threat comes from small arms/AAA/small SAMs ... Wonder if the USAF CBU 87/89 has been considered.'

In response, JHQ called for any information held on the weapon in theatre. The RAF apparently had some knowledge of CBU-87 but believed it to be another low-level bomb. In fact, it was equipped with a ground proximity fuse that allowed it to be delivered from medium altitude. Preliminary investigations by the Central Servicing Development Establishment at RAF Swanton Morley revealed that CBU-87 could be compatible with the Jaguar for emergency/war-only use. Therefore, on 17 December, the MOD called for loading trials to provide the necessary information for an interoperability clearance.

Unfortunately, this request did not elicit a rapid reaction. In the Gulf, the UK Air Headquarters waited until 9 January (barely a week before the start of the air campaign) before cautiously enquiring of JHQ whether any progress had been made. 'The medium-level delivery option appears very likely so capability to drop CBU type wpn would be extremely useful.' They received a very discouraging reply:

Data on wpons that is required ... to work paper work clearances is being collected from US this week. Obviously this will take some time. If you require this to have top priority let us know and we will inform Air Off 9 [in the MOD's Directorate of Air Force Operations]. One agency is progressing all the clearances and they are very busy. Air Off 9 has asked: have you confirmed with Americans that they will give you CBU87/89 from their in-theatre stocks?

From this, it appears that the Jaguar detachment's need for a medium-level weapon was not fully appreciated at every level of the command chain, which is unsurprising given the prevailing confidence in low-level tactics. Partly as a consequence, the command chain did not accord a high enough priority to the trial, clearance and acquisition of CBU-87: the UK Air Headquarters' initial request for consideration of the weapon was not couched in terms that suggested much urgency, and they were

slow to seek more rapid progress later. It also seems that the agency responsible for obtaining the necessary clearances (A Arm at MOD PE) was over-burdened with work and that Air Off 9 doubted that CBU-87 was, in fact, available in the Gulf.

On 14 January, the UK Air Headquarters reiterated its previous warnings about the likelihood of medium-level operations and requested that CBU-87 trials be given high priority. If weapons were not available in theatre, they should be sought direct from the US. MOD PE issued a further request for loading trials on the following day, declaring that they were 'now an urgent Op Granby requirement'. The trials finally took place on 17 January, Day 1 of Operation Desert Storm.

CBU-87 now acquired priority status for two reasons. First, the RAF's deliberations on tactics for the Muharraq Jaguars were finally resolved in favour of the medium-level option; the UK Air Headquarters delegated the ultimate decision to Wing Commander Pixton, the Detachment Commander. Pixton reasoned that the Jaguars' most likely area of operations would be dictated by their base location and operational radius of action without AAR, which was in very high demand. Depending on their weapon configuration and fuel load, their targets would therefore lie between 240 and 310 nm from Muharraq, which suggested that the main area of operations would be Kuwait. Located in Kuwait was perhaps the densest concentration of GBAD systems anywhere in theatre – a serious threat to aircraft flying at low level in daylight. By contrast, medium-level flying promised to render the Jaguars immune from small arms, light AAA, and most of the IR SAM systems. It would bring the aircraft into the envelope of radar-guided SAMs and heavier AAA, and of Iraqi fighters, but there would also be more protection from coalition defensive counter-air assets such as Wild Weasels, EF-111s, and F-15 fighters. Overall, there would be fewer threats and therefore better survivability.

So Pixton opted for medium-level delivery of the 1,000lb free-fall bomb, the limitations of which have already been described. This proved a wise choice for, as JHQ had predicted in October, coalition air formations quickly found that 'AAA [was] extremely heavy over all tgts.' When the true capability of Iraqi AAA became clear, the UK Air Headquarters agreed with Pixton that operations should continue at medium level. Hence the urgent need for an appropriate cluster bomb.

Second, the RAF's stocks of 1,000lb bombs proved inadequate to sustain intensive operations for very long. As one signal from theatre put it on 19 January,

Stocks of relevant tails/fuses for 1,000lb bx may be limiting factor in future ops so CBU 87 considered essential and AHQ very keen to obtain wpn soonest.

It transpired that the Americans could provide 500 CBU-87s from in-theatre stock immediately, and a further 500 within a matter of days.

The MOD issued a service deviation providing for carriage and release of CBU-87 by the Jaguars on 20 January 1991. It permitted the carriage of two weapons, one on each of the Jaguar's two inboard pylons (the outboard pylons were occupied by an ECM pod to port and a chaff pod to starboard), but specifically forbade the location of CBU-87 on the Jaguar's tandem beam stations.² It also identified the most appropriate live bomb ballistics in the Jaguar's OFP – ballistics designed for an offset 540lb bomb. A UOR for the procurement of CBU-87 was submitted for ministerial approval on the 23rd.

The Jaguars first employed CBU-87 operationally on 28 January with results described as 'excellent'. Two CBU-87s apparently caused as much damage as three 1,000lb airburst bombs, and the mission hit four DMPIs in total. However, on the following day, all eight CBU-87s released by the Jaguars fell short of their DMPIs and caused no damage to their targets. Detachment-level efforts to devise an aiming solution produced no immediate improvement, and another signal from the Gulf advised JHQ on 3 February that 'results from accurate 1,000lb bx more effective [than CBU-87] although accurate CBU 87 much sought after for battlefield targets.' At this stage, CBU-87 carriage was halted altogether, and the detachment reverted to 1,000lb bombs, consuming more than 300 between 3 and 9 February. Missions with CBU-87 may only have been resumed thereafter because of the shortage of 1,000lb bomb components.

Accuracy improved with practice and variations in tactics, but the tendency of pilots to release CBU-87 early remained a problem until the final week of hostilities. On 14 February, for example, the detachment mounted two very successful CBU-87

2. The second weapon station on each inboard pylon.

missions that employed a higher dive angle than had previously been used, but a third mission dropped four of its eight bombs short of the DMPI. The fundamental problem was the Jaguar's OFP, which was not designed for the weapon.

The prohibition of CBU-87 carriage on the Jaguar's tandem beams also reduced mission effectiveness. As one signal from the detachment put it, 'This limits Jag to two weapons only, which appears to be a waste of capability.' By contrast, the Jaguar could carry four 1,000lb bombs. Thus, although approximately 270 sorties were flown with each weapon during Operation Desert Storm, the Jaguars dropped 741 1,000lb bombs but delivered only 387 CBU-87s. The difficulty lay not so much in the carriage of CBU-87 on the tandem beams (they fitted well enough) but in their release, which posed a serious threat to flight safety. Extensive trials by the A&AEE were required before release could be sanctioned but these were not allowed to delay procurement. Thus, the emergency clearance of CBU-87 only provided the detachment with limited authorisation for delivery. As the procurement of CBU-87 was not seriously considered until the eve of Desert Storm, little or no work had been undertaken to remedy the twin problems of aiming and release. It was not until 29 January that the Jaguar detachment formally requested 'clearance for CBU 87 release from tandem beams ... [and] CBU 87 computed weapon aiming'.

