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RAA LIAISON LETTER

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ROYAL REGIMENT OF AUSTRALIAN ARTILLERY

LIAISON LETTER



PUBLISHED BY THE DIRECTORATE OF ARTILLERY,
DEPARTMENT OF DEFENCE (ARMY OFFICE), CANBERRA, ACT

May 1978

'WITH THE SINGLE EXCEPTION OF THEOLOGY
THERE IS NO STUDY WHICH IS SO FULL OF
PREJUDICES AS ARTILLERY'

General Gerhard Von Scharnhorst

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HQ RAA 1 Div	2
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4 Fd Regt	5
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Other Units

P&EE (Port Wakefield)	2
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Defence Research Centre Salisbury (1 for Army Projects Officer)	2

School and Training Units

JSSC	1
Staff College	2
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EDITORIAL

THE 'AUSTRALIAN GUNNER'

It is with mixed feelings that I announce that this will be the last edition of the RAA Liaison Letter. This august publication which was first produced in the early 60s, has at last reached retiring age, and in August/September this year the first edition of AUSTRALIAN GUNNER will reach you.

The AUSTRALIAN GUNNER will be an entirely new Artillery publication, commercially printed in the 'glossy' format, and available to all gunners free of charge. The costs of its production will be met by selling advertising space.

The content of AUSTRALIAN GUNNER will also be new. Articles and pictures will be aimed at all gunners and will range from informal pictorial spreads to advanced technical articles from overseas. The standard of the article and its relevance and interest to the RAA will be all that determines if it will be included.

The editorial staff of the AUSTRALIAN GUNNER has been given approval by the major overseas Artillery publications to reproduce their articles if we wish, and this gives a huge range of high quality articles to supplement our own contributions.

Good pictures are vital to the AUSTRALIAN GUNNER. Not only are they 'worth a thousand words', but they make a magazine interesting and pleasant to look at. Please send <u>all</u> interesting photographs to us at DARTY. Attached captions would be a help too. When you write an article for the AUSTRALIAN GUNNER try to include some photographs. If you don't have any, we will probably be able to help you out.

We are looking forward to editing the AUSTRALIAN GUNNER. It will be an enjoyable and interesting magazine which is produced for you. Let all of us, ARA and ARES officers and other ranks join in in making the AUSTRALIAN GUNNER a professional publication that we are proud of.

Patrick V. McKenna

Editor
RAA Liaison Letter and
AUSTRALIAN GUNNER

LETTERS TO THE EDITOR

Dear Sir,

I must disagree with the suggestion made by Lieutenant Colonel S.N. Gower in his 1977 RAA Association (NSW) Prize Essay published in the September, 1977 issue of the Liaison Letter. He suggests that one way of maintaining and developing technical and tactical standards in the RAA in a period of financial constraint and no specific threat is, 'to raise an "elite" gunner unit, or "Special Artillery Regiment", along the lines of the British Army RHA'.

In his essay, Colonel Gower refers to an article by Lieutenant Colonel M.B. Farndale, titled the RHA System, which appeared in The Journal of the Royal Artillery, Volume XCIV No 2, September, 1967. This article, written in the form of an appreciation, examined the merits of the RHA system and concluded that the best course of action is to maintain the RHA system in the Royal Regiment. The article did not lead me to that conclusion.

I believe that an 'elite' organisation, such as the one suggested by Colonel Gower would create a 'them and us' environment and become 'elite' at the expense of the rest of the RAA. Surely to belong to one of the regiments of The Regiment and the desire to make that regiment the best whilst you are part of it, is sufficient motivation to maintain and develop technical and tactical standards.

In the 1700s when the RHA had a special and specific role, then perhaps, there was justification in calling that unit, 'elite'. To do so to-day is anachronistic. The regiments of the RAA in the field branch all have the same role and to have one designated as the "superior" regiment is a retrograde step.

D.J. Tys
Major
School of Artillery

PROMOTION AND YOU, THE REGULAR SOLDIER

GENERAL

In an environment where people tend to talk in initials and abbreviations, some are more important than others to the soldier with an eye to the future. MEROR, CARO, PE GP, PAB, AAF A26A and DPE, are in this category for they are signposts along the road from private to warrant rank. In this article, the Director of Personnel Employment - Army, Col H.M. Lander, explains for readers, the painstaking procedures which must be followed to enable the right soldiers to be promoted at the right time.

AIMS

The promotion system aims at promotion the most capable soldiers who are qualified, providing an incentive for every soldier, and creating a satisfying career in the Army. At the same time, promotions must meet the needs of the Army. The ability to promote soldiers varies because it depends on establishment vacancies and the availability of qualified soldiers. Only soldiers who have proven ability and experience, who demonstrate potential to cope with the responsibilities of higher rank, and who are qualified and recommended, are promoted. Sometimes there are more eligible soldiers than there are vacancies - in short the 'supply exceeds the demand'.

MERIT - THE BASIS OF PROMOTION

Simply put, promotion is based on merit. The Army can readily identify its most capable men and women by taking into account conduct, qualification, past performance potential to do well at the next higher rank and your seniority.

THE 'TOTAL FILE CONCEPT'

When considering soldiers for promotion, the Army uses the total file concept. This means that a soldier's whole record is studies to ensure fairness. No one single factor - one annual or course report, one posting, or one individual award or achievement is considered in isolation. This is made possible because every action that affects you is processed at the Central Army Records Office - CARO - by the Personnel Employment Group - PE Gp.

AUTHORITY FOR PROMOTION

A Commanding Officer has the authority to take the first step and promote soldiers to Lance-Corporal or Corporal within the unit. But if you are to be promoted to those ranks on posting, the Director of Personnel Employment - DPE - is the authority.

The authority for promotion to senior NCO and warrant rank in the Australian Regular Army is centralised at Army Office level with the final processing handled by the PE Gp.

This arrangement ensures uniformity within the Army because all eligible soldiers - those who are fully qualified by December 31 of the previous year and recommended by their CO - are considered, regardless of their present posting.

PROMOTION PROCESS

The promotion process starts when a CO recommends promotion and submits a Report Other Ranks - AAF A26A - through Corps Directorates to PE Gp. If your CO does not recommend your promotion he will say why and explain how you can reach the required standard. AAF A26As are forwarded by units to reach Corps Directorates by November 15th each year.

Directors review the A26A and endorse them with the ECN in which you are to be streamed for promotion.

This is generally your primary or base ECN.

Corps Directors also state whether there is any special Corps promotion requirements and their recommendation for promotion.

When the reports are received by PE Gp they are examined to ensure completeness, accuracy and the target rank is confirmed.

Files of all soldiers eligible for consideration for promotion are then assembled according to the target rank for promotion.

Reports are "scored" by giving numerical values to commanding officers' assessments in each of the reports submitted on each soldier during the three years.

Results of this scoring are recorded in a computer programmed to apply a weighting factor to give some recognition to the most recent reports.

The fact that some ECNs are classed as being in operations, training, logistics or specialist streams is also given consideration.

Subsequently, the computer produces a list of all eligible soldiers, in an order of merit by Corps, target rank and ECN.

This is known as the preliminary "Merit Order Other Ranks" - MEROR - list which is used by the DPE and the Promotion Advisory Board - PAB - when considering each individual's total personal file.

The MEROR list and your score are handled on a "need to know" basis to preserve confidentiality and the PE Gp ensures strict control of this aspect.

The DPE, in consultation with the PAB, then considers all eligible soldiers for substantive promotion to senior NCO and warrant ranks during the annual promotion series which begins in February and ends in May.

The PAB comprises SO1 PE Gp, your Corps Director or his representatives and the SO2 in charge of the relevant promotion section in PE Gp.

Promotion to warrant officer is usually dealt with first followed by promotion to staff sergeant and sergeant.

During the series the complete written record of all eligible soldiers is examined personally by the DPE and PAB and an assessment is made of trade qualifications, course reports, previous AAF A26A, breadth and depth of experience, citations, conduct, medical status and seniority.

The procedure for promotion consists of two parts, clearance and selection.

Soldiers the DPE consider suitable for promotion are "cleared" on merit irrespective of known or forecast vacancies and their files are then endorsed accordingly.

Every soldier who has been considered for promotion is advised of the decision as soon as possible after each Corps segment of the series is completed.

Those cleared for promotion are recorded on a confidential Final Order of Merit List.

The list - which does not include the MEROR score - is sent to Corps directorates who initiate promotion of soldiers to Sergeant and above.

The next step is to take promotion action on selected soldiers who have been cleared.

As establishment vacancies occur, Corps directorates submit a Recommendation for Posting - Form F Post 1 - to CARO following as closely as possible, the merit order, but subject to any Army requirements.

The records of soldiers whose promotion has been recommended are once again screened to ensure standards have been maintained.

If they have, promotion is approved and PE Gp raises the Routine Order Part 2 or posting order as appropriate.

Regardless of the time of year the vacancy occurs, all soldiers promoted before the next promotion series are given seniority of February 1 in the year they were last cleared.

For example: A soldier who was cleared in March 1977, who is selected and promoted in August, has seniority of February 1, 1977.

Cleared soldiers not promoted due to lack of vacancies will be included in the next promotion series if they continue to be recommended by their CO.

TEMPORARY PROMOTION

Temporary promotion is not granted lightly. Commanding officers may approve promotions to temporary Corporal to meet unit requirements; but temporary promotion to senior NCO or warrant rank must be in the interests of the Army as a whole and the processing is done at CARO.

Many things are considered before temporary promotion to senior NCO rank is approved.

For example:

. The soldiers must be recommended for promotion to the higher rank by his CO.

. The soldier should be qualified for the higher rank.

. The rank is essential for command purposes.

. Temporary rank is held only while a soldier remains posted to the position into which he was promoted, or for such additional periods which may be approved by the DEP or the SOl PE Gp CARO.

. Temporary rank is granted only where circumstances prevent the vacancy being occupied by another soldier who is cleared for promotion or who holds the required rank.

. The soldier's performance and conduct has been satisfactory.

. It is assessed that the soldier will be cleared for substantive promotion at the next series.

ROAD TO SUCCESS

The DPE suggests how soldiers can start themselves on the road to higher rank:

. Continually seek to gain all promotion qualifications - remember you cannot be substantively promoted unless you are fully qualified. Talk to your superiors about your attendance at career progression courses.

. Achieve and maintain a high level of proficiency - remembering that promotion is based on merit.

. Make certain you know the primary ECN (Career Stream) in which your Head of Corps has you recorded because under the centralised system you compete for promotion in your primary ECN.

. Ensure that your highest education standard is recognised by the Director of Army Education BEFORE the submission of your annual report.

. Don't forget that the burden of movement within the Army must be shared by all soldiers.

. If you have been selected for a job which will involve

movement on promotion and you claim to be unable to move, your promotion chances may be prejudiced.

Also remember that the Army is prepared to try and adjust movements to fit in with family circumstances.

CORPS CAREER MANAGEMENT GUIDELINES

The Directorate has introduced guidelines for the career management of RAA other ranks. These guidelines were drafted with the Army promotion system and posting policy as principle factors. The guidelines were prepared in two parts:

- Career Streaming.
- Career Progression.

It is intended to reprint the guidelines in future issues of the Liaison Letter.

FIREX 76

"... the largest Field Artillery exercise in the free world...."

By

Major Thomas K. Gaither, FA
S-3
XVIII Airborne Corps Artillery

Major Bobby J. Getz, FA
Assistant S-3

FIREX 76 was more than the largest Field Artillery exercise in the free world. FIREX 76 was a coordinated exercise to train artillerymen within the sections, batteries, battalions, groups, division artilleries, and corps artilleries to improve their abilities to deliver timely and effective artillery fires at all levels. The exercise included units from the Active Army, the Army National Guard, the Army Reserve, the US Marine Corps, the US Air Force, and the US Air Force National Guard. FIREX 76 was conducted in the training areas of Fort Bragg, from 11 through 14 November 1976. The dates spanned the week-end to permit Reserve and National guard unit participation.

Twelve Field Artillery battalions and four separate Field Artillery batteries participated in the exercise with weapons ranging in size from 105mm howitzers through 175mm guns. Over 6,000 personnel, including support troops, participated in the exercise.

The exercise was conducted under the control of XVIII Airborne Corps Artillery with Field Artillery units participating from the 82nd Airborne Division Artillery, the 101st Airborne Division (Air Assault) Artillery, the 2nd Field Artillery Group (USMC), the 113th Field Artillery (Kentucky National Guard), and the 4th Battalion, 17th Field Artillery Group (USAR). The 1st Battalion, 84th Field Artillery, 9th Infantry Division Artillery, Fort Lewis, Washington, participated using the equipment of the XVIII Airborne Corps Artillery's 1st Battalion, 39th Field Artillery which was training at Fort Lewis during the exercise.

Support personnel were provided by the 1st Corps Support Command, the 12th Aviation Group (CBT), the 16th Military Police Group, the 20th Engineer Brigade, and 35th Signal Group, MIBARS and the 4th PSYGPS Group. The US Air Force supported the exercise by transporting elements of the 101st Airborne Division (Air Assault) Artillery to Fort Bragg from Fort Campbell, Kentucky, and by providing Aircraft for reconnaissance and live-fire close air support(CAS) missions. Marine Corps aircraft supported the exercise by conducting CAS missions in support of planned operations.

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The scenario around which the exercise was developed embodied the philosophy of the "Quick Win" concept involving the three services. The exercise was divided into three phases. Phase 1 consisted of inserting Airborne and Air Assault forces astride the enemy's main lines of communications (LOC) thereby seeking to entice and canalize the enemy forces into preplanned Armour Annihilation Zones (AAZ). Phase 11 consisted of enticing enemy forces into the preplanned AAZ's. During Phase 111, enemy forces were encircled and sealed in the preplanned AAZ's. The Corps then conducted operations incorporating massive indirect fires and airstrikes to annihilate the enemy forces trapped in the AAZ's. Although range constraints at Fort Bragg inhibited the ability to conduct a free play exercise with simultaneous airborne and airmobile insertions, exercise play did enable conduct of enticement and encirclement operations around the major impact areas.