The request for tandem beam clearance reached MOD PE on 4 February, but the necessary trials could not commence without eight dummy CBU-87 ballistic test vehicles from the United States, which were duly ordered on the 12th. Trials began in the final week of February and were ongoing when the cease-fire with Iraq came into effect on the 28th.

Work on a new OFP providing for medium-level release of CBU-87 commenced early in February, but the best estimate for completion was '2/3 weeks', a schedule understandably greeted with dismay in theatre. The OFP, which also covered the CRV-7 rocket, received formal clearance on 20 February and was available in the Gulf by the 22nd, but this left just two days for both CBU-87 and CRV-7 to be used with the new software owing to the various constraints on Jaguar activity during the closing stages of the air campaign. Consequently, only 16 CBU-87s were employed in conjunction with OFP 08-09 before the ceasefire. On 23 February, two Jaguar missions delivered 12 bombs. No assessment of the weapon's effectiveness exists

for the first mission, but the second was successful, three out of four aircraft hitting the target. Another mission released four more CBU-87s on 24 February, all of which fell in the target area, and the pilots saw secondary explosions as they pulled off.

In all, the Jaguar detachment flew 273 sorties with CBU-87 during Operation Granby. According to mission reports, of the 387 bombs dropped, 294 (76 per cent) fell in the target area, while 65 bombs fell wide; the results for a further 28 were not known. As with the CRV-7 rocket, there was clearly scope for accelerating the introduction of computed weapon aiming for CBU-87 during the operation. Had the weapon been obtained earlier there would have been more time for trials and testing; the shortcomings of the existing software would then have been identified earlier and the upgrade ordered and delivered sooner. The critical delay clearly occurred between 17 December and 9 January, when there was, in reality, very little progress at all with the procurement of CBU-87. It resulted from continuing uncertainty about wartime tactics and from a failure to attach a sufficiently high priority to the bomb's acquisition.

4. Desert Storm

Introduction

The Jaguar detachment was brought to full war readiness on 16 January 1991 and flew its first mission on the 17th, when four aircraft were tasked against targets in Kuwait. In the subsequent campaign, the Jaguars launched missions every day except for 21 January and 17 February, when all flying was cancelled due to bad weather. In addition, a combination of adverse weather conditions, poor visibility and deconfliction problems prevented any release of weapons during the final three days of the operation, 25-27 February.

Tasking fell under three headings – attacks on ground targets in Kuwait, SUCAPs, either in support of coalition naval forces or in Combat Search and Rescue (CSAR), providing cover for search and rescue operations, and reconnaissance. All missions were planned by the CENTAF CAOC at Riyadh as part of the daily Air Tasking Order (ATO) and communicated to the detachment (through the Jaguar desk at the UK Air Headquarters) in the form of a Fragmentation Order or FRAG. On take-off, air interdiction missions would first identify themselves to the duty AWACS before being

passed to the Airborne Command and Control Centre (ABCCC). The ABCCC acted as the control authority until the mission passed into its kill zone (a box of 30 minutes latitude by 30 minutes longitude). The kill zone contained the interdiction target.

Each interdiction target comprised several DMPIs, but tasking had to be flexible enough to accommodate the extremely fluid tactical situation prevailing in the Kuwaiti theatre of operations (KTO). If, as was often the case, the tasked target had moved or had already been attacked by coalition forces, or if it was obscured by cloud or smoke, the Jaguars were free to locate one of their alternative DMPIs within the same kill zone without referring to the ABCCC. If the search for a different target or a Target of Opportunity (TOO) involved a move to another kill zone, ABCCC authority was required. The SUCAPS were controlled by the naval task force. The Jaguar detachment was generally satisfied with these tasking procedures and the liaison maintained by the Jaguar desk at the UK Air Headquarters.

The Jaguars were refuelled in the air by RAF tankers on 138 occasions during Desert Storm. In the early stages of the operation, AAR was employed to extend the duration of SUCAPs; the longest recorded sortie exceeded five hours. AAR was not subsequently required until the beginning of the land campaign, as missions moved north from Kuwait into Iraq. According to one post-operation study, 'co-location of the Jaguar force with its dedicated AAR assets (Victor K2) proved beneficial because problems and misunderstandings encountered in the air could be resolved easily on landing.'

SUCAPs

SUCAPs were flown by pairs of aircraft during daylight hours with AAR support; sortie durations typically varied between three and five hours. Most Jaguar strikes targeted Iraqi naval vessels like FPBs, light attack craft, barges and landing craft. All attacks on such targets were described in some detail in the previous section and require little further comment here.

Operations commenced on 22 January, and the last SUCAP was flown on 4 February. Several missions were not tasked – when the Iraqi Navy stayed in port or targets were assigned to other coalition air forces. However, the Jaguars attacked enemy naval vessels on 25, 29 and 30 January. The most significant action was the

engagement on the 29th involving 16 Iraqi FPBs, four of which were destroyed, none of which escaped without damage. For the detachment, the satisfaction derived from mounting several successful SUCAP missions was tempered by frustration with the inaccuracy of their principal anti-shipping weapon, CRV-7. By contrast, the Jaguars employed their cannon to considerable effect, although low-level strafe attacks required pilots to accept greater risks.

During SUCAPs, Jaguars could also participate in CSAR operations. They were tasked with CSAR on 22 January but were not used by their controlling agency. Their other CSAR mission, which occurred on 2 February, was more eventful. Two Jaguars on SUCAP were vectored to the island of Jazirat Miskin to hold a CSAR CAP for a downed US Marine Corps A6. They maintained the CAP until forced to refuel, after which they were tasked with suppression of enemy air defences on the nearby Faylakah island, while another A6 conducted low-level reconnaissance. The pair released eight 1,000lb bombs in the airburst mode, and the leader's bombs were seen to impact directly above a six-gun AAA emplacement. Sadly, coalition efforts to find the Marine Corps pilot ended in failure.

Neither SUCAP task could be pre-planned in any detail, so there was no little uncertainty about weapons carriage. As RP seemed appropriate for most potential targets, the Jaguars initially carried two CRV-7s and a tank on the centre line. However, CRV-7's apparent inaccuracy then persuaded the Detachment Commander to consider alternative tactics and weaponry – direct overflight of the target at low level with the BL-755 cluster bomb. On 31 January, two Jaguars equipped with BL-755 were conducting a CAP when they were diverted by the controlling AWACS and re-tasked against Iraqi armour, which was crossing the border and moving south to attack Khafji. In the words of the Detachment Commander, 'They were now stuck, with a low-level only weapon, over land where they shouldn't have been, doing what they hadn't expected to be doing.'

The Jaguar pair flew at low level up the Saudi coast and located the Iraqi armour on the main north-south road. One aircraft attacked two trucks, while the other targeted what appeared to be an armoured personnel carrier; it was later identified as a ZSU 23/4 – a Russian-built mobile radar-guided anti-aircraft artillery system. Although neither aircraft was hit, both came under fire, and the Iraqis launched a missile

against the leader as he pulled away. He was forced to execute a missile break and jettison all external stores.

This mission accounted for the only BL-755s released in the campaign; the rest were returned to store. For the last four SUCAP missions, the Jaguars flew with the free-fall 1,000lb bomb, which benefited from computerised weapon-aiming. While the bomb would have been unsuitable for many potential SUCAP targets, it was successfully employed in the specific circumstances of the 2 February engagement over Faylakah island.

Discrepancies between US and UK ROE periodically complicated the Jaguars' SUCAP task. Although the respective ROE were similar, the American rules permitted attacks on civil vessels suspected of involvement in hostile acts, including surveillance, whereas UK rules required merchant ships to commit a hostile act or be 'directly engaged in or in support of Iraqi military operations' before they could be targeted. Reviewing the Jaguar strike on the Iraqi barge on 25 January, the UK authorities found cause to question whether the necessary engagement criteria had been satisfied, and they cancelled SUCAP missions on the 26th and 27th, pending clarification of this complex issue. The US Navy subsequently confirmed that all Jaguar tasking would comply with British ROE requirements.

Air Interdiction

The vast majority of Jaguar missions – around 70 per cent – involved attacks on ground targets in Kuwait. Iraqi artillery was by far the most common target, but they also struck SAM, AAA, Silkworm and Surface-to-Surface Missile sites, ammunition dumps and logistics centres, command and control positions, and infantry barracks. Operations were initially confined to Kuwait, but the Jaguars attacked targets further north and east inside Iraq as the campaign progressed.

The detachment mounted their first AI mission, involving four aircraft, on 17 January. The formation entered its assigned kill zone without contact with the control agency and opted to attack the pre-briefed alternative target, a command post located within an army barracks. The Jaguars released eight 1,000lb airburst bombs from medium level in a 30-degree dive. Although some munitions fell slightly short, the overall result was assessed as good. However, the mission report also commented that

more effort was needed to suppress enemy air defences in the area concerned, which had been formidable. The detachment's Operations Record Book recorded that the conduct of this first mission demonstrated the effectiveness of the war plan, which allowed the formation to operate without communications in an area of intense combat air activity, yet deconflicted from other air traffic.

The UK Air Commander selected the first Jaguar mission of 18 January for special mention in a debriefing call to the Joint Commander:

Turning to the first of today's Jaguar missions, that too has gone rather well. An eight-ship in pairs trail going against SAM 2 sites, a very difficult sortie as they were in cloud for most of the time. They burst out at 15,000 feet with just a minute to go to their target, entering a 30-degree dive and bottoming out at 6,000 feet with heavy AAA coming up ... Seven scored direct hits on three SAM 2 sites – all confirmed by film.

One experienced pilot described this mission as the most difficult he had ever flown.

The detachment soon established a routine pattern of activity. They received the FRAG at about noon each day, which allowed the flying programme for the following day to be determined. Most missions were tasked in fours, although pairs, fives and eights might also be scheduled depending on target requirements. As a rule, the same pilots flew together, obvious advantages being gained from working in teams. At least sixteen sorties and a maximum of eighteen were required per day. As it was preferable for pilots to fly no more than one daily mission, the maximum rate left little scope for contingencies, and more pilots therefore deployed from the UK, raising the total to 21 – a pilot-aircraft ratio of 1.75:1. On a given day, three or four pilots might be stood down.

The FRAG rarely specified which weapons should be carried and left the detachment with discretion to choose the best available, the actual selection being made by the QWIs. The Jaguar had two weapon stations over-wing, four under-wing, and one on the centre line. During Operation Granby, the over-wing stations were occupied by AIM9-L Sidewinder missiles, and the two outboard under-wing pylons were also accounted for: the ALQ 101-10 ECM pod was on the port side, while the Phimat pod

was on the starboard. The most common weapons configuration therefore placed one CBU-87 or CRV-7 (neither was cleared for twin carriage) on each of the Jaguar's inboard pylons, or two 1,000lb bombs on each of the tandem beams; a single 1,200 litre drop-tank occupied the centre line. For longer-range sorties without AAR, drop-tanks replaced weapons on the inboard pylons, and two 1,000lb bombs were carried on the centre line.

The Jaguar detachment's contribution to AI in the Desert Storm air campaign can be divided into five distinct phases. The first extends from 17 to 27 January, when AI missions were primarily conducted with 1,000lb bombs. Between 28 January and 2 February, the detachment experimented with CBU-87 but then resumed carriage of the 1,000lb bomb on the basis that it was more accurate.

Yet components for the 1,000lb bomb, such as 960 Multi-Function Bomb Fuses (MFBF) and freefall tails, were in short supply, and the Jaguar detachment only maintained operations in early February by resorting to a variety of expedients. To alleviate the MFBF shortage, which became acute after two weeks of hostilities, they fitted single 947 impact or 952 airburst fuses to each 1,000lb bomb, instead of the normal nose fuse and tail fuse back-up. When stocks of these fuses were also exhausted, they resorted to pistols and delayed arming devices, and dispensed with fuses altogether. They addressed the tail shortage by modifying retard tails for use in the freefall mode. Nevertheless, on the 9th, the Jaguars had no option but to fly with CBU-87 again, and it subsequently predominated to the virtual exclusion of other weapons until 23 and 24 February, when both types of bomb were carried, as well as the CRV-7 rocket.

The heights which the formations reached as they entered the target area depended on their weapon loads and the distance flown. For targets in southern Kuwait, the altitude was about 23,000ft. The following heights applied to the 1,000lb bomb and to CBU-87:

<u>Phase</u>	<u>Altitude (ft)</u>
Transit	25,000
Enter dive	23,000
Target Acquire	17,000-18,000
Weapon Release	15,000
Recover	12,000
30° dive angle	

When they encountered heavier AAA in the target area, the Jaguars adopted the following profiles:

<u>Phase</u>	<u>Altitude (ft)</u>
Transit and Target Acquire	32,000
Weapon Release	22,000
Recover	15,000
45°-50° dive angle	

When CRV-7 was employed, there was no reason to strive for such high altitudes: to keep within the slant range, the rockets had to be fired at a maximum altitude of 17,700ft. Transit altitude would normally be around 25,000ft.