All FIREX objectives were achieved:

* Artillery fire support and coordination procedures were improved.

* New doctrine and techniques to increase responsiveness were evaluated.

* Corps level fire planning, fire support coordination and live-fire artillery gunnery was accomplished.

* Joint command and staff training was accomplished.

* Nuclear fire and nuclear release procedures were incorporated into fire planning.

* The Corps Combat Support and Combat Service Support elements and the Corps Tactical Communication System were effectively utilized.

* A 4-battery battalion with 8 guns per battery was organized and tested under field conditions.

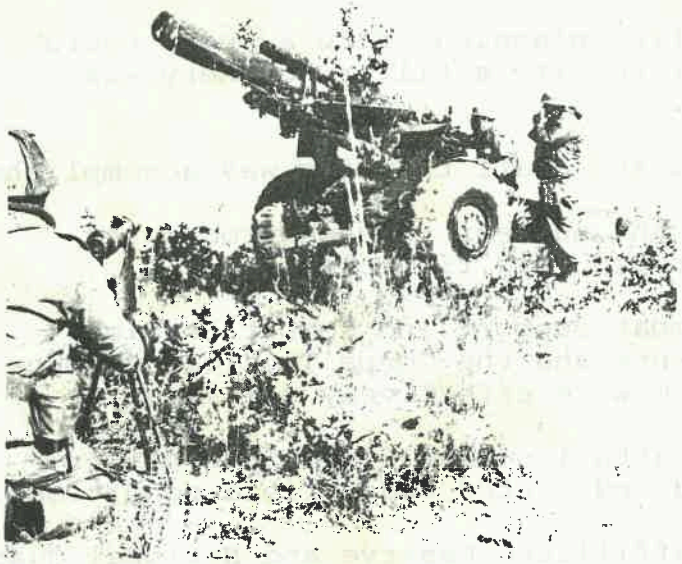
* Training of affiliated Reserve and National Guard units was accomplished.

Emphasis during the exercise was on physical and firepower mobility. Physical mobility was achieved through frequent day and night moves which improved survivability and, through careful planning, provided the bulk of the Corps Artillery well forward to influence the action. A total of 97 battery-sized moves were executed in support of operations under simulated but realistic combat conditions, of which 21 were airmobile moves. To preclude check fires and to reduce aircraft vulnerabilities, aircrews employed terrain and map of earth flying techniques.

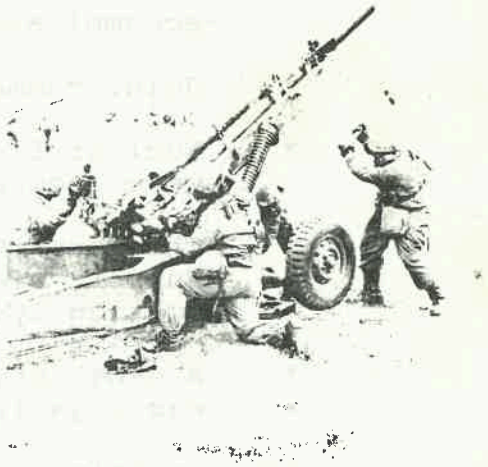
Firepower mobility was achieved through detailed joint fire planning. Extensive and continuous fire support coordination insured the responsive massing of fires, uninterrupted by round-the-clock repositioning of firing element.

All Army artillery units applied new doctrine contained in recent US Army Field Artillery School Training Circulars. The new doctrine had broad implications for both the DS and GS artillery roles, all geared towards improving the combined arms team's ability to mass rapidly decisive firepower on the battlefield at the crucial point in the battle. The XVIII Airborne Corps has incorporated the new doctrine into recent CPX's, ie, CABER WARRIOR, CABLE CUTTER, ABLE ARCHER and SOLID SHIELD, FIREX 76 enabled the employment of the new doctrine into support of the Airborne/Air Assault, Enticement/Encirclement Anti-Armour concept as part of a tactically realistic live-fire exercise.

Target intelligence was developed to support a fast moving, fire power oriented scenario. Circuits leading to the Divarty TOC's were deliberately saturated with intelligence data because it was there that the decisions had to be made regarding how, when, where and at what fires would be directed. The exercise provided the opportunity to debug the systems and to train key staff and command elements who play vital roles in intelligence, target acquisition and fire support.



A howitzer section of the 1st Bn, 84th Arty



A unit of the 101st Div Arty

Close air support targets were marked with Marine Artillery Firing White Phosphorus (WP) rounds. Although not a new technique, this procedure kept the airborne Forward Air Controller (FAC) out of the immediate target area and allowed concurrent artillery firing during delivery of Close Air Support (CAS) munitions. Aircraft employed high threat tactics. A PPN-18 beacon was also used by Marine ANGLICO teams from Camp LeJeune to direct CAS strikes in support of operations. This procedure proved effective, again improving the proficiency of the Combined Arms Team.

FIREX 76 was an ideal training vehicle for the reserve component artillery battalions participating in the exercise, providing them their only opportunity during the year to train with Active Army units in a live-fire exercise. Participants

were able to evaluate the state of training readiness of their units. Weak areas indentified will form a basis for planning future training.

Another major factor was the emphasis placed on COMSEC procedures and camouflage techniques. FM secure voice communications were used extensively with frequencies and call signs being changed a minimum of twice daily. Although electronic countermeasures (ECM) were employed, the frequent changes in callsigns and frequencies insured continuity of operations.

Throughout the exercise, camouflage training was evaluated. US Air Force and Army Aviation reconnaissance missions were targeted against exercise participants. Units who violated survivability considerations or were located by target acquisition means were required to displace to new positions or were provided on-site instruction as required to correct deficiencies.

FIREX 76 was logistically supported from tactical field sites. The 1st Corps Support Command provided a large measure of the services which included GS/DS maintenance Support and the establishment of a field Ammunition Supply Point (ASP). Support requirements to sustain an operation of this magnitude provided an ideal opportunity for realistic training in a tactical environment for service support elements. A Logistical Support Activity (LSA) provided Class I, II and IV supplies plus equipment maintenance support. Water and shower points were established and maintained. The 8th Ordnance Company deploying in conjunction with an annual readiness evaluation maintained a tactical Ammunition Supply Point which stored and distributed approximately 6,000 rounds of artillery ammunition, FIREX provided training benefits for the unit which are not available in other exercises.

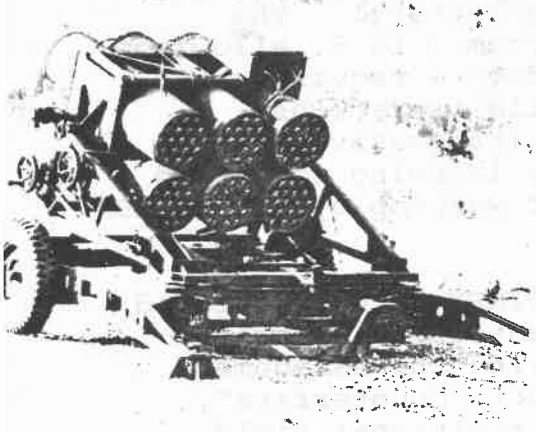
During FIREX 76, a new concept to improve firing responsiveness and flexibility was tested by units of XVIII Airborne Artillery. In a special organization for combat, the 1st Battalion, 73rd Field Artillery was augmented with weapons from the 1st Battalion, 6th Field Artillery to form a four battery battalion with 8 guns in each battery. The reorganization increased firing elements from 3 to 8, allowing the battalion and batteries to react rapidly to requirements for firepower. Through extensive airmobile operations, tremendous firepower was available to simultaneously conduct routine fire missions and raids. A study is being completed that critically analyzes the concept as it was employed in FIREX 76.

One of the major efforts during FIREX 76 was directed toward the field evaluation of the new counterfire doctrine under realistic tactical conditions. During the assignment of missions specifically designed to support "Counterfire", it became apparent that none of the four traditional field artillery missions was, in and of itself, adequate to produce the results for which the new doctrine was conceived. A proposed new mission which encompasses appropriate inherent

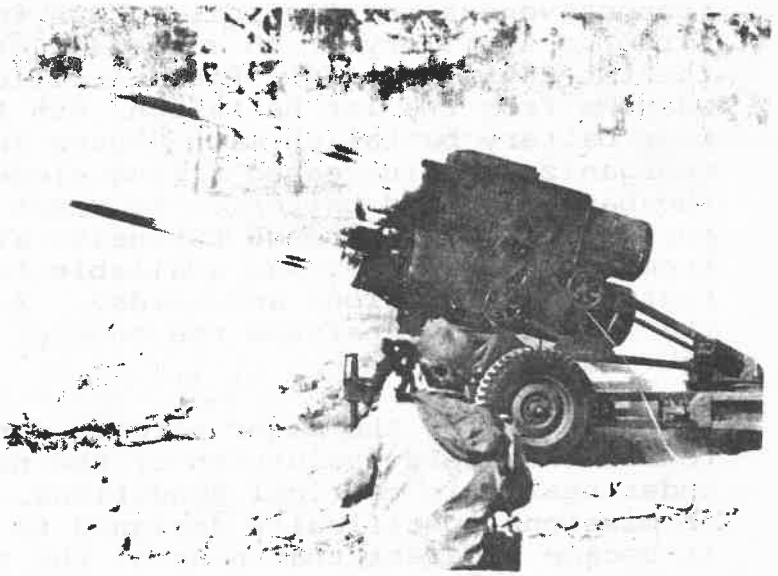
responsibilities that accomplish counterfire doctrine is currently being staffed at XVIII Airborne Corps Artillery and with FIREX 76 participants. "Direct Support" and "Reinforcing" missions provide the majority of ingredients for "Counterfire" but fail to provide artillery assets with which the Corps Commander can influence the situation. "General Support" and "General Support Reinforcing" missions provide fires responsive to the Corps Commander but do not provide for the quick fire channels and required liaison which constitute the counterfire foundation.

Concurrent with the inadequacies which were determined to exist in the traditional Field Artillery missions, it was discovered that emergency action channels/procedures to accommodate transmission of nuclear weapons related information are not provided for in the non-nuclear capable Division Artilleries. Proper procedural/mission changes necessary to support new doctrine are inevitable. The realistic environment provided by FIREX 76, and the field testing therein of counterfire, should result in a significant contribution to the Field Artillery community.

A new weapon system, a 2.75 inch multiple rocket launcher under development by Redstone Arsenal was test fired and evaluated during FIREX 76. SLAMMER, as the system is called, consists of 6 M-200 rocket launcher pods of 19 rockets each mounted on a modified M-91 Chemical launcher. SLAMMER has the capability of firing its complement of 114 rockets either singularly or in groups. All rockets can be fired in less than 30 seconds. Firings of the SLAMMER were incorporated into mass fire missions during FIREX 76. SLAMMER performed adequately as an area fire weapon, placing a high volume of destructive fire on the target with acceptable accuracy. Developmental firings will continue at Redstone Arsenal.



Slammer, a 2.75" MRL



Adjusting Rounds

The night Vision Laboratory, Fort Belvoir, made available during the exercise a Night Observation Device, Long Range (NODLR). The NODLR was used to acquire targets and adjust artillery fires without illumination. It greatly enhanced the element of surprise and increased the probability of first round target hits. By eliminating illumination of the battlefield, the individual's night vision was preserved and position security of friendly front line elements and artillery firing positions were protected.

A high state of readiness is the ultimate and most important goal of every unit in the Army. FIREX 76, by providing a means to train troops in the field under realistic simulated combat conditions, aided participating units significantly in the pursuit of that gaol. Firing procedures, communications systems, camouflage, artillery position defense and all phases of support from field locations were tested and improved.

FIREX 76 was much more than an artillery live fire exercise. It was an exercise in joint training with Army, Marine Corps and Air Force units working in close cooperation with each other. The National Guard and the Reserves military proficiency was improved by working together with Active Army units.

Once the firing had ceased and the smoke had cleared from the battlefield, it was readily apparent that FIREX objectives had been met and, in most cases, exceeded. Participants unanimously declared FIREX as "the most valuable training we have all Year". FIREX was tactically realistic. It allowed artillerymen to develop and execute joint fire support at the Corps level; it involved the entire spectrum of deployment considerations. It was the "One Army" in action. Most important, FIREX 76 was XVIII Airborne Corps' most effective training vehicle for ensuring that all firepower assets available to the Corps are prepared to assure the success of the "Quick Win" concept.

MAN-PORTABLE AIR DEFENSE SYSTEMS

(A COMPARISON)

By

Captain Rhoi M. Maney

Editor's Note: The technical nature of the information in this article would seem to make it more valuable to our technicians than to readers in general. However, the extent of the information is sufficient to capture the interest of virtually all readers, especially airdefensemen.

The worldwide development of manportable air defense systems since World War II has added a new dimension to modern conventional warfare. These systems are lightweight and can be deployed easily and flexibly throughout the forward battle area. Moving with frontline combat troops, these unique systems can continuously provide responsive local air defense during hours of daylight in good weather conditions. The systems presently in existence throughout the world have many similarities in their configurations, performance, and functioning. However, each system has marked differences in capabilities. Presently, six manportable air defense missile systems are either fielded or under development. They are produced by the United States, Great Britian, Sweden, and the Soviet Union.