The ultimate success of these tactics (and of the air campaign as a whole) should not be allowed to obscure the considerable difficulties that the Jaguar detachment encountered in their efforts to conduct AI missions at medium level. Medium-level tactics may have rendered them immune to AAA, but target location became more difficult in conditions of poor visibility. Conditions were by no means always poor,

and targets could be identified from distances of as much as 40 km from medium level in fine weather. However, in conditions of cloud or haze, they often proved impossible to spot. As a result, numerous missions were aborted in the air. In February, the Jaguar detachment Operations Record Book recorded that 'there was great frustration with both the unusually bad weather and the smoke from oil fires in Kuwait, which prevented crews from releasing their weapons onto their targets.'

The bland figures collated for OR purposes after the cease-fire tend, if anything, to understate the problems involved: they are based on the total number of missions of all types, whereas weather aborts were overwhelmingly confined to AI missions, which accounted for about 70 per cent of this total. No SUCAP missions were aborted because of poor weather or visibility. As an alternative, Annex A provides a chronological illustration confined to the AI role alone. Of 156 missions/617 sorties flown by the Jaguars, 113 missions/440 sorties attacked primary or alternative target areas. Poor weather in the target area caused 16 missions/75 sorties to be aborted in flight and represented the largest single cause of air aborts. A further five missions or 16 sorties were aborted in flight because the target was obscured by smoke. In addition, poor weather, occasionally at Muharraq but mainly in the target area, accounted for more than 40 per cent of the 29 mission aborts that occurred before take-off –13 missions, or 60 sorties. A number of these cancellations occurred when earlier Jaguar missions reported that the weather was unsuitable for operations; in other words, extensive cloud cover was concealing the target.

A second problem confronting the Jaguar pilots concerned deconfliction with other coalition units. Generally, the tasking arrangements described earlier in this section worked well: the number of deconfliction issues was small given the intensity of operations and the numerous countries participating in the coalition. The detachment's experience suggests, nonetheless, that large-scale multinational operations of this nature are unlikely ever to achieve absolute deconfliction and that aircrew must always be prepared for unexpected encounters with friendly forces.

The first such incident occurred on 24 January, when two Jaguars that had lost communications with their controlling AWACS were locked up by an F-15. Fortunately, they managed to re-establish communications, and the F-15 was duly instructed to break lock. On 31 January, according to the mission record, four

Jaguars 'encountered no enemy defences but were continually being locked up by friendly fighters before, during and after being in the KTO, even though the controlling AWACS had the mission on their screens throughout.' On 2 February, a five-aircraft mission against a Silkworm site encountered 'intense friendly air activity' as well as poor weather in their target area, which 'caused loss of mission effectiveness'. Only one aircraft hit the target. Three further incidents occurred on 12, 15 and 23 February.

The start of the land campaign added a new dimension to the problem. The mission records state that on 24 February, four Jaguars 'having arrived in the target area, were prevented from releasing [their weapons] due to the close proximity of friendly [ground] forces to their primary target'. On the final day of Desert Storm, 27 February, the first Jaguar mission arrived at its target area only to be informed that CSAR activity was in progress there; the formation was then vectored to an alternative kill zone, but poor weather precluded weapon release. The second mission encountered precisely the same difficulties. The final mission located a suitable target but 'clearance to engage was not obtained due to the close proximity of friendly forces.' Fortunately, this particularly bad day for the detachment was exceptional.

Iraqi air defences represented the other major threat to mission effectiveness. On 19 January, two Jaguars sustained minor damage from AAA. On 22 January, a mission observed AAA up to 17,000ft; the following day, it 'was heavy in [target] area up to 16,000ft'. On 23 January, a mission reported 'Carpet AAA at Ras Al Qualayah', the target which an OR study had previously recommended attacking with lay-down HE bombs or cluster bombs from an altitude of 150ft! In fact, the anti-aircraft threat remained significant throughout the air campaign, and numerous mission reports refer to heavy AAA and evidence of SAM radars. The Jaguar formations operated on their own and were not accompanied by specialist defence suppression aircraft, but their raids were timed to coincide with other defence suppression missions transiting nearby.

Their main countermeasure was, of course, medium-altitude flying. Otherwise, the threat could be reduced by tactical changes. The low-level sorties to which the Jaguar pilots were accustomed normally involved the maintenance of a precise time-

on-target (TOT), especially when flown in co-ordination with other forces; during the opening phase of Desert Storm, eight-aircraft formations adopted a similar approach at medium level. Yet it soon became clear that the first four aircraft of each formation were alerting the Iraqi defences to the imminent arrival of the second four, which were consequently drawing considerably more AAA fire. The formations were therefore reduced in size: eight-aircraft missions with a single TOT were replaced by multiple two or four-aircraft missions, which attacked the same targets but worked to an extended TOT. Of 113 successful attack or reconnaissance missions, those comprising two aircraft or more were divided as follows:

Missions	Aircraft
72	4
17	2
12	8
7	5
3	6

As we have seen, the RAF's Jaguars delivered a total of 741 1,000lb bombs and 387 CBU-87s during the air campaign. Operational research conducted after the war calculated an overall mission success rate of 77 per cent, based on aircrew observations and HUD video, but warned of the dangers of accepting such figures at face value. Post-raid BDA was very limited, and results were often difficult to quantify; the cloud cover, dust, and smoke that often obscured the targets likewise frustrated attempts to assess bomb damage. What were described as 'successes' at best only signified the probability of weapons landing in the target area, for the HUD video lacked sufficient resolution to provide qualitative BDA information. The fact that a weapon landed in the target area did not necessarily mean that the target had been hit, let alone destroyed. The following figures must therefore be treated with some caution.

Weapon type	1,000lb	CBU-87
Sorties flown	268	273
Weapons used	741	387
Results:		
Success	594	294
Fail	109	65
N/K	40	28
% Success	80	76
% N/K	7	9
Successful deliveries	2.2	1.1
per sortie flown		

The Jaguar pilots were unhappy about the lack of timely BDA. Although they had access to their own HUD videos, centrally collected BDA delivered promptly to the detachment would have helped them to assess their performance and refine tactics if necessary.

Photographic Reconnaissance

The deployment of 41 Squadron aircraft and aircrew at the beginning of Operation Granby clearly signified a reconnaissance role for the Jaguar detachment in Desert Storm. The UK Air Headquarters was initially slow to exploit this valuable resource, and capability issues presented a further obstacle, but the Jaguars ultimately flew reconnaissance sorties in support of their AI missions to great effect.

The Jaguar's reconnaissance pod was normally optimised for low-level operations and had only a limited stand-off capability. It usually contained four cameras but was fitted with just one during Operation Granby, the F-126, which had a 6-inch lens. Operated from medium level, say 25,000ft, it produced images equivalent to a 1:50,000 scale map, and covered an area of 9 km x 9 km. The images displayed positional information taken from the Jaguar's inertial navigation system but were not detailed enough to provide much intelligence about the status of individual targets.

In November 1990, Vinten Defence Systems offered on free loan two Long-Range Oblique Photography (LOROP) Pods, which were designed for slow Islander-type aircraft and helicopters rather than fast jets. However, they boasted 36-inch lenses. From 25,000ft, the LOROP produced photographs covering approximately 1 km x 1 km. They contained no positional information but were far more detailed than those of the F-126. On this basis, in consultation with the detachment, JHQ and the UK Air Headquarters agreed that the LOROP should be installed on an experimental basis. As one officer at JHQ put it, 'Large lens would provide useful additional coverage, especially after start of any conflict, and would plug a gap in existing capability.' In particular, it would enable the Jaguars to conduct medium-level vertical or oblique stand-off photography, confirm whether proposed Iraqi target locations were occupied and facilitate BDA activity. After installation and operational trials in the UK under STF procedures, the two pods were sent out to the detachment in mid-January for operational evaluation. On 22 January, the MOD issued an appropriate Service Deviation, and authority to install the LOROP pod on all Granby Jaguars followed on the 26th.

During the early stages of Operation Desert Storm, the FRAG did not provide the Jaguar detachment with any reconnaissance tasking – a curious oversight given the scarcity of coalition reconnaissance assets and the insufficiency of resources to provide timely BDA. The detachment's single criticism of coalition tasking procedures concerned the apparent 'under-utilisation of their reconnaissance capability at the strategic level'. Their first dedicated reconnaissance missions therefore involved the trial of the LOROP between 29 January and 1 February and were unsuccessful. Although the system produced excellent photographs, it suffered from poor instrument layout, and the lens would not deploy from its normal standby position in flight; instead, it had to be positioned before take-off.

Most of all, the LOROP was too difficult to aim accurately from high altitude because of its small image area: the task was said to be 'like aiming through a straw'. Photographic Interpreters (PIs) could not identify the precise locations being photographed, for there was no Integrated Navigation/Attack System (INAS) datum printed on the negatives, and the paucity of ground features in the (largely) desert environment provided minimal scope for cross-referring to maps. Most of these problems resulted from the LOROP's rapid acquisition and the consequent absence of aircrew and groundcrew training or experience in its use.

As the air campaign progressed, the detachment was compelled to seek improved intelligence on target areas. By early February, many static Iraqi facilities in Kuwait had been destroyed, and air campaign priorities were shifting to attacks on more mobile battlefield targets, such as towed and self-propelled field artillery. An abundance of ready-prepared sites for these units, such as entrenchments and revetments, prevented their active positions from being established with certainty very far in advance. Increasingly, tasking orders merely referred to a grid reference, assigning the Jaguars to 'targets in the area of ...'

The drawbacks of this situation are illustrated by one mission report for 5 February. On that date, a formation of four aircraft tasked with AI in the KTO found its target area in poor weather, but it transpired that the target, an artillery battery, had moved elsewhere. Identification of further targets within the kill zone was very difficult and only one aircraft released its weapons onto an enemy position, the others returning to base with their bombs. Another such formation was likewise unable to locate its target at the prescribed position and elected to bomb targets of opportunity within their kill zone instead. As the Detachment Commander put it, 'The FRAG had not kept pace with the real time int[elligence] situation. Disappointing given the effort involved to mount these missions.'

Subsequent missions went to considerable lengths to ensure that target areas were occupied before they bombed, and the detachment noted a tangible improvement in the supply of up-to-date intelligence: on 11 February, some excellent reconnaissance photographs provided the basis for a particularly successful attack. Clearly, there was scope for the detachment to employ its own reconnaissance

resources to make such photographs available every day if only means could be found to aim the LOROP accurately.

The solution was to launch pairs on reconnaissance missions, one aircraft flying with the F-126 survey camera while the other carried the LOROP. F-126 photographs, with their 1:50,000 coverage and their overprint data matrix of inertial position, would then enable the PIs to plot the location of enlarged LOROP photographs taken from the other aircraft alongside. The obvious disadvantage – increased exposure to Iraqi air defences – had to be accepted. The tasking authorities at the CAOC duly agreed to add a reconnaissance pair to the flying programme for each afternoon so that the following day's FRAG was available at detachment level and could be used to plan the photographic objectives.

This approach was first attempted on the very same day, 11 February, but the F-126 unfortunately became unserviceable. Nevertheless, the detachment remained optimistic, and the Muharraq Operations Record Book records that another pair successfully photographed an artillery position the following day. 'Coverage of the Arty positions by both LOROP and the F-126 confirmed that the guns had been moved and 3 new positions were located for the next day's missions.' On that day – the 13th – the photographs helped a four-aircraft formation to acquire its target early, but another F-126 malfunction and continuing difficulties with the LOROP denied similar imagery to attack formations on 14 February.

The reconnaissance mission of the 14th was more successful. To quote the Muharraq record again:

Practice makes perfect, as the saying goes, and the pair achieved excellent coverage of both targets for the following day, an Arty Bty and an Astros II MRL Bty, with both F126 and LOROP. This gave the pilots both high-level imagery for target acquisition and detailed target coverage for selecting DMPs.

On the following morning, a four-aircraft formation released eight CBU-87 bombs on to the target, causing severe damage to command and control facilities and destroying several vehicles.

The Jaguar detachment's achievements in the reconnaissance role soon attracted the attention of other coalition formations, some of which were struggling to obtain imagery through the formal tasking channels. A series of specific collection requests followed over the next few days, which were routed to the detachment via the JFHQ. Poor weather and smoke from burning oil wells prevented execution of this tasking until 18 February, but the Jaguars then managed to locate several enemy positions for the US Marine Corps and photographed a previous Jaguar target for BDA purposes. They also identified an Iraqi logistics site that was subsequently attacked by two Jaguar formations. On the 19th, the reconnaissance mission encountered AAA as high as 22,000ft but nevertheless obtained some excellent imagery of the Kuwait/Saudi border area for the British Army and the USMC.