The manportable, surface-to-air missile systems are of two varieties, command or passive guidance. Within the category of passive guidance air defense weapons, the three present systems are the SA-7 Grail, produced by the Soviet Union, and the US Redeye and Stinger, the latter of which is still under development. These systems incorporate many commonalities in their design, operation, and basic functioning. Each is characterized as a manportable, shoulder-fixed, clear day-only operation system requiring visual target acquisition. Each system employs contact fuzing with small warheads for target destruction and passive infrared homing guidance through proportional navigation. However, a detailed study of these three systems discloses notable differences in their capabilities and applications. A comparison of their detection systems reveals differences in the operation of their seeker section. The seeker head is a sealed infrared optical tracker containing a folding reflective optical system that functions as a space stabilized gyroscope. The seeker section, which houses an infrared energy detector, senses the infrared energy

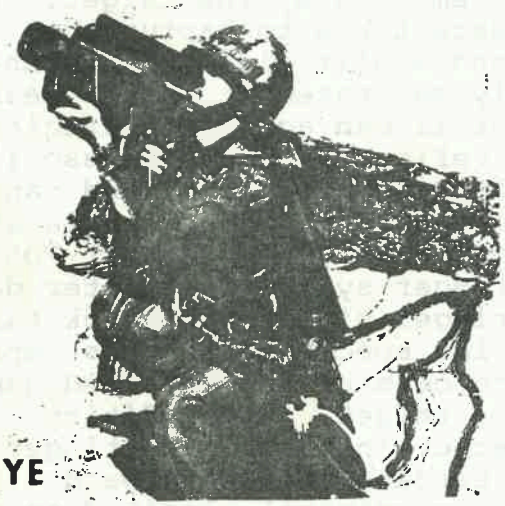
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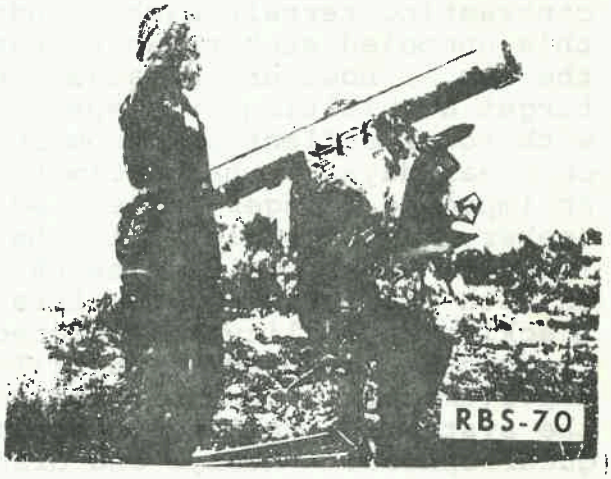
emitted by aircraft engines and their exhaust plumes. The detector cell converts the infrared energy striking its surface into an audible signal that indicates to the gunner when the missile has acquired the target. Redeye and Stinger missiles employ Freon and Argon gas-cooled detector cells, respectively, which increase missile sensitivity to the target, especially helpful at angles near the sun. Use of a cooled infrared energy detector also insures that these systems are less susceptible to distraction by reflected sunlight from coluds, aircraft canopys, and other sources. A noncooled detector system is used in the SA-7 Grail, which tends to make the Grail less sensitive to infrared energy emitted by the target. Therefore, the Grail seeker is susceptible to capture by contrasting terrain backgrounds and sunlit clouds. Furthermore, this uncooled seeker can be easily saturated at angles near the sun. However, because the Grail can achieve sufficient target acquisition from specular reflectivity often associated with solar reflections from fuselages, rotor hubs, and canopies on clear days, it has a limited all-aspect engagement capability. An improved Stinger seeker section, called the Stinger POST seeker, may be employed in the Stinger system at a later date. The POST seeker will allow the Stinger missile to track targets in both the infrared and ultraviolet spectrums. This improved tracking capability is designed to counter any infrared jamming techniques employed by an airborne target. In addition, improvements in the infrared detector in the basic Stinger give the system the ability to engage targets in the forward quadrasphere. Redeye and Grail are primarily limited to rear quadrant target engagements.

Each of the three missiles employs a control system that uses proportional navigation to guide it to a predicted point of intercept. The functioning of the control section is dependent upon the continual positioning of target infrared energy on the face of the infrared detector cell. This process continues throughout each cycle of the seeker's conical scan pattern. The resulting pattern of infrared energy striking the infrared detector is directly proportional to the angle at which the seeker is tracking the target. Missile maneuvering is initiated by the positioning of a pair of variable incidence wings. These control surfaces are driven by a small servomotor assembly that operates in conjunction with the control section. The control section, sensing the difference in the missile's line-of-flight and the seeker's line-of-sight, transmits guidance commands to the servomotor which changes the attitude of the variable incidence wings. This, in turn, guides the missile to a predicted point of intercept, which is continually computed by the control section throughout missile flight. Both Redeye and Stinger incorporate a pair of fixed wings for missile stability and a pair of variable incidence wings, moving in coincidence with each other, for system maneuverability. The wings are mounted 90° apart on the missile airframe, except for the Grail, which uses only one pair of wings mounted 180° apart on its control section. The wings are alternately commanded and moved between two extreme positions for missile maneuverability. No fixed wings are on the Grail control section.

To provide electrical power to these missiles through out flight, each has an on-board, squib-activated thermal battery. The missile battery contains a solid electrolyte, which is in a dormant state. The electrolyte is surrounded by a pyrotechnic paper that ignites upon activation and melts the electrolyte to render it active for immediate use just prior to missile launch.



REDEYE



The fuze and warhead sections of all three missiles are quite similar. All three systems incorporate small warheads that detonate upon impact with, or penetration of, the target. In the event of a target miss, each missile incorporates a self-destruction mechanism in its fuze that detonates the warhead after approximately 15 seconds of flight. The fuze in both the Redeye and Stinger missiles also ignites the second stage of the missile rocket motor. The fuze in the Grail system does not fire the second stage of the missile rocket motor. Instead, a pyrotechnic delay system is used to ignite the missile sustainer motor.

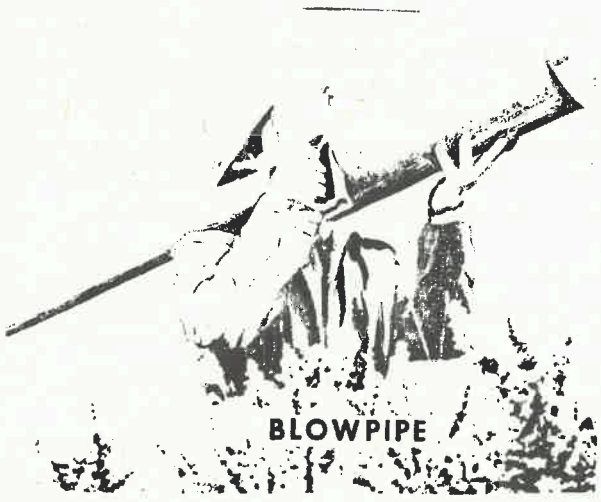
The rocket-motor sections of these missiles are quite similar in that each has a two-stage, three-phase propulsion system. Upon pressing the firing trigger, the eject phase of a rocket-motor operation is initiated. The ejector motor propels the missile from the launcher and is completely expended before the aft end of the missile clears the forward end of the launcher. The missile then undergoes a no-power phase and coasts for a short distance to protect the gunner from toxic rocket-motor exhaust gases. At the end of the no-power phase, the second stage, called the sustainer motor, ignites and initiates the acceleration and sustaining phase of missile flight. This phase culminates in the missile achieving supersonic speed.

The Stinger rocket motor, which has the same functional characteristics as its counterparts, differs somewhat in its configuration. Singer's propulsion system, unlike the self-contained system used by the Redeye and Grail, consists of an externally attached launch motor assembly and a flight motor. The launch motor provides the thrust to eject the missile from the launcher. Once the aft end of the missile and the launch motor have cleared the forward end of the launcher, the launch motor separates from the missile (during the coast phase). This action, in conjunction with the release of a lanyard and the fuzing mechanism, ignites the flight motor, which functions in the same capacity as the sustainer motor used in both the Redeye and Grail systems.

The tail assemblies, used on all three missiles, have similar functions. Each causes a counterclock wise roll of the missile throughout flight, which adds to flight stability.

In each system, the missile is sealed within a disposable launch tube constructed from a reinforced fiberglass material. The missile can be removed from the launcher only by firing. The launchers, except in the case of Stinger, house the sighting and acquisition indicators, as well as all the necessary operational switches to activate and fire the system. In the Stinger system, while the sighting and acquisition indicators are integral parts of the launcher, a separable and reusable gripstock assembly houses all operational controls. In addition, affixed to the separable gripstock is an identification, friend or foe (IFF), system used to aid the gunner in target identification.

All prelaunch electrical power for each system is provided by squib-activated thermal batteries. The power produced by these batteries allows the gunner to perform all prelaunch and final launch operations. Although the function of these batteries is similar, those in both the Redeye and Stinger systems incorporate a charge of compressed coolant gas. The gas is channeled from the battery into the missile where it cools the infrared energy detector prior to missile launch.





These weapons, characterized as being highly mobile, weigh between 23 and 35 pounds. This mobility allows the systems to operate in terrain that is inaccessible to other air defense systems.

The remaining manportable air defense surface-to-air missile systems fall into the category of command-guided weapons. These include the Blowpipe and the RSB-70, produced by Great Britain and Sweden, respectively. In addition, a system designated Stinger Alternate has been evaluated by the United States.

Like their passive homing counterparts, each of the command-guided systems is a relatively lightweight, manportable, surface-to-air missile system designed for the protection of frontline troops from low-level air attack. Although the command-guided systems are remarkably similar in their capabilities and principles of operation, each has numerous individual distinctions that become apparent upon close examination. Employing advanced guidance technology, these systems achieve missile guidance through use of a guidance and tracking unit that must be operated by the gunner throughout missile flight. A distinctive example of advanced command guidance is illustrated in the RBS-70 and the Stinger Alternate systems. Each of these weapons employs an optically directed laser beam-rider guidance system. Upon sensing any missile deviation from the center of the projected laser beam, electrical impulses are generated in an on-board receiver and transmitted to a rate sensor assembly. The assembly generates inputs to the missile's automatic pilot. As a result, the autopilot, or computer in the RBS-70 system, generates error guidance corrections that are processed through an integrated control assembly for missile guidance. Incorporated in the Stinger Alternate system, reaction control nozzles located just forward of the missile aft section aid the missile in achieving both stability and realinement with the projected laser beam. In both systems the process of the missile's constant alinement with the laser beam is continued throughout missile flight until target intercept has been achieved. The basic principle involved in these systems is that the missile will ride the laser beam to whatever point it is projected.

A contrast to the laser command guidance system is the optical tracking and radio command guidance system used in the British Blowpipe. In this system, guidance commands from the guidance unit are transmitted to the missile by means of an FM radio frequency link. Reception antennas in the missile receive the guidance commands generated and transmitted by the guidance unit. Guidance commands are processed through a receiver and decoding network in the missile and then passed to the control section in the forward end of the missile. The control system operates on a "twist and steer" principle and provides mechanical movement to two pairs of control surfaces mounted peripherally on the nose of the missile. The control surfaces, while working differentially, produce missile roll and lateral movement. Maneuver commands sent to the missile are generated by the movement of a small, manually operated joystick located on the guidance unit. Aided by detection

flares mounted on the rear of the missile, the gunner visually determines what corrections are necessary to insure target intercept, since both missile and target are within the field of view of the sight system. The gunner must actually fly the missile to the target by manipulating the guidance joystick. The fins, located on the aft end of the missile, serve only to maintain missile stability throughout flight.





To provide electrical power during flight, each system incorporates an internal squib-activated thermal battery that is activated just prior to missile launch. The battery provides the necessary power for all missile electronic functions.

The fuze and warhead section of the RBS-70 and Blowpipe systems are similar in that they employ larger warheads than their passive homing counterparts. The RBS-70 and Blowpipe incorporate selective fuzing mechanisms for either impact or proximity detonations. Although Stinger Alternate, if adopted by the United States, may incorporate a proximity fuzing capability, it is not known whether it will have a selective fuzing system. Each of these command guided systems may be employed against ground targets with some degree of effectiveness.

The propulsion systems in these command-guided weapons incorporate the same basic functional design as their heat-seeking counterparts. Each has an eject phase to propel the missile from the launch tube, a coast (no-power) phase to protect the gunner from toxic rocket-motor exhaust gases, and an

acceleration-sustain phase during which the missile achieves supersonic velocity.

Command-guided systems employ a detachable guidance-tracking unit that mates with its respective launcher in a matter of seconds. On the RBS-70 and Blowpipe controls, necessary to perform prelaunch, launch, and guidance functions, are an integral part of the guidance unit. Stinger Alternate has several operational controls on its guidance unit as well as on the launcher for command and control of the system. The RBS-70 and Stinger Alternate both use stabilized sights that attenuate all gunner induced movement during an engagement. Also included in each of these laser guidance units is the laser beam projector, a transmitter assembly, a zoom optical subassembly, and other associated electronics necessary to track and designate a target. In contrast to these laser guidance units is the FM radiofrequency command guidance unit used for generating missile guidance in the Blowpipe weapon system. Contained in the Blowpipe guidance unit is an automatic gathering system, which assists the gunner in situating the missile in the center of the guidance unit field of view immediately after missile launch. In addition, an FM radiofrequency transmitter assembly and a monocular sighting system are housed in Blowpipe's guidance unit.

All command guided systems can accommodate an identification, friend or foe, system. An added safety feature of the Blowpipe and RBS-70 IFF system is its ability to electronically prevent the engagement of friendly aircraft due to incorrect identification by the gunner.

Peculiar only to the RBS-70 is its capability of being electronically linked to a specially designed search radar designated the PS-70/R. By means of radio communications links and an audible tone transmitted to the fire unit from the radar system, as many as five fire units can be directed to the azimuth of approaching aircraft. In addition, all fire units can be simultaneously updated on target speed, flight course, and target position during each engagement.