This pattern of operations, combining collection for BDA and target location for the Jaguar detachment with more general tasks for other force elements, continued for the remainder of Desert Storm (except 22 February, when the reconnaissance crews were stood down). It is recorded that the mission of 21 February obtained some good imagery, while that of 23 February achieved 'excellent results with several occupied revetted Republican Guard positions located'. These were attacked the following day. By then, reconnaissance missions were employing AAR to penetrate deep into Iraqi airspace and experiencing almost continuous lock-ups from enemy SAM radars.

For the reconnaissance team, as for the rest of the Jaguar detachment, the victorious culmination of Desert Storm was very slightly tarnished by several successive days of abortive operations. On 24 February, the F-126 camera again became unserviceable, and it was therefore impossible to exploit the excellent imagery acquired with the LOROP; on the 25th, all potential target areas were hidden by cloud. On the 26th, another reconnaissance mission found its objectives obscured by cloud, so the pilots agreed to reduce altitude. They emerged from the cloud at 10,000ft and promptly came under attack from nearby Iraqi SA-6 and SA-8 batteries. Although they evaded the missiles, the pilots returned to base vowing never to fly reconnaissance again. On the 27th, the final Jaguar reconnaissance mission of Operation Granby was once more defeated by the weather.

5. The Jaguar at War

The Jaguar entered service with the RAF in 1973. By modern standards, it was a relatively simple aircraft, and this was reflected in the ease with which it was deployed and maintained in theatre during Operation Granby, relative to more advanced types like the Tornado GR1. Nevertheless, in terms of operational capability, it left a lot to be desired, and it was therefore subject to a range of enhancements either for general modernisation or adaptation to the specific circumstances of the Gulf conflict.

Throughout its service history, the Jaguar's reliability record was excellent, and it emerged from Operation Granby with its reputation unscathed. Over the entire August 1990-March 1991 period, the detachment maintained a flying rate averaging some 53 hours per aircraft per month, which was double the peacetime rate. During the Desert Storm phase of the operation, the Jaguar detachment mounted up to 18 sorties per day without losing a single sortie to a major engineering malfunction; one aircraft flew more than 50 operational sorties. Some engineering-related ground and air aborts occurred, but the problems were almost always quickly rectified; turn-around times were sometimes extended if spares were tied up in transit from the UK, but spares availability was generally good. The detachment's headline serviceability figures were as follows:

Sorties planned:	627
Ground aborts:	10 (2 for crew sickness)
Percentage ground aborts:	1.5
Sorties flown:	617
Air aborts for engineering reasons:	13
Percentage air aborts for engineering reasons:	2.1

The Jaguar's average availability rate of 97.2 per cent compared favourably with the rate of 78.5 per cent recorded for the Tornado GR1/1A. The ratio of engineering/support man-hours to flying hours for the Jaguar was 1.3:1 whereas for the Tornado GR1A the ratio was 5.1:1.

The climate represented the most serious threat to serviceability, especially during the first months of the deployment, when temperatures in excess of 40°C were the norm. Associated engineering problems included canopy expansion, cockpit misting, low engine thrust, fuel leaks and poor engine starts. The effect of high temperatures in the cockpits also caused concern: the canopies magnified ambient temperatures, and heat was absorbed by the black cockpit interiors.

The detachment engineers found partial solutions to the problem of canopy expansion by cutting back the canopy leading edge and by leaving the canopies open on the stay when the aircraft were parked. However, sun shelters were needed to cover parked aircraft in order to moderate cockpit temperatures, as well as to protect groundcrew while they were servicing aircraft in the open. The design and trial manufacture of mobile sunshades and improved canopy covers for the Jaguar was immediately initiated, and the new equipment became available in September. Minor improvements to the air conditioning system were incorporated into all Jaguars deployed to the Gulf, but anti-misting provisions were only improved during the final stages of the operation. Poor engine starting was initially addressed by ground-running problem engines early in the morning, while temperatures were still moderate; subsequently, the problem was solved by an increase in the automatic starter cut-out speed from 6,000 to 7,000 rpm.

Hardly any other standard items of Jaguar equipment otherwise experienced serviceability problems in the Gulf. The one major exception was the F-126 camera, which suffered three failures in eleven sorties during February, as we have seen. The files do not record that the F-126 was often subject to poor serviceability, nor are any remedial measures described.

Although the Jaguar had an exceptionally good record for reliability and maintainability, the prospect of live action against a potentially formidable adversary focused attention on its operational limitations and encouraged numerous proposals for enhancement. These were implemented in three stages. Stage 1 modifications

applied to the first aircraft sent to the Gulf; Stage 2 added a further nine modifications and was completed in October; Stage 3, combining all previous modifications with Radar Cross Section (RCS) reduction measures, began the following month. The enhancement programme seems to have been well orchestrated and quickly implemented. The only reservations expressed at detachment level concerned a shortage of spare parts for some Stage 1 and 2 equipment; spares provisioning was probably sacrificed to increase the number of aircraft modified to Stage 3 standard.

The most important items in the Jaguar enhancement programme were new weapons – the CRV-7 rocket and the CBU-87 cluster bomb – which have been considered elsewhere in this study. These were accompanied by improved self-defence measures in the form of modifications to the ALE 40 flare dispenser under Stage 1, and Sidewinder AIM 9L AAMs fitted to the over-wing pylons under Stage 2. In the event, the Jaguars never deployed AIM 9L operationally because the anticipated threat from the Iraqi Air Force failed to materialise, but the combination of ALE 40 and the PHIMAT bulk chaff dispenser provided an effective flare and chaff capability. Other enhancements, such as IFF Mk 12 Mode 4 and jam-resistant Havequick radios, common to the majority of RAF aircraft deployed in the Gulf, were major components of Stage 1.

Otherwise, the key Stage 1 modification concerned the Jaguar's Adour engine. Although the engine's thrust had been much improved since the Jaguar's introduction, the RAF had only taken its development one stage – from the initial Mk 102 to the Mk 104 – whereas some foreign air forces had purchased the more advanced Mk 811. The RAF's decision was apparently based on the assumption that the thrust provided by the Adour Mk 104 would be adequate in the Jaguar's planned operational theatre – northern Europe. Unfortunately, in the high ambient temperatures encountered in the Gulf, the Mk 104 suffered a 17 per cent loss of thrust.

The Stage 1 enhancement, which was trialled and embodied in theatre under Special Trial Installation (STI) procedures, increased the Adour's turbine temperature limit to restore some six per cent of lost thrust. Inevitably, there was a price to pay in terms of increased maintenance: the engine had to be subjected to regular

borescope inspections because of the increased likelihood of turbine blade failure. In an attempt to increase thrust further, modifications were subsequently introduced to the engine control amplifier and the fuel pumps under a second STI, but the resulting performance increase was accompanied by a reheat screech problem that was only remedied in the Gulf under a third STI.

Apart from the procurement of new weapons and self-defence equipment, the main Stage 2 enhancements involved the installation of the Vinten video HUD camera/recorder, the replacement of the Jaguar's analogue RWR with Sky Guardian digital RWR, and the provision of an interim Night Vision Goggles (NVG) standard. The video HUD recorder was procured to improve both the timeliness and quality of post-attack analysis. The 'wet film' HUD recorder system in service at the beginning of Operation Granby was unsuited to conditions in the Gulf, as the developed film often failed to provide good-quality imagery in bright or hazy sunlight. This was one investment that paid handsome dividends during Operation Desert Storm: until 11 February, the video HUD recorders were the detachment's only source of BDA apart from the pilots' observations.

The Sky Guardian RWR was procured for the Jaguar to replace the MDSL RWR – a very basic first-generation system that was inadequate for combat operations. It lacked a display and provided only limited directional information through a system of lights; it was unable to discriminate between threats, had poor high-signal density performance, low sensitivity and no capability against complex emitters. By contrast, Sky Guardian boasted an alphanumeric display together with threat detection, discrimination and identification capabilities, and a capability against complex PD radars.

Sky Guardian therefore represented a major improvement on the MDSL RWR. Nevertheless, a range of teething troubles complicated its introduction into service. The system suffered from display, audio and false alarm problems, some of which were software related, some of which were caused by dormant wiring faults. Remedial measures were hampered by the RAF's inexperience with Sky Guardian and a lack of supporting technical information. The most significant fault was a noise breakthrough on the CW audio channel, which was not eradicated until January 1991. Thus, in the words of one senior Jaguar engineering officer, 'although Sky

Guardian proved its worth during the hostilities, this was only after considerable effort had been expended to improve the confidence of the pilot in the effectiveness of the system.'

The NVG enhancements were no less problematic. Ironically, the high ambient light conditions prevalent in the Gulf inhibited daytime visibility of several instruments, such as the Projected Map Display and the Inertial Navigation Units, which had been adapted for night vision. By 6 November, the engineering staff at RAF Coltishall were proposing to remove the modifications that were not day compatible and replace them with conventional equipment. However, before the equipment was replaced, the Jaguar detachment mounted several sorties to evaluate the feasibility of night operations in the desert environment. Their subsequent report concluded:

The overriding lesson learnt is that it is not possible to fly at operational altitudes over flat featureless desert without the benefit of moon. In areas where strong relief features or where a horizon reference is created by man-made lighting then flight could be feasible in starlight conditions.

The RCS reduction measures incorporated under Stage 3 included Radar-Absorbent (RA) paint, Radar-Absorbent Material (RAM) and RAM tiles. Trials undertaken in October established that the Jaguar's RCS varied considerably according to altitude. However, on average, the modified aircraft demonstrated a reduction in RCS of between 25 and 30 per cent by comparison with the unmodified one. The CTTO described this as a 'significant' reduction which 'operationally would further enhance Jaguar survivability' and recommended the modification of all Operation Granby Jaguars.

The first aircraft to be modified suffered RAM tile adhesion failures in their engine intakes, and six had to be de-tiled pending the introduction of a more effective grouting technique. Yet more serious were the performance problems that arose with some of the tiled aircraft: their engines showed a clear but unpredictable tendency to surge. By February 1991, the Coltishall engineers were promoting more limited RCS reduction measures that did not involve the use of RAM tiles. A subsequent Rolls-Royce investigation confirmed that the tiles could disturb the engine airflow. It appeared that they had not been adequately trialled and tested at the start of the

Stage 3 programme. In the end, only one Jaguar with RCS modifications ever reached the Gulf, and this aircraft exhibited handling and performance problems at high angles of attack.

The Jaguar's operational capability and survivability were undoubtedly improved by the enhancement programme, and it is impossible not to be impressed by the speed with which it was implemented. However, the claim made in one top-level post-operation report that 'all the Jaguar modifications were fully effective' except for the RCS reduction measures was clearly too optimistic. The enhancements were at their most successful when the installation of fully developed equipment, such as Havequick or IFF Mk 12 Mode 4, was involved. Difficulties arose when the normal trials and testing procedures were accelerated to exploit the 'procurement window'. Some enhancements proved defective or difficult to employ in an operational environment; others had an adverse effect on the performance of the aircraft. This was the price the RAF paid for equipment economies and deferred procurement decisions in previous years.

6. Conclusion

The initial Jaguar deployment to the Gulf achieved its basic objectives, which were overwhelmingly political. As a component part of a much larger coalition force, the detachment helped to demonstrate international resolve to liberate Kuwait and deter further Iraqi aggression. Its location at Thumrait clearly underlined the UK's commitment to Oman's territorial integrity and the Sultanate's affinity with the coalition's cause; it also left the UK with some freedom of action if open hostilities between Iraqi and coalition forces erupted further north. From a military perspective, the decision to deploy to Thumrait was more questionable, but operational factors were always secondary in the deliberations that preceded the Jaguars' deployment. Nevertheless, it was almost immediately necessary to consider the difficulties they would face in the event of war, and the Joint Commander was soon pressing for their relocation to Bahrain. Ultimately, the Tornado GR1s deployed there first; the Jaguars moved up to Muharraq at the beginning of October.

Both the initial deployment to Oman and the subsequent move to Bahrain were complicated by a range of political and practical problems. Deliberations with Arab governments required consummate tact and diplomacy; basing arrangements had to

be carefully co-ordinated with the arrival of British and other coalition reinforcements; the administrative task, not least the provision of adequate air transport, was formidable. The RAF confronted and overcame all these challenges, although the Jaguar detachment's rapid relocation to Bahrain in October relied heavily on American air lift.

Overall, the Jaguar force viewed their deployment as a resounding success. Extensive preparation for their NATO-assigned reinforcement role allowed them to deploy into an unfamiliar and potentially hostile environment and achieve operational status in just one week. Nevertheless, the experience suggested that pre-planned annual exercises from a narrow range of established forward operating bases in the NATO area was by no means always conducive to the maintenance of a genuinely mobile capability, and the conclusion of hostilities was quickly followed by recommendations for improved logistical arrangements to facilitate similar movements in future.

The Gulf War cast the Jaguar in two new operational roles, both of which required specialised weaponry. The anti-shipping role with CRV-7 was not successful. Although preliminary trials had identified aiming problems with the rocket, no remedial measures began until live action confirmed its tendency to fall short. By the time computed weapon aiming became available, anti-shipping operations had ceased. Nevertheless, CRV-7 was employed to great effect against land targets in the final stages of Desert Storm.