The power sources necessary for performing prelaunch operations and transmitting guidance commands to these command guided missiles while in flight are varied. For example, a standard Swedish Army battery is the power source for the RBS-70 guidance-tracking unit. The Blowpipe guidance-tracking unit is powered by a thermal battery arrangement located within the launcher canister assembly. The Stinger Alternate system uses a battery power pack contained in the guidance-tracking unit.

ROVING GUN BATTERIES AND THEIR NEUTRALISATION

by

Colonel V. Saksonov

Modern self-propelled guns (SPGs) possess high manoeuvrability: within a couple of minutes they can occupy firing positions and get ready to open fire, quickly fulfil a fire mission and change position. Most SPGs are armoured and it takes quite a few shells to knock them out.

Fighting against roving batteries demands high organisation and team-work of artillery subunits and excellent training standards of their officers and men.

A roving battery carries out its missions from several firing positions, simulating an artillery group. To create the impression of artillery group actions and consequently to draw attention of the enemy's reconnaissance, roving batteries fire only at the most important targets. The battery commander does his best to secure diverse, adjusted, accurate and effective fire. The battery can fulfil its missions by day and by night using illumination means and radio equipment.

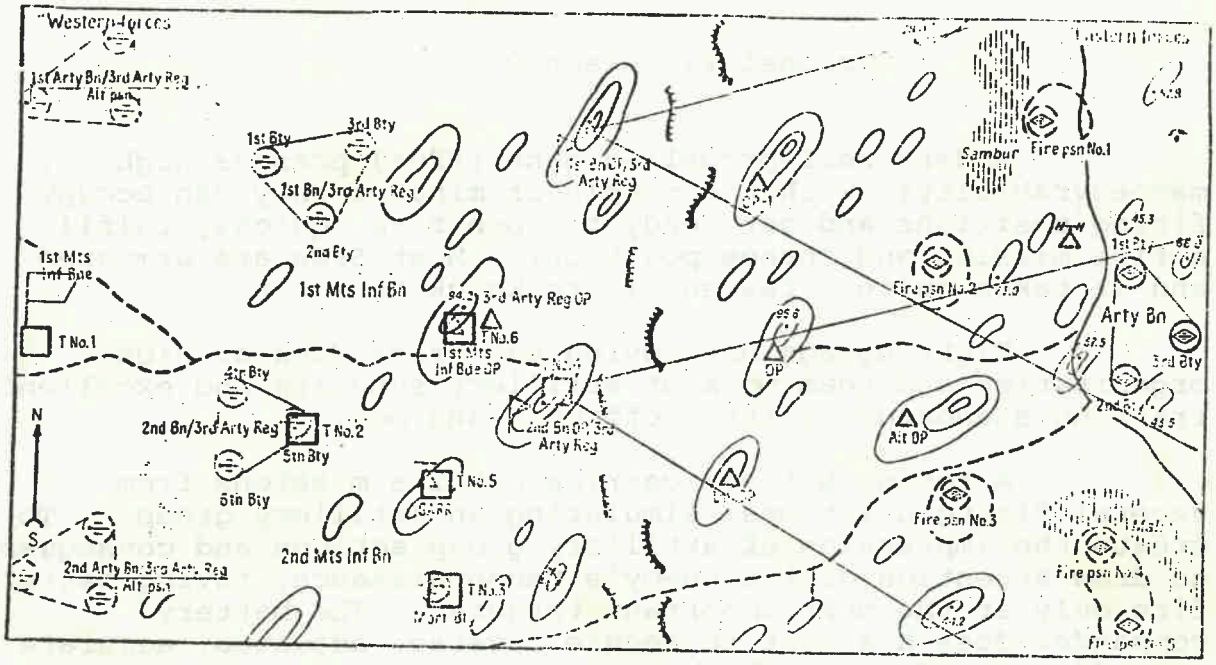
Firing positions and OPs for a roving battery are chosen in areas where the actions of an artillery group are to be simulated. It is also very important to have convenient and unobserved access routes ensuring a quick change of firing positions. Two or four and sometimes even more firing positions are prepared for a battery. This makes it possible to simulate the actions of one or two artillery battalions.

The number of OPs depends on the character of the terrain and the situation. A battery may have one or two OPs, one occupied by the battery commander and the other by the control platoon commander with one or two recce men and a radioman. The latter is used if it is difficult or impossible to adjust fire from the battery commander's OP.

The actions of roving batteries are planned in detail by the senior artillery officer. To this end a "Plan of Roving Batteries' Actions" is drawn up showing the batteries, the order and time of their actions, firing positions and Ops, fire missions, recce equipment, ammunition consumption and so on.

When carrying out certain tasks the battery is served by a radar station, a helicopter or aligned OPs of the artillery battalion.

This article appeared in the November 1977 issue of the Soviet Military Review.



The battery commander can open fire at the time indicated in the plan or on the command (signal) of the senior commander.

Firing positions are not organised completely - pits for the crews are dug but those for the guns are only designated. It is sufficient to choose for SPGs even ground with a side slope of not more than 20 degrees.

Some firing positions may be decoy ones with dummy guns. Fire from such positions is simulated by roving batteries.

Here is how the fighting against a roving battery was organised at a tactical exercise in a desert.

The "Eastern" and "Western" forces, holding defences, accumulated forces for decisive combat actions. The "Eastern" forces employed a roving battery on one sector. Its actions were so sudden that for a time it was difficult for the "Westerners" to organise successful fighting against it.

This was due to the fact that the "Westerners" failed to organise properly the tour of duty of officers and artillery recce men at artillery subunits' OPs. The battery was therefore spotted and flash-ranged with delay and had time to change positions. The "Western" forces had to take definite measures. They organised officers' tours of duty at OPs and firing platoon positions, defined the reconnaissance

sectors where artillery subunit commanders were responsible for neutralising the roving battery and began to make wide use of technical equipment for detecting this battery and serving the friendly artillery.

Then events developed as follows (see Sketch).

The roving battery of the "Easterners" occupied firing positions in the area of Heights 66.0, 57.5, 43.5.

The battery commander was ordered: to carry out on-the-spot reconnaissance and choose firing positions in areas Nos. 1, 2, 3. In area No 4 (Mali Saline) to prepare dummy firing positions (No 4 and No 5).

The battery commander was given an extract from the roving battery's plan of action.

The battery commander chose firing positions and set missions to platoon commanders.

In the battery a survey of all firing positions was made, the ammunition was prepared, the co-ordinates of the targets to be destroyed were designated, a gun was detailed for night firing of illumination shells at target No. 5.

Telephone communication was established between OPs (OP, OP No 1, lateral OP, Alt OP). Communication with fire platoons was maintained by radio.

The signal "Start" for changing firing positions followed by the number of a firing position was established.

Soon the battery occupied firing position No 1. Using basic firing data, the battery commander gave the order to open fire.

The battery fired the established number of shells at target No 6 in seven minutes. After that it started moving to firing position No 2.

Then the battery carried out fire missions according to the operations plan.

The artillery battalion CO of the "Western" forces was ordered to flash-range and neutralise the roving battery. He ordered the reconnaissance officer to intensify observation and, using the sound-range reconnaissance platoon, to define the co-ordinates of the battery, which was firing.

As soon as the roving battery opened fire the sound-ranging platoon defined its co-ordinates. The artillery battalion CO prepared basic firing data according to these co-ordinates, and ordered two batteries (one battery had suffered losses) to open fire. After the fulfilment of the fire mission the battalion changed its firing positions, going to the alternate area.

The senior commander detailed one more artillery battalion to fight the roving battery and designated important sectors of reconnaissance and neutralisation for the battalions. 1st Arty Bn: to the right - Height 43.5, to the left - Height 28.0; 2nd Arty Bn: to the right - Height 44.2, to the left - Height 73.0. He ordered continuous observation of the "enemy" battery, using a ground artillery reconnaissance radar (GARR) and preparation of basic firing data for all the detected firing positions in the designated sectors using available photos of the terrain in the "enemy" positions.

During the day the "enemy" roving battery fired at targets No 3 (mortar battery), No 4 (OP of the 2nd Arty Bn), and at night at No 5 (GARR) using illumination shells.

By the next morning the losses of the 2nd Bn (5th Battery) were restored. A proper tour of duty of officers at battalion OPs was organised, communication with the GARR was established and basic firing data on all possible firing poisitions in the sectors mentioned were prepared.

Early in the morning the GARR reported to the 1st Arty Bn CO movement of the "enemy" battery from the area of Height 57.5 in the direction of the Sambur Saline. It was also detected in the area of Height 45.3 from the lateral OP of the 2nd Arty Bn.

The GARR reported to the 1st Arty Bn CO that the battery had stopped in the area of the Sambur Saline. The 1st Battalion immediately opened fire at it.

According to the data of the chief reconnaissance officer, two damaged guns remained on the firing position in the area of the Sambur Saline, the others had moved to another position. Thus, the roving SP gun battery was meautralised as a result of proper measures and co-ordinated actions of artillery subunits.

THE HISTORY OF THE 106TH FIELD BATTERY

ROYAL REGIMENT OF AUSTRALIAN ARTILLERY

by

MAJOR P S Sadler, RAA

INTRODUCTION

One-Oh-Six was first raised in Egypt over sixty years ago. Since then it has seen action in France and South Vietnam; been disbanded four times and reraised three times; served in Singapore; and been garrisoned in Hobart, Brisbane and Townsville. In its time it has been a howitzer battery, a field battery and a trials unit. It has been a part of 22 Howitzer Brigade; 6 Australian Field Artillery Brigade; 4 Field Regiment RAA; and 28 ANZUK Field Regiment.

FOUNDING AND THE WESTERN FRONT

106 Howitzer Battery (together with 104 and 105 Howitzer Batteries), was raised as part of 22 Howitzer Brigade at Moascar, near Ismalia, on the Suez Canal in Egypt. 22 Howitzer Brigade's War Diary records that the first troops arrived on 8 March 1916; that the brigade paraded for the first time as a unit on a 2 Division Artillery parade on 12 March; and then entrained for Alexandria on 17 March. 22 Howitzer Brigade sailed for Marseilles on 19 March, arriving on 25 March.

2 Division Artillery, (4, 5 and 6 Australian Field Artillery Brigades and 22 Howitzer Brigade), moved from Marseilles to Le Havre where new 18 pounder guns and 4.5 inch howitzers were issued on 27 March 1916. On 8 April, 2 Division took over part of the front line South-East of Armentieres from 34 (British) Division. 22 Howitzer Brigade took over positions from 176 Brigade Royal Field Artillery on 10 April, less than five weeks after being formed. (In his 'Official History of Australia in the Great War', C.E.W. Bean records that the Royal Artillery gunners left their old, worn guns in position for 2 Division Artillery units to take over, and took the Australians' brand new guns in lieu!). Initially 106 Howitzer Battery occupied billets in the 1 Division area, and did not join the rest of the brigade until 30 April.

6 Australian Field Artillery Brigade's diary records that they had 105 Howitzer Battery attached from 22 Howitzer Brigade at least as early as 13 April. The diary entry for 29 April reads (in part) '...handed over 105 How Bty and took over 106 How Bty...'. Thus began 106 Howitzer Battery's long association with 6 Australian Field Artillery Brigade. It was to last, almost without interruption, for nearly 35 years.

Both brigade diaries record that 106 Howitzer Battery first fired on 5 May 1916. The 6 Australian Field Artillery Brigade diary entry gives a mildly dramatic account of 106 Battery's first shots fired in anger:

> 'Bois Grenier. 5 May 1916. The Mobile How 106 Battery at 1 am fired 18 shells from H30, B1.5 at Bas Hau, Ferrentic and Bas Champs. Two loud explosions were heard after firing at Bas Hau'.

The 22 Howitzer Brigade diary records the implementation of a major reorganization of the British and attached artillery on the Western front, when howitzer brigades were abolished and their batteries distributed to existing 18-pounder brigades.

> '13 May 1916. 1200 hr. 104, 105 and 106 Batteries taken over by 4, 5 and 6 FA Bdes. 19, 20 and 21 Bdes were transferred, making this the 22 FA Bde. HQ 22 How Bde transferred to 22 FA Bde. The batteries remained grouped as before for tactical work'.

6 Australian Field Artillery Brigade diary merely records:

> '14 May. 1800 hr. New establishment created. 106 How Bty joins Brigade and 21 Bty going to 22 AFA Brigade'.

(See C.E.W. Bean, 'Official History of Australia in the Great War', Volume 5, Appendix 1, which explains this, and other, reorganizations affecting the Australian Artillery during World War I).

106 Australian Field Artillery Brigade was organic to 2 Division Artillery until the spring of 1917, when it became an 'Army Brigade' and served where, and as, required.

From April to July 1916, 6 Australian Field Artillery Brigade served in Flanders, mainly around Ypres. Between July and September 1916 it was on the Somme, then back to Flanders for a fortnight. It was in Picardy from October 1916 to May 1917, then back to Flanders between July 1917 and April 1918, and on the Somme again from April to July 1918.

In August 1918 the Brigade took part in the drive to the Somme River. The following month it was with Australian and American troops in the attacks on the Hindenburg Outpost Line and the push to Le Cateau. In October 1918 the rapid advance left the Brigade behind - its exhausted horses could tow the guns no further.

Like most AIF troops, 6 Australian Field Artillery Brigade was not actually involved in the final fighting up to Armistice Day. During December the Brigade moved East and took up a garrison position at Boussu - Lez - Walcourt in Western Belgium, where it remained until disbandment in March 1919.

During World War I, 106 Battery, as part of 6 Australian Field Artillery Brigade and occasionally acting independantly, supported 1, 2, 3, 4 and 5 Australian Divisions; 32 and 62 British Divisions; and 27 and 30 American Divisions. The 6 Australian Field Artillery Brigade diaries record that 106 Howitzer Battery members were awarded two Military Crosses; one Distinguished Conduct Medal; seven Military Medals; one Meritorious Service Medal; one Mention in Dispatches and one Belgian Croix de Guerre.

The citations for some of these awards add substance to the bland statistics of the war's progress and show the character and bravery of some of the men who made up the battery.

The battery's first award was a Military Cross to Lieutenant R. Collings in July 1917 for:

> '...having regard to the heavy shelling and the fact that all its own officers were incapacitated one by one, the continuation of the battery continually in action ... was essentially due to the character, bravery and self discipline of this officer...'

Bombadier W.J. Wilson won both the Distinguished Conduct Medal and the Military Medal, the latter in October 1918 for '...bravery and the delivery of dispatches through HE and gas barrages'.

Perhaps 106 Howitzer Battery's greatest day of glory was 8 August 1918 - the day Ludendorff described as 'Der Schwartze Tag' - when the 4th Army, (which included the Australian Corps), shattered the German front on the Somme. Initially positioned near Villers Brettaneax, 6 Australian Field Artillery Brigade, (supporting 5 Division), moved about 10 000 yards during the day to Bayonvillers.

In the Official History C.E.W. Bean records that 106 Howitzer Battery was caught in heavy shelling and had three guns put out of action near Hamel. The brigade diary records that Gunner H. Holman was awarded the Military Medal during this action for:

> '...bravery and devotion to duty at Villers Brettaneux on 8 August 1918 when he continued firing his gun single handed when the rest of the detachment became casualties.'

Later the diary records that the Battery Commander of 106 Howitzer Battery, Major A.M. Grainger, was Mentioned in Dispatches, in part for:

> '...on 8 August 1918, at Villers Brettaneux having emplaced his battery 1 200 yards from the front line, fought it with the greatest determination and at one time had four guns out of action...'.

The brigade diary does not resolve the discrepancy between Bean's statement that 106 Howitzer Battery had three guns out of action, and Grainger's citation which says that four guns were out of action, for it fails to mention this incident at all! The diary does however record that on that morning, between 0420 hours and 0643 hours, the 4.5 inch howitzers fired 1932 rounds.

6 Australian Field Artillery Brigade spent its last few months quietly at Boussu - Lez - Walcourt. Equipment maintenance, the return of stores, education classes and local leave filled the troops' days, while Christmas Day 1918 was celebrated in a comparatively lavish manner by those who had survived the fighting. The Prince of Wales awarded medals on a parade on 2 January 1919 and later that that month the 'Early 1915-ers' were repatriated to Australia. During February 1919 the numbers dwindled as men marched out.

The last entry in the 6 Australian Field Artillery Brigade diary was made on 9 March 1919. It reads:

> 'Boussu - Lez - Walcourt. Bde marched out for attachment to units of the 4 AFA Bde in accordance with Demob Order 15, and cease to function from this date'.

Across the bottom half of the page is scrawled the final word:

'Finnish'

BETWEEN WARS

6 Australian Field Artillery Brigade was reraised in Tasmania on 31 March 1921. It initially consisted of 16, 17 and 18 Field Batteries and 106 Howitzer Battery, though by 1929 it appears that only 16 Field and 106 Howitzer Batteries were still active. 106 Howitzer Battery was based in Hobart during this period.

The battery was disbanded for the second time on 28 February 1941, when 6 Australian Field Artillery Brigade was reorganized as 6 Field Regiment RAA, (consisting of 16 and 17 Field Batteries).

THE LURE OF THE EAST

One-Oh-Six had to wait a quarter of a century for its second resurrection. In December 1966 it was reraised as 106 Field Battery in 4 Field Regiment at Wacol in Brisbane. During April and May 1967 the battery moved to South Vietnam, where it served with 1 Australian Task Force until March 1968.

Major E.D.M. Cape commanded the battery until December 1968 when Major P.C. Jones took over. Warrant Officers Class Two H. Iddon and D. Duggan were the Battery Sergeants Major.

106 Field Battery was the Direct Support Battery to 7 Battalion RAR for most of the tour. Much of its time was spent in Phuoc Tuy Province, though the battery also operated in Bien Hoa Province during the Tet Offensive in February 1968. On three occasions the battery acted as infantry, forming a 'fifth' company of 7 Battalion during cordon and search operations of villages in Phuoc Tuy Province.

During Operation Ballarat in August-September 1967, Lieutenant N.J. Clark, one of the battery's Forward Observers, won the Military Cross while working with A Company, 7 Battalion. During this particular action the battery fired over 800 rounds in just over an hour.

On Operation Coburg, during the Tet Offensive in February 1968, Gunner M.B. Williams won the Military Medal. He was a signaller with a Forward Observer's party supporting C Company, 7 Battalion.

The battery returned to Wacol for a few months in March 1968. Then, in July 1968, it moved to Townsville to prepare for its second tour in South Vietnam. Under the command of Major D.J. Gilroy, and with Warrant Officer Class Two A.W. Singh as Battery Sergeant Major, 106 Field Battery returned to South Vietnam in February 1970.

Once again the battery was in Direct Support of 7 Battalion RAR for most of its tour, during which it fired about 68 000 rounds, including over 1 000 in one day while supporting a bunker clearing operation by D Company.

Much of the latter part of the tour was spent at the 'Horseshoe' Fire Support Base, though one gun from the battery was deployed on the coast near Long Phuoc Hai as an infantry 'Night Defence Position' called 'Brigid'.

The following members of 106 Field Battery were Mentioned in Dispatches for their service on that tour: Major D.J. Gilroy; Captain B.J. Campbell; Sergeant B.J. Ruddock; and Sergeant M. O'Sullivan (AACC).

The second tour of South Vietnam finished in January 1971 and the battery returned to Townsville. In December 1971 it moved to Nee Soon Barracks, Singapore to become part of 28 ANZUK Field Regiment, where it was under the command of Major J.H. Townley, with Warrant Officer Class Two W.J. Gallagher as Battery Sergeant Major. At the end of its tour in Singapore in November 1973, One-Oh-Six disbanded for the third time.

OF TRIALS AND TURTLES

In October 1975, 106 Battery was reraised for the third time, rejoining 4 Field Regiment in Townsville. Captain R.J. Collins was acting Battery Commander until Major P.S. Sadler assumed command in January 1976. Warrant Officer Class Two E.B.N. Hampson was the first Battery Sergeant Major, followed in May 1976 by Warrant Officer Class Two L.W. McMullin.

After taking its place for a few months as 4 Field Regiment's senior gun battery, 106 Field Battery became the core of the RAA Trials Unit. From August 1976 to July 1977 the Trials Unit evaluated the XM204 105mm Field Howitzer; the XM198 and FH-70 155mm Medium Howitzers; and a number of associated gun tractors. Trials were carried out at Lavarack Barracks; High Range Training Area; Tropical Trials Establishment (Cowley Beach and Tully); and in the Hughenden area.

In November 1977, 106 Battery disbanded for the fourth time, having finished its trials commitments. Some of its members moved to Holsworthy shortly afterwards, to join 104 Field Battery which was being reraised in 8/12 Medium Regiment. (This was not without significance to 106 Field Battery. 104, 105 and 106 Howitzer Batteries were raised together as part of 22 Howitzer Brigade in March 1916, but on the re-organization of May 1916, 104 Battery became part of 4 Australian Field Artillery Brigade. It was into this Brigade that the last elements of 6 Australian Field Artillery Brigade (including 106 Howitzer Battery) were absorbed when it disbanded in March 1919).

Prior to its first tour in South Vietnam the battery acquired the nickname 'the Turtles', which members of One-Oh-Six regarded with affection. Shortly before the battery's fourth disbandment, Department of Defence (Army Office) approved a battery crest design showing a green turtle on a gold field, surrounded by a brown border. (The gold is for the sands of Egypt, the brown for France's agricultural land and the green for the jungles of Vietnam).

This crest was displayed publicly for the first time on the battery's guns and vehicles during the final parade of 106 Battery at Lavarack Barracks on 3 November 1977.

A PLEA FOR REALISTIC FIREPLANNING

By

Captain D.C.D. Milne

The Time and Place: Any Regimental Practice Camp

The Scene: The Battery Commander walks up to the Troop Commander, doffs his "battle bowler" and starts speaking in his best "grunt".

"FOO, where are you, oh yes, well as you are no doubt aware we have just run into the enemy. Do you see that elbow lake, from the top right corner, one o'clock at forty mils is their main position, about a platoon well dug in and with anti-tank weapons. ZP 2100 for that? Alright, but I've also got another anti-tank gun right down on the corner of that lake and one of my troops reports a section with some heavy machine guns dug in on that dyke running through that star shaped lake. ZP 2101 for the anti-tank and ZP 2102 for the machine guns you say? Right. Now I'll be forming up in those trees below us and break out in about twenty minutes, we'll blast right through the middle as we've no covered approaches and I know I can rely on you for lots of boom-boom. Unfortunately the damn mortar platoon has gotten lost somewhere and I'm taking the tanks with me so you'll be by yourself. Now the two near ones, the anti-tank gun and machine guns, I'll want hit from about -1 to +3 and, oh yes, could you finish them off with a round of coloured smoke so my chaps will know thats the last on those. What's that? Rounds on ZP 2100. Hum okay could be a bit more this way and a touch more to the right but I'm also worried about the ridge between by first two targets and the objective. Could we have one on call around that group of tanks on the ridge about halfway between 2101 and 2102. ZP 2103 then and I'd like that on call from +3. Now I'll want all those quaranteed and I suppose I'd better have a couple of DF's on the ridge plus on my objective. One on the right in that little valley and one on the left near those trees. Yes I'll accept predicted fire on those - ZP 2104 Right and ZP 2105 Left, OK. Then that should be about all, oh dear only 15 minutes to H hr, I must be off to give orders, any last questions?

Although this has been a rather lengthy narrative I do believe that it is fairly indicative of the general sort of fire plan depicted at CAS[1] and within units. It involves a large amount of adjustment, a fair degree of mental exercise and organization but unfortunately does not properly stress a true to life situation and in fact tempts many people to avoid good basic gunnery in finding a solution to the intricacies of the many problems posed by the originator.

My first criticism is that we always seem to be advancing or attacking. While one must certainly maintain an offensive spirit, too great an emphasis on what is, after all, only portion of war's spectrum can only cause us to neglect the other aspects - to our detriment. A fire plan designed to cover a withdrawal, a delaying action, a defensive position, or a hasty

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1 Canadian Artillery School

fire plan in support of a counter-attack all offer equal challenges to the Troop Commander. One of the artillery commander's prime roles is to provide advice to the supported arms commander. Are we to deprive our FOOs of the opportunity to gain valuable experience in these facets of military operations? Are we being fair to him and to the supported arms commander? We would be well advised to look to 1914 and the French Army to gain a glimpse of the results of a single-minded offensive spirit.

My second criticism deals with the format of this "typical" fire plan that one so often sees in live firing training. The overwhelming majority of fire plans that I have seen both from the OP and the CP have fallen into the category of two section targets followed by a battery target with one or more predicted DF's. Within this framework various "funnies" may be posed but at its simplest this is how the bulk of fire plans end up. In addition the enemy has always managed to cunningly place himself in this tactical posture. A platoon battle position with two minor out posts well forward. Is this enemy posture a realistic one? A quick galnce at NOTES ON THE SOVIET GROUND FORCES shows us that in coming across the enemy in both his Security Zone and main defensive positions we are much more likely to come upon mutually supporting platoon, company and battalion defended localities - all well dug in and supported by tanks and artillery. Is our standard training scenario an adequate preparation to meet this kind of threat?

Major formation level exercises such as the REFORGER series, German Corps and home defence exercises, practice us in dealing with an enemy who is numerous, well equipped, fully mobile and as well trained as any modern troops. This enemy is skilful in his use of terrain and camouflage and his tanks have a nasty habit of popping up just when you don't want them. The type of fireplanning that is conducted in these large scale exercises is generally to put everything on the village or woods where the enemy company is dug in to keeping something in hand for that "nasty surprise" that inevitably pops up. Most squadron commanders that I have been associated with want everything they can get on what they consider to be the main threat - the objective. Considering the effective ranges of modern anti-tank weapons this is a most prudent and realistic approach.

A Civil War general once said war consisted of "GITTIN THAR FUSTEST WITH THE MOSTEST". In a future war we must get there with all the fire power available. We will not achieve this by teaching our OP officers to penny packet artillery. In recent years much controversy, hair pulling and gnashing of teeth has accompanied the adoption of the six gun single fire unit. The debate still continues as to the effectiveness of three M109's as a fire unit. To be quite frank I consider three M109's as a totally inadequate source of fire power to attempt to deal with the enemy. Those readers familiar with the fire power scores assigned by Americans during REFORGER exercises know that no fire power value is assigned to a section of M109's. They deal in battalions not sections. Is it not at least a little more realistic to confine our training to battery targets where we have at least a viable fire unit? -

The basic principles of fire planning are:

a. simplicity;

b. co-operation;

c. flexibility;

d. surprise; and

e. concentration of fire.

By keeping to battery targets you retain a simple and flexible framework with a recognized degree of concentration of fire. Adjustment can still be carried out by sections but Fire For Effect must come from the battery. A fire plan that follows these principles and is accurate and on time cannot fail unless the enemy is too numerous for our resources.

If we can overcome our training syndrome and provide varied and challenging situations for our fire planners and ensure that they follow the basic principles we will help ourselves greatly in preparing for our profession.

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FORT GLANVILLE

A SHORT HISTORY

South Australia's first fortification, Fort Glanville, dates back to 1878 when work commenced on its massive construction. At that time the Colony was completely defenceless and the Fort was built in answer to the Russian scare of the day when it was common knowledge that a Russian squadron was prowling the Pacific.

The Fort was designed by Major General Jervois, R.E. and Lieutenant Colonel Scratchley, R.E. and built by J. Robb Esq. 400,000 best Melbourne hard bricks, 15,000 yards of lime concrete and over 3,000 cubic feet of assorted timber went into the construction. Costs were £15,000.

The Battery consisted of two 10 inch muzzle loading 20 ton guns and two 64 pounder Flank guns plus rifle positions. Each charge of the 10 inch guns consisted of 130 lbs of powder and a ten inch shell weighing 400 lbs.

The two 10 inch guns were made by Sir W.G. Armstrong. They had rifled bored barrels and were manned by mechanical loading gear under cover of parapets. Both small amd main magazines were bomb proof. Serving lobbies were provided on either side of the entrance to the main magazine. Between the shell and powder rooms the ammunition was served on hand operated lifts, conveying it to the manning rooms under the parapets.

The small laboratory (which is the present day ironing room) under the south-east corner of the Fort was known as the Filling Room and was equipped for filling shells in safety from the gun positions. At the back of the Filling Room was the Guard Room which is now the No 1 ladies toilet. A hardwood stockade was facing the back of the Fort. Today the southern part is the Laundry and northern part is the Gents Shower Room.

The two Flank gun positions were on concrete bases on either side of the 10 inch guns and the bases, when in commission, were floored with timber. The entrance to the small magazine was covered with timber making it safe for the handling of live shells and the racks on either side held the rifles. The guns were first fired on Saturday, 2nd October, 1880.

The Fort was capable of accommodating a garrison of 40 men and covered an area of 14 acres overlooking a strategic position of the gulf.

Eventually the Russians landed at Glenelg in 1882 - but it was a friendly visit and the guns were never fired in anger.

With the construction of Fort Largs, the Fort's importance declined and during World War I it was used merely as a detention barracks. Later the garrison was withdrawn and only a caretaker remained.

In 1935 Fort Glanville was leased to the Boy Scouts Association and at the outbreak of the last war was taken over by the V.D.C.

After hostilities ceased the Fort lay idle for several years, then, in March 1949, it was transferred from the Commonwealth to the State, partly by gift and partly by purchase. In 1951 it was dedicated as a National Pleasure Resort with the dual purpose of being preserved as an historic building while a portion of the adjacent area was developed as a seaside camping ground and caravan park.

Fort Glanville's two 10 inch guns remain near their original site but the 64 pounders repose as mounted ornaments in a North Adelaide public garden.

THE RENEWED ARTILLERY THREAT TO ARMOUR

By

Major D.A. Gronbeck-Jones, CD

An essay on the artillery's recently improved capability to engage tanks and other armoured targets, with emphasis on the development and introduction of the Cannon-Launched Guided Projectile (CLGP).

When the tank first appeared on the battlefield in the First World War, its invulnerability to small arms fire made it a formidable platform for machine guns and light, direct-fire guns used in support of assaulting infantry. Its invulnerability was challenged only by other high-velocity direct-fire guns on other tanks or those manned by artillery personnel. Indirect-fire artillery was of limited value against these behemoths, primarily because the contemporary fire control techniques did not permit quick and accurate shifting of fire on a fast-moving target. Thus, a direct hit was seldom possible, and with the light guns predominately in use, near-misses were usually ineffective against even the thin armour of the time. A truly effective anti-tank gun was not in the field by war's end, although several had been developed which were suitable to counter the thin armour of the day.

Between wars, despite having to take second place to the counter-air problem, guns were developed by various nations in the 37-mm (2-pdr.) range to defeat known First World War tanks. This classic piece of retrograde vision became painfully clear when, at the start of the Second World War, it was discovered that the light guns were ineffective against the new tanks fielded by the Germans. In the North African Campaign, this marked deficiency in anti-tank capability on the part of the artillery was overcome in part by the use of direct support field guns in the anti-tank role, and later by the introduction of specially designed anti-tank field guns such as the British 17-pdr.

Equally important to the problem was the development of new ammunition which was more successful at defeating armour. The concurrent development of tungsten APDS projectiles during the first years of the war resulted in a stabilized situation at the end of the war, with most belligerants fighting tanks with artillery guns of 75-mm or more, employing armour-piercing discarding sabot (APDS) and hollow-charge high explosive anti-tank (HEAT) munitions.1

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1 Ian Hogg, Artillery (New York: Ballantyne Books, 1972).

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It is significant that in the Second World War, as in the First World War, artillery fire in a direct role was a threat to armour, but seldom was indirect fire used with effect. Experience had shown that indirect fire was wasteful in ammunition when used against tanks, and of limited value. Furthermore, the infantry lost its close artillery support when guns were employed in the anti-tank role. The period following the Second World War, and even right up until the present day, had done little to change people's minds about the ineffectiveness of indirect-fire artillery against tanks. Virtually every country had adopted recoilless guns and/or anti-tank guided missiles (ATGM) in the interim, controlled by infantry. Notably only the Soviet-block countries keep large numbers of anti-tank guns in inventory, and these are only complementary to the infantry ATGMs.

Significant in the formulation of opinions on the subject of defeating armour had been the development and success of aircraft-delivered munitions. It has come to be assumed that the FGA aircraft would be the partner of the contact arms in the anti-tank confrontation. Battles between two modern nations in which there has been extensive use of armour have been few and far-between. Notable exceptions have been the Arab-Israeli conflicts of 1967 and 1973.

In 1967, the Israeli artillery was far down in the military packing order. Everything, even infantry, was in support of armour. The Israelis looked upon their air force as the premier arm in support of tanks, and the main source of firepower to destroy tanks in depth. After all, in the Middle East the weather is seldom a problem; their Phantom and Skyhawk aircraft carried, even in artillery terms, a formidable punch; and since an aircraft flies back to base to re-arm it meant a simplified logistic problem. We all know the Egyptian Air Force was destroyed on the gound, giving total air superiority to the Israelis and permitting them to fight as they had foreseen: aircraft in support of tanks, with artillery doing nothing against the Egyptian armour. The already-discussed conception about the value of artillery was reinforced. 2

In the 1973 conflict, popularly called the Yom Kippur War, there were no successful pre-emptive air strikes on Egyptian airfields. Not only was an air superiority battle to be superimposed over the land battle for the duration of the war, the increased air defence effort on the part of the Arabs made Israeli incursions into airspace over the forward battle area very expensive in terms of downed aircraft. Close air support was not there when it was needed in the quantity required to do the job.

This lesson, that an effective air defence is a realistic option for the first time in history, must be accepted. The second lesson is that without close air support, or even with moderate close air support, ground forces have to rely upon their own indirect fire weapons. 3 The Israelis found out as well

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2 Brigadier T.L. Moroney, OBE, "Artillery Support in the Yom Kippur War," Journal of the Royal Artillery, CII (March, 1975), p. 11.

3 Ibid., P.12

that the 105-mm howitzer has no place on the armoured battlefield. This late observation only confirmed what had already been determined by NATO countries when they decided to adopt guns of 155-mm calibre as standard. The Israeli observation was an empirical one, however, and not based entirely on the same basis as NATO's. The Israelis found that 155-mm guns firing indirect could and did stop assaulting tanks on several occasions. A concentration of 10 rounds fire for effect by three regiments (36 guns) would outright destroy any tanks which received a direct hit on any portion of the tank, and even near-misses broke tracks, aerials, and sighting equipment. Fuel tanks punctured by shell fragments were common, and the use of white phosphorus shell in conjunction with HE turned minor casualties caused by splinters into major ones when the ruptured fuel tanks exploded. 4

The Israelis found in this rather short war that conventional artillery, even in the indirect fire role, is effective against all types of armour, even modern Russian tanks. The Israeli reaction in the days following the Yom Kippur War has been to plan an artillery reorganization which could be considered quite radical. What they want to do is make General Support (against the tank threat) priority one for divisional artillery units. Second priority for artillery would go to counter-bombardment, for the gun line found in Soviet-bloc armies is formidable. Given those priorities, guaranteed response to calls for fire by supported formations would be impossible. Thus, the Israelis plan to give infantry and even armoured units their own 81-mm and 120-mm self-propelled mortars. To do so in my opinion is a mistake, a solution based on a single battle scenario. As I will discuss later, other solutions are possible, and other developments of recent years may render organization changes of this magnitude unnecessary. Nevertheless, the protagonists of the Yom Kippur War and their allies are aware now that even conventional medium artillery as found in most NATO and Soviet-bloc countries is effective against armour if it is employed in sufficient mass.

Concurrently, development of specialized ammunition has been going on, and although few types have seen war service these Improved Conventional Munitions (ICM) designed for 155-mm tubes have a primary target- the tank.

There are good reasons why the tank-killer role should be taken on by the artillery. Even if one accepts that there are effective anti-armour weapons systems in the hands of the infantry and other combat arms, these elements of the battle are detracted from their main tasks when they alone take on all the tanks expected to be seen on the enemy side. Lack of visibility out to maximum effective ranges as well as the strain of real battle conditions promise to limit the effectiveness of anti-tank guided missiles. Range is, and always has been, a limiting factor of recoilless guns. Mines take too long to lay and there is always the possibility that the enemy will come where the mines are not, or that his prior planning will allow him to locate mines quickly and breach the minefields with dispatch.

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4 Ibid., p. 12

Superimposed on all of these systems is the critical limiting factor: the sheer tonnage of ammunition which is needed by these forward troops to accomplish the job of defeating a majority of the advancing armour.

The artillery does not at present suffer to the same extent when supply of ammunition is considered. The tonnages of ammunition which are routinely handled could, if they included armour-defeating ICMs, nicely complement what is in reality only a short-range capability possessed by Infantry ATGMs and recoilless guns. The artillery can fire with relative impunity from their gun positions at armour in depth even while forward troops are engaged in close battle. The infantry anti-tank weapons will be laid aside at this time when bayonets are in demand. We are at present depending upon FGA aircraft to hit those tanks in depth while troops are in contact and otherwise engaged, but as previously pointed out that is not a viable solution to the problem if we cannot depend on air forces to be there under all conditions of air superiority and weather.

Although conventional medium artillery can stop tanks as the Israeli experience has determined, the situation is enhanced by the ICM. One type of ICM is the 155-mm projectile which is in fact a carrier of smaller "bomblets" which are expelled from the shell by airburst over an advancing tank column. Each bomblet is a baseball-sized shaped-charge munition capable of penetrating top armour on any tank it hits. The scattered bomblets permit saturation of an area with a relatively small number of full-sized rounds.

The bomblet projectile is adaptable to any artillery round larger than 155-mm, and an ICM warhead is also available for the 762-mm Honest John rocket. This latter weapon will distribute, with one warhead, sufficient bomblets to saturage several grid squares of terrain. Needless to say, the target must be seen by an OP or other acquisition means and still be on the target when the rounds arrive in order to be effective. It remains a difficult gunnery problem to hit a moving target, and even stationary vehicles under trees have some degree of protection from the light bomblets.

To overcome the mine-laying problem, a projectile is feasible which scatters mines in the same manner as the bomblet ICM. These "stick-mines" are sown quickly, and where needed, to meet a sudden armoured advance. Each mine is capable of blowing a track, stopping the tank or other vehicle cold so that it can be easily engaged by other weapons, thus slowing down the momentum of the attack. While these mines are only scattered on the surface and can be relatively easily removed, they achieve their effect by blocking what the enemy thought was a secure route, possibly one over which reconnaissance elements had already passed and safely cleared. The resultant delay thus imposed on the armoured assault force stuck behind the barrier would give our commander the opportunity to destroy the elements on our side of the barrier at a minimum, and ideally the opportunity to deliver a counter-stroke against the main body while it is in its temporary state of disorganization and confusion. Of course, mines scattered in this manner will self-destruct after a designated period of time to permit our own advance when this is possible.

ICMs, as the name implies, are just conventional ammunition, albeit improved, fired from conventional artillery equipments. Their use would not be practical if it were not for all of the other improvements to artillery techniques and procedures in recent years. Reaction times to calls for fire have been significantly reduced. The probability of achieving a first-round hit has been increased by more accurate methods of position determination, both at the gun end and at the target. We can safely say that today it is possible to hit a portion of a target with the mean point of impact of a battery, without adjustment. Put into other words, any given round directed at a target will almost certainly impact within 100 metres of it, and probably within 50 metres of it. 5 That means a technical "hit", since the lethal radius of a shell is sufficient to cover the target.

Impressive as this may seem compared with where we were only 10 short years ago, the ability to hit a pin-point target is a task nearly as difficult as it was in the First World War. Artillery system errors are comulative. A centimetre's error in survey at the gun adds to a metre at the observer's location (transmitted to target location by his laser rangefinder); to this add a change in projectile velocity caused by a change in air temperature since the last meteorological readings; a gunner's firing at one mil over or short of the desired elevation because he is tired; and the end result is a projectile which statistically never lands "in the bucket". Even if the "bucket" is the size of a tank, it is probably moving around anyway to make the problem seem insurmountable.

Probable error has always been a function of hit capability for more than artillery weapons. Credit for solving the problem has to go to the US Air Force, which has been developing several systems which allow bombs and missiles to be terminally guided to a pinpoint target. One system, that in which the missile seeks a target which has been laser-illuminated, has been tried in the Vietnamese War with great success.

The principle was seen to be adaptable to an artillery projectile, in theory, from the outset of development. The hardest part of the challenge was to make complex electronic circuits which would withstand the very high stresses encountered by an artillery shell on firing. Those stresses are complicated in an artillery tube by the rotation imparted to the projectile by the tube's rifling. At the moment of firing an M109A1 155-mm howitzer (with extended range tube), acceleration stresses on the projectile reach 9,000 Gs. To adapt the terminally guided bomb meant that such elements as the gyro-scope, electronics, and optics had to be redesigned. Special mountings had to be invented, and in some cases completely different approaches had to be considered.

One feature of the terminally guided bomb or missile is the relative ease with which wings and fins can be added. This is not all that simple with an artillery projectile, as such control surfaces must be retracted inside the projectile while

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5 Based on a six-gun battery with a frontage of 150 metres, equipped with 155-mm howitzers.

the projectile is in the barrel. The projectile's rotation is also detrimental to a guidance system using control surfaces, and the rotation must be reduced to a much smaller level than a normal projectile has upon leaving the gun.

Despite a relatively small research investment of $25 million, the Cannon-Launched Guided Projectile (CLGP) has been developed and tested. The prototype was produced by Martin-Marietta Aerospace for the US Army, for use in the 155-mm howitzer M101A1. It may be fired without any modification to the howitzer, alone or in combination with conventional rounds, and it may also be fired from any other 155-mm howitzer. Normal propellant charges are employed.

Fortunately for the developers, nowhere near the HE content of a standard projectile is needed to destroy a tank, given a direct hit and a shaped-charge warhead. Thus, the projectile contains a goodly weight of guidance components and control surfaces without exceeding the weight of the standard round. The resulting CLGP is approximately twice the length of the standard 155-mm HE round. The rotation problem was overcome by employing a freely rotating driving band which keeps the projectile stable instead of rotating it as it goes up the tube. On egress from the tube, the control surfaces and wings extract, and from that point on the projectile is capable of being guided by receipt of reflected laser illumination in the target area.

The latest prototype has both fins which are control surfaces, and wings which are fixed which give the projectile the ability to glide, thus extending range and permitting the round to be "flown" beneath cloud cover. This is essential to allow the maximum time for guidance and thus increase accuracy.

The CLGP requires an illuminated target at present, that is, a target which is being "painted" by a laser beam which is coded to match the projectile's receiver. If the projectile does not receive its proper signal it will continue on its near-ballistic trajectory. The laser illumination is conventionally provided by a ground observer, but can also be provided by a heliborne one, or even a remotely-piloted vehicle (RPV) equipped with a television camera to extend the range and altitude of a human observer's eyes.

During trials conducted by the US Army at White Sands Missile Range, eight missiles were fired. Seven direct hits were obtained under a variety of conditions. Two hits were obtained against moving tanks, the most difficult of which was crossing the line of fire at 20 mph at a range from the howitzer of 4 km. Under these circumstances the projectile has a minimum of time to manoeuvre to score a hit. Another significant hit was obtained against a tank at 8 km range, with both target acquisition and laser designation by an Aeronutronic-Ford Praeire 2 RPV. The operating observer, at his television monitor, commanded

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6 Clarence A. Robinson, Jr "Wings to Boost Guided Projectile Range," Aviation Week & Space Technology, CIII (October 13, 1975), p. 56.

the operation via data link to the RPV, designating the target by laser while the CLGP was in the terminal phase of its flight. A direct hit was obtained to the tank turret.

The extent to which the CLGP can be terminally guided is limited, of course. The CLGP must be directed into what is called an "acquisition basket" in order for the reflected laser illumination to be seen by the CLGP's sensor. In addition, there must be sufficient airspace to allow the projectile room to manoeuvre.

With all the other modern improvements to gunnery that have been previously discussed, achieving the acquisition basket should not be a serious problem. As with the air force's smart bombs and missiles, a low cloud cover can have a deleterious effect of the homing capability and the CLGP may acquire the laser designation too late to permit the required flight correction to be made.

As long as the OP/RPV can keep the laser beam on the target, the projectile will continue to home on it. Any interference with this capability of keeping the laser on target for ten seconds or so will cause mission failure. A fast-moving target could move out of the target area of the CLGP or go behind cover, but the skilled OP will learn how to anticipate where the target will be at a given time, just as he does now in engaging a moving target with HE.

Trial firing of the CLGP prototypes have shown so far that an accuracy of less that one metre is possible. That's the "bucket" into which gunners have been trying to drop rounds ever since the Battle of Crecy! Not only that, a range of 20 km is expected to be achieved during trials.

Also in the development process are 8-in howitzer CLGPs, which will increase the HE content delivered to the target and permit a larger variety of targets to be engaged. A terminal guidance system employing infrared homing is also being tried by the US Navy for its 5- in. 54-cal. gun. That saboted for use in the 155-mm howitzer. It could mean that the projectile could find its own target, or that the OP need only give it rough steering with his laser designator. In any case, the accuracy is assured by such improvements.

The addition of an RPV as a designator is an exciting prospect for the future. In the forward battle area, it means that enemy tanks will no longer be able to rely on the cover afforded by ground to shield themselves from view. They will be as vulnerable to artillery fire as they are to aircraft, perhaps even more so since the RPV can fly overhead without risk to human life and with minimal financial risk.

An RPV such as Canadair's MARASTAS, or any other of a large number of RPVs under development, could carry a georeference system, a television camera, and a laser designator. It is so small that the chances of detection are remote. Hovering or orbiting hundreds of feet above the enemy's rear echelons, its

remote operator can select targets at will, send fire orders to the guns, designate the target with the laser, watch the target being engaged, determine the damage done, and repeat the procedure on another target until the RPV runs out of flying time or is destroyed. Repeat this sequence of events many times over the battlefield, with simultaneous engagements potentially as many as one per gun per 20 seconds, and no one could deny that there has been a significant change in the capability of the artillery to destroy.

As the British artillery found in the North African Campaign, and as the Israeli artillery found in the Yom Kippur War, the requirement to engage tanks with artillery will become so large that the primary role (at least the traditional primary role) of neutralizing enemy infantry will be in jeopardy. With the CLGP, unlike the previous two historical precedents, the requirement is not dependent upon masses of artillery. It could be, but it need not be.

Close support artillery regiments should retain their primary role and there should be no degradation of their ability to answer calls for fire on a priority basis from their supported formations and units. They should, on the other hand, be able to deliver ICMs as a part of that close support role. It would be the exception, rather than the rule, however, that the CLGP would be used in that role as the supported formation or unit should have its own capability to destroy any tanks within its 1000-metre sphere of influence.

A divisional general support artillery regiment, long needed in any case for counter-battery tasks, could also assume the tank-killer role with the CLGP as its primary weapon. It would include an RPV troop in order to give it its own long-range target acquisition capability. Employed with covering troops prior to the main defensive battle, they could begin attrition of enemy tanks long before we now foresee that event happening. From the primary gun positions behind the obstacle, it would continue to engage tanks long before they come into ATGM range. OP parties, using either RPV control units or the ground-mounted laser designator when appropriate, should be decentralized to formations and come in direct support to them only when the tanks that remain come within the sphere of influence of their supported formation.

Given a stable situation vis-a-vis enemy tanks and anti-tank weapons, the general support regiment could concentrate on counter-battery tasks using the RPVs and either CLGPs or conventional munitions.

As with all artillery, especially in the defensive battle, the divisional artillery commander must retain control of his general support artillery regiment and keep the ability to change operational relationship as the battle progresses. In most types of offensive operations, centralization of control of the general support regiment is also called for, unlike conventional artillery, in order to achieve economy of effort. Observers should accompany reconnaissance in order to begin the earliest possible attrition of enemy armour. That attrition should continue throughout battle procedure and attack phases

without hindrance. If the general support regiment is dedicated to tank destruction there is no doubt that it should be the divisional commander's resource. Observers belong where they can do the job best; there is no point in their being shared equally among the brigades or allotted to a reserve force.

The renewed artillery threat to armour will not go on without a counter from the enemy, just as we cannot expect that it will long before the enemy employs the same devices and tactics against us. We would, of course, be ready to counter his efforts. This "chicken versus egg" situation is a result of every technological leap.

Our counter is two-fold. Primarily, defensive measures must be taken at all times to decrease the ability of the enemy to produce effective counter-battery fire. Secondly, we must improve our ability to locate enemy guns quickly and accurately, retaliating as soon as possible with better methods of bringing down fire onto gun positions far in the enemy's rear echelons.

By way of defensive measures, we must first of all keep gun positions a matter of mystery to the enemy until they are occupied. They must not be occupied until they are going to be used, and once used, the guns must move elsewhere before retaliation is brought to bear. Fortunately, technology is at hand with a solution once again, or will be very soon.

Canada's Gun Alignment and Control System (GACS) gives self-propelled guns the ability to leave a gun position while it is not being used for firing, and to return to it and recommence firing within a minute or so of arrival. The GACS system, or one similar to it, allows a battery to have several alternative battery positions, or, on the other hand, occupy more than one position at a time with only a few guns in each. While firing CLGPs, there is no need for massing of guns, and guns could even be located singly with fire orders being received by radio from a command post in central location. The guns could also retain battery control, yet disperse much more widely about a single GACS reference unit if the terrain permitted. They could move after each few rounds to a new position, individually, still within range of the GACS reference unit yet providing sufficient dispersion within the battery that enemy counter-battery fire could never be effective. When required to mass for a conventional fire mission, the guns could adopt a standard battery layout for the shoot, still using the same reference unit, and then disperse again immediately for their own protection.

While potentially expensive in GACS equipment, the results can be maintained in the battle area with minimal risk to the gun batteries. Only a lack of imagination would limit deployment possibilities. Close support regiments, with most of their fire being conventional missions, would have to continue to deploy in battery groups. Keep in mind that an enemy's counter-battery (CB) capability, though perhaps enhanced to counter the CLGP threat, would work just as well against the close support batteries. Since a battery's role could be interchangeable, the CB threat applies equally to all batteries. One can see that mobility is the best defence for any artillery battery, and

the only rest to be had will be while well-camouflaged in a hide. It remains for technology to come up with a device that defeats laser illumination without blinding the protected unit (better smoke, perhaps). The best defence is mobility and concealment from the far-reaching television camera in an RPV.

I feel that the locating battery needed by a division should be a part of a divisional general support regiment, including the RPV troop as part of that battery. We would not take lightly the enemy's capability to destroy our tanks, and thus our artillery must have the ability to locate his batteries as soon as they fire.

While once again the RPV-mounted television camera (or other sensor) comes to mind, it must first have a place to go to look for guns. Conventional target acquisition methods as we have them now remain extremely important. Those which provide real-time intelligence, even if relatively inaccurate, are the most important. We can no longer wait for pinpoint accuracy if it is too late in arriving, thus those acquisition methods which employ film photography will certainly become only an adjunct to the artillery intelligence system. In-flight reporting by aircraft may also become a thing of the past if the enemy's air defence system is as good as we hear it is.

Sound ranging, for all the world the same system it was in the First World War, can tell us where to look in a hurry, and that is really all that is needed when an RPV is going to go out and make a positive location of the hostile battery (and engage it at the same time).

The RPV of the future will accomplish more than any other device has ever done as far as target acquisition is concerned, and it will, in conjunction with the CLGP or conventional munitions, provide us with our best means of accurately bringing down fire on a hostile battery. This same device will let us know what damage has been caused, and even follow the fleeing battery to re-engage it in another location or even on the move.

With accuracy of location, and accuracy of retaliatory fire, we have a CB capability such as has never been known before. Add to that winning combination a gun locating radar such as that recently produced for evaluation by the Hughes Corporation for the US Army, and it will be seldom that the enemy fires his guns without being detected. Once seen, our new capabilities will ensure his ultimate destruction.

The CLGP has provided a truly cost-effective method of destroying the tank. The 155 mm round will cost approximately $3500 each in terms of constant 1975 dollars.7 In considering cost one can ignore the delivery system, already in use, and thus the CLGP is the most cost-effective means of destroying a tank at long range that has ever been developed. Add to this a one-round hit and kill probability, the short time involved in the destruction of each tank, the relative immunity of the delivery means, the outstanding range of the weapon, the compatibility with other current developments, and it must be agreed that the CLGP is certainly one of the most significant breakthroughs in the history of modern war.

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7 Ibid, p. 57.

For the first time, artillery in the indirect-fire role is not restricted to neutralization of an area. It can destroy, and it can destroy the tank and other armoured vehicles which we see as our greatest threat on tomorrow's battlefield.

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SOVIET RECONNAISSANCE IN THE '70S

by

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As in any modern ground force, the role of reconnaissance in Soviet operations is critical. Soviet doctrine spells out in great detail both offensive and defensive applications for reconnaissance. Extensive training supports these tenets and has done for years.

One historical reference of particular note is found in General Jomini's Outline of the Art of War which suggests the Russian capability in tactical reconnaissance:

> With reference to information obtainable from forward patrols, the Russian Army, thanks to its cossacks ... (contemporary Soviet motorized rifle soliders), is better served than any other.[1]

This article describes modern Soviet reconnaissance doctrine and equipment and attempts to portray the present Soviet tactical intelligence capability. In Soviet parlance, reconnaissance includes the collection of all tactical intelligence such as target location, order of battle data and information on terrain. Particularly important is artillery reconnaissance, including near, mid-range and long-range target detection and identification.

Soviet doctrine calls for fully integrated, organized and continuous combat reconnaissance.[2] Their doctrine also requires that a unit commander be as expert on enemy capabilities and activities as are his intelligence, reconnaissance and operations officers. Doctrine further suggests that he be thoroughly aware of the capabilities and limitations of the surveillance and target acquisition equipment which he has at his disposal. In the article "How to Obtain Reconnaissance Data" (Military Herald), a Soviet officer states that:

> Under modern conditions, the importance of reconnaissance continues to increase. At the present time, each unit commander is obliged to always have at his disposal complete and reliable data on the enemy, with such data being obtained not only from senior commanders (from higher headquarters), but also through the use of his own forces and equipment.[3]

Focusing on the Soviet reconnaissance activity on or near the forward edge of the battle area (FEBA), short-range reconnaissance, including the use of night vision equipment, is

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a matter of so-called observation training. Soviet literature has numerous examples of troops gathering tactical data. Operationally, Soviet combat reconnaissance is more at home with patrols than with extensive electronic surveillance. The fact is supported by the structure of Soviet command echelons, which include numerous patrolling units, and a significant amount of training in collection and reporting of enemy information.

Practical training in exercises and classroom instruction point to Soviet "scouting" as the focal point of combat reconnaissance for the motorized rifle and tank unit. Typically, an exercise director may prepare a mockup of a regiment or battalion area of operation. The tactical situation is depicted on the mockup, and trainees have one to two minutes to study the board. Objects, representing large and small enemy assets, are then moved elsewhere, and the trainees again study the mockup for a very short time, after which they are quizzed on enemy activity. This training strengthens the observation and reporting capabilities of the troops in contact. It most certainly makes the line units more aware of the mechanics of combat or tactical intelligence - that is, the observation of enemy activity.

Regarding equipment for patrolling and reconnaissance, a number of vehicles should be described. The PT76 light tank is used exclusively as a reconnaissance vehicle. The BRDM and BRDM2 armored scout cars are the most commonly used vehicles for performing the patrolling and observation function. The BRDM2 is replacing the older vehicle and has a 750 kilometer range, an increase of 250 kilometers over the range of the earlier BRDM. Both vehicles are amphibious. The road speed of the BRDM2 is 95 kilometers per hour and is upgunned over its predecessor with a recast turret which accepts the 14.5 mm machinegun. Both vehicles mount a 7.62 mm machinegun. The speed, maneuverability and limited firepower of the BRDM2 make it an excellent scout car, especially in a probing role, and provide the vehicles with some antiair capability as well.[4]

BRDM - type vehicles also are found in chemical, biological and radiological (CBR) reconnaissance modes, designated BRDM-2RKh. The reconnaissance company, organic to each Soviet motorized rifle regiment, is comprised of about 50 men; three PT76 light tanks; and numerous BRDM - type scout cars, including the CBR variants.[5] Chemical reconnaissance plays a major role in Soviet military planning and operations. Soviet emphasis on chemical warfare training suggests the immediacy and priority they place in this aspect of modern warfare. Use of chemical agents and, more importantly, the ability to operate in a chemically contaminated environment becomes for the Soviets an alternative to nuclear warfare. The probable effects on enemy troop concentrations are equally devastating, but without the permanent damage which accrues to the use of nuclear weapons. Thus, petroleum, oils and lubricants facilities and other useful logistic supplies can be used by the Soviets after a chemical attack, after some necessary decontamination.

Soviet capabilities to reconnoiter targets beyond the visible range of patrols begin with sound ranging. It normally would be used for prepared, defensive artillery observation batteries of the motorized rifle divisions. Their role is to maintain a 24 hour, all-weather watch and to detect and locate enemy ground weapons. But with full survey required, deployment time is quite long, perhaps one or two hours, making it suitable only for static, slow-moving or defensive operations. On the positive side, the equipment is simple, rugged and reliable. It provides the Soviets with a location capability against mortars and high-velocity, low-trajectory weapons.[6]

A typical sound ranging installation, as described in Soviet military guidelines and handbooks, consists of a central post (equipped with a recorder, central power source and communications center), a warning post, or advance-warning post, several sound posts and a meteorological post for determining weather conditions.[7]

Six sounding posts generally are used although four are satisfactory for rapid, but less accurate, ranging. Sound posts are arranged in pairs, constituting a sound base. A typical installation has three sound bases. As for equipment arrangement, the posts are placed from 2 to 4 kilometers back from the FEBA, depending on the circumstances, and at intervals of 1 to 1.5 kilometers along an arc facing the enemy. The control post is placed 1 to 2 kilometers from the rear center of the sound ranging bases. The warning post is placed in front of the sound posts at a point .5 to 1 kilometer from the friendly line.

The Soviets claim successful location of enemy mortars at distances up to 5 kilometers by reducing the distances between sound posts to approximately one-half of those usually employed. The width of the zone of observation also is reduced by approximately one-half. The principal sound ranging equipment is called SChZ6. It was developed after World War II and is still in use today.[8]

A sound receiver for the unit contains carbon microphones that are sensitive to infrasonic vibrations. The system is designed to operate in the infrasonic range, rather than the audible, since the longer wavelength signals propagate better over terrain variations and are not affected by local obstacles. Best operational ranges are obtained at night, and sometimes at dawn and dusk. Additionally, the advance warning post personnel are trained to recognize the sounds of various guns and mortars.

Another surveillance and reconnaissance capability of the Soviet Army is the highly mobile radar systems. In an article appearing in the Soviet publication, Technology and Armament, in 1972, the battlefield surveillance radar SNAR2 was described in great detail.[9] Perhaps complementing SNAR is another highly mobile battlefield radar which is a reconnaissance variant of the infantry combat vehicle (CV) BMP. The BMP reconnaissance variant was described recently in a West German periodical as an artillery observation vehicle.[10] First observed in 1975, the BMP has a redesigned turret, mounting a radar antenna which may give it a surveillance or mortar/artillery locating

capability.[11] It appears to be compatible in protection and mobility with the new Soviet self-propelled artillery. This fact reinforces the application of the BMP reconnaissance vehicle to artillery support. It has been suggested that the radar antenna is similar in appearance to that of existing radars, both Soviet and Free World including the German-French Ratac system.[12]

Another article appearing in the July 1976 issue of Soldat und Technik, comparing the BMP ICV with the reconnaissance variant, describes the modified vehicle as having "... a wider, flatter, two-man turret located behind the engine compartment."[13] The additional crew space would seem to be needed to accommodate the numerous sensor devices evident on the BMP reconnaissance variant. Describing its assets, International Defense Review states:

> The new turret houses 2 men, rather than one ... The left hand hatch has 2 periscopes, one facing forward and one half left ... the right hand hatch has 3 ... Two so-far unidentified optical units ... are mounted one in front of each turret hatch ... On the right side of the turret is a projecting, armoured box-like housing, with an elbowed tubular linkage attached to an armoured front cover and connected at its other end to the turret. It is thought that this housing is most probably an IR/white light searchlight of new design, since no other searchlight or powerful IR projector is fitted on the vehicle. The housing could, however, conceivably contain the optics of a laser rangefinding system.[14]

It seems apparent that the Soviets' mobile reconnaissance capability is quite sound, and such recent technical adaptations as the BMP reconnaissance variant suggest that it is still developing and improving.

Soviet reconnaissance in support of artillery operations, which we may call target acquisition, includes more than the sometime operation and defensive use of sound ranging, plus surveillance and countermortar radars. The mainstay of artillery reconnaissance, for bringing and correcting close-in fires, is comprised of command observation and auxiliary observation points and (for longer-range purposes) artillery reconnaissance groups. In an article "Artillery Reconnaissance in a Division", appearing in the Military Herald, it is stated:

> A division's command-observation and auxiliary observation points and batteries are deployed in a manner such that they will be able to maintain complete observation of the enemy and the terrain, throughout the entire reconnaissance zone, and on the flanks. In order to conduct reconnaissance of an enemy and the terrain, a division is assigned a zone or reconnaissance axis and so-called regions of special attention. A battery is assigned a zone (sector) or reconnaissance axis and the regions of special attention are brought to its attention.[15]

In order to illustrate better the operation of artillery reconnaissance by zone, an artillery reconnaissance scenario has been provided, based on the above information, and what is known of complementary artillery acquisition assets.

The article also describes a reconnaissance controller who apparently would coordinate and perhaps set priorities for targets for the entire combat reconnaissance system. Little more is known. Flexibility of the system also is described:

> ... a division may be assigned a radar set and sound and radar reconnaissance subunits, or it may work in close collaboration with such units. In the case of those targets that cannot be observed from ground observation points, closely coordinated communications must be established with aerial reconnaissance units for the purpose of conducting reconnaissance and furnishing gunnery corrections for these targets.[16]

This capability and flexibility is important. For close-range targets, optics may be the prescribed target acquisition capability. The most common such device is a direct support-type stereoscopic range finder. The radar, which it is stated can be used, is not named although it can be expected to be a portable set, possibly similar to the US system AN/PPS4.

The remaining aspect of Soviet reconnaissance is long-range target acquisition. Three quite different means exist for long-range reconnaissance. Aerial platforms, such as Fishbed-H and Foxbat-B, are described in Jane's All the World's Aircraft, 1975-76, as strike/reconnaissance aircraft.[17] Camera equipment would provide information to commanders on troop concentrations, command centers and perhaps on nuclear targets. This aerial capability will be enhanced with the advent of television, now found on some aircraft, according to Soviet sources.[18]

The next long-distance target acquisition capability is long-range air-mobile patrols. Colonel Erich Sobik, of West Germany, writing in Truppenpraxis suggests:

> ... long range reconnaissance patrols, equipped with long range radio sets, will try to accomplish their mission no matter in what situation they may find themselves, especially operating in the rear of the enemy.[19]

The colonel suggests that the purpose of their efforts will be to locate nuclear targets.

The final and perhaps most persistent and threatening form of long-range target acquisition is radio intercept.

> The enemy's command system, concentrations, re-groupings, as well as his order of battle can be determined by taking bearings on his command transmitters and intercepting his radio and radio

link traffic (radio relay). Minimum time and (good) accuracy turn radio intercept into a reliable source of information.[20]

The Soviet capability to acquire targets, with numerous assets, very simple to very complex and sophisticated, represents impressive capabilities for combat reconnaissance. Patrolling and observation, artillery reconnaissance, CBR reconnaissance and electronic target acquisition comprise that capability. Most impressive is target acquisition support to the artillery forces which now may include television. The short and mid-range capabilities, such as battlefield radars, and the long-range, described as long-range patrols, aerial platforms and radio intercept, provide the Soviet commander a total capability to find, fix and ultimately try to destroy enemy forces across the FEBA.

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EDM 1976

By

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Introduction

Surveying is the art of making relative large, precise measurements with a maximum amount of accuracy and with a minimum expenditure of time and labor (1). It is used for two specific purposes: The first is to make maps, charts, and profiles and, therefore, to find exactly the relative precisions of existing objects, thus becoming the basis of plans for all engineering projects. The second is to layout or make the desired positions and elevations of objects to be built or placed as directed by a complete plan.

The history of surveying and surveying instruments is long and interesting (2). It is almost certain that one of man's first activities was a form of surveying. Early man, as he traveled from place to place and as his curiousity and culture developed, became more and more curious about distance and direction, so he learned to use his arms, his legs, his eyes, and his brain - and eventually developed surveying iinstruments. As civilization developed, the division of land for various uses and the construction of such structures required higher and higher accuracies. In this regard, accurate surveying practices were used by the Babylonians, the Egyptians, and probably the Chinese. The Greeks and Romans improved on these methods of instrumentation and thus employed the science of geometry, plus the crude instrumentation of the time. The accuracy became greater and greater as time passed on.

Early instruments consisted of such crude devices as rope and markers at some unit interval, plumb bobs, and, ultimately, for the measurement of angles, the merchet was utilized. Egyptian hieroglyphics indicate that they were used for the alignment of temples and pyramids with true north and with great accuracy. From these beginnings, the science and art of surveying has progressed until modern times, where it is now the key to successful layout in our technically-oriented society.

It has been said that the sciences have progressed more since the end of World War II to the present than they did from the earliest days of man to the end of World War II. The reason for this progress is that the sciences developed at a rate that was relative to the changes in man's problems and the problems of his encironment. A notable difference in the science and art of surveying, as compared with advances in other fields, is that although man's environmental problems changed, basic surveying

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problems have remained the same. The factors, then, that induced change in this field were dictated by economics and the normal evolution of higher proficiency in surveying.

Keeping abreast of development in the fields of optics, physical phenomena, and engineering, the manufacturers of surveying equipment seem to have followed the same progressive trend, albeit at a shower rate, at least until the late 1950's, when certain electronic breakthroughs occurred that brought about a new era in surveying. It is this period of development with which this paper deals.

The Modern Trend

As in all applied sciences, the desired result of a new development is the ability: (1) to do things not formerly possible, and (2) to meet the needs of scientifc apparatus required to solve problems. To this end, the designers of equipment rely upon their ability to put to work for them the physical forces of nature and to utilize, at a rate that is as fast as possible, the technoligical developments of any given era.

In the past 25 years, these basic principles have been essentially applicable to the development of distance-measuring equipment. Factors that have been taken into consideration in these developments are:

(1) the ability to measure angles and distances easily,

(2) the production of work at very high accuracy, and

(3) the ability of a field operator to utilize a minimum of personnel.

Until the late 1950's, the measurement of extremely long distances could not possibly be done without the use of elaborate technical triangulation networks that were, at best, approximate, since in the establishment of these networks the technical scale and the visual acuity, not to mention the physical prowess of the surveyors, were the key factors in their establishment. Much credit must be given to the stalwart individuals who made these measurements, for the net result of their work is still in evidence and will be for some time to come. However, in the late 1950's, the use of physical phenomena, such as microwaves and light, were harnessed to measure distances with extremely high precision.

Since those early days of electronic distance measurement, generations of new equipment have been developed, which have been designed from a functional standpoint, rather than relying upon the availability of contemporary hardware. Needless to say, this functional development came about largely because of the development of such things as the transistor and the integrated circuit.

Comparatively speaking, instruments which were used for distance measurement in the late 50's up to the mid-60's the

average mean weight of which was always 25 to 50 pounds have been reduced to small and convenient packages which now weigh five to ten pounds, some of which have the same performance capability as their electronic predecessors.

With the development of new equipment, new techniques manifested themselves and, whereas triangulation was once the gospel of the trade, now trilateralation and the open traverse have taken their places in the jargon of the surveyors. Optically speaking, in the same period when the transit was the tool of the trade, the theodolite has supplanted it for high precision work. Projecting, the rod, which is still in widespread use, will undoubtedly be augmented by the laser beam, again utilization of the physical spectrum.

With the improvement of the capabilities of instruments, the demand for more and more precise work has accelerated and, indeed, the qualifications for the criteria of measurement, vis-a-vis first, second, and third order, also will increase. (3) A good case in point for this comparison is that, when the first Tellurometers appeared in 1957, their accuracy, after many corrections