The second (and much more important) role involved medium-level air interdiction, a radical departure from the low-level operations for which the Jaguar force had been trained and equipped. The RAF clearly understood the threat presented to low-flying aircraft by Iraqi GBAD, yet there was no co-ordinated action to develop different tactics or procure weaponry suitable for medium-level delivery. Such medium-level training as occurred in theatre was entirely initiated by the Jaguar detachment, but most training was conducted at low level. The decision to fly at medium level on Day 1 of the air campaign was taken at the very last moment and delegated to the Detachment Commander.

JHQ and the MOD certainly attempted to identify a cluster bomb suitable for medium-level delivery, but without success. It fell to the Jaguar detachment to locate

such a weapon – CBU-87. Unfortunately, due to the prevailing uncertainty over wartime tactics, its procurement was not actioned with enough urgency or haste for the accompanying problems of computed weapon aiming and tandem-beam carriage to be addressed until the last week of hostilities. Thus, although many successful sorties were flown with CBU-87, its accuracy remained a matter of some uncertainty for much of Operation Desert Storm, and the Jaguars could only carry two such bombs whereas they were cleared to carry four 1,000lb bombs.

The Jaguar itself performed well in the Gulf, proving easier to deploy and maintain than more modern fast jets and achieving significantly higher serviceability rates. Like other RAF aircraft, it was provided with a range of enhancements, which were at their most effective when fully trialled and standardised equipment was involved. Well-intentioned attempts to accelerate the normal procurement, trials and testing procedures were less successful.

The Jaguar detachment's participation in Operation Desert Storm comprised SUCAPs, AI, and reconnaissance. Tasking procedures worked well, providing flexibility in target selection and usually ensuring deconfliction from other coalition air missions. The detachment's reconnaissance role was exploited in the later stages of Desert Storm, when the LOROP and F-126 cameras were used together. In the SUCAP role, the Jaguars participated in the destruction of a number of Iraqi naval vessels and were on one occasion sent on a CSAR mission. However, the main Jaguar task was AI. The most successful AI missions were flown with 1,000lb bombs in January and early February, but a shortage of munition components then compelled the detachment to switch to CBU-87, which could not be employed so effectively.

From the outset, the Jaguars encountered formidable opposition from Iraqi GBAD. Medium-level flying virtually eliminated the threat, and no Jaguars were lost to enemy fire, but target identification from medium altitude was often difficult. More sorties were aborted due to poor visibility in the target area than to any other cause. It is nevertheless impossible not to be impressed by the speed with which the Jaguar detachment adapted itself to medium-level operations, and their recorded success rate can only be considered high in relation to the novelty of the tactics and weaponry involved. Acknowledging this achievement, the Officer Commanding the

RAF detachment at Muharraq wrote that 'thanks to our people and our training we have been able to adapt to an unforeseen set of circumstances and fight, most successfully, a war in a different way and in a different part of the world than we had ever expected.' He did not record that the task had been easy:

Never again should we in the Services become blinkered in our tactics or in our equipment provisioning so that we prepare for a particular kind of war in a particular location such as Central Europe. If we are to be truly effective, we must be prepared for any eventuality.

ANNEX A

Target Acquisition from Medium Level: The Visibility Problem

This diary illustrates the difficulties that the Jaguar detachment encountered in locating targets from medium level. Entries were made when at least one mission struggled to find its primary target. The diary does not include the many individual sorties that attacked alternative targets after failing to locate primary ones.

January 91	
18	3 out of 4 aircraft in a 4-aircraft mission aborted due to poor weather.
19	2 sorties aborted due to poor weather.
20	1 4-aircraft mission found target obscured by fog and aborted; 3 4-aircraft missions cancelled due to bad weather in KTO.
21	2 8-aircraft missions cancelled due to poor weather in KTO.
25	1 8-aircraft and 1 4-aircraft mission aborted due to poor weather in KTO.
27	1 8-aircraft mission aborted due to cloud in KTO.
30	Thick haze made target acquisition difficult and BDA impossible; one 4-aircraft mission aborted due to smoke and haze in the target area.

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2	Deconfliction problems, AAA and poor weather affecting a 4-aircraft mission caused 3 of 4 aircraft to abort.
4	All AI missions had difficulty finding targets due to haze and smoke.
5	Weather affecting a 4-aircraft mission caused 3 of 4 aircraft to abort.
6	8-aircraft mission aborted due to poor weather.
7	Final missions on late TOT had problems locating target due to low sun and haze; BDA impossible.
9	2 missions had difficulty finding target due to cloud; no BDA.
11	2 4-aircraft missions aborted due to poor weather.
13	A 4-aircraft mission found target acquisition difficult because of poor weather; weapons released on target area but BDA impossible.
16	2 4-aircraft missions aborted due to oil well smoke obscuring target.
17	All missions cancelled due to poor weather in KTO.
19	Oil well smoke forced all missions to attack alternate targets; BDA impossible.
20	Cloud made target location difficult for 3 missions; 2 aircraft unable to acquire target in poor weather.
20	2 4-aircraft missions aborted due to cloud in KTO; BDA difficult or impossible.
22	2 4-aircraft missions aborted because smoke was obscuring targets.
25	All missions aborted due to poor weather.
26	All missions aborted due to poor weather.
27	Poor weather and deconfliction issues prevented weapon release.

ANNEX B

Summary of Principal RAF Lessons Learnt in Operation Granby

1. The war exposed some important gaps in the RAF's war-fighting preparedness and capability.
2. Better communications, navigation and self-defence equipment is required across the front-line aircraft fleet.
3. There is a need to improve interoperability with the Americans.
4. There is a need to rebuild a logistical and maintenance capability for deployed operations outside the NATO area.
5. Better air-to-air refuelling provisions are needed to increase the range of aircraft operating away from main or forward operating bases.
6. Air transport capacity proved insufficient.
7. The coalition as a whole was too dependent on the United States for the suppression of enemy air defences.
8. There is a need to improve mission support.
9. Offensive operations would benefit from more timely and accurate battle damage assessment information.
10. The Tornado F3 suffers from a number of capability limitations.
11. Precision-guided munitions played an important part in the conflict, and the RAF intends to employ more such weapons in future.
12. There is a need for a stand-off anti-armour weapon.
13. There is a need to train and equip aircrew to operate at higher altitudes.
14. The RAF remains committed to maintaining low-level capabilities, which are still believed to offer a greater chance of survivability in operations in the NATO area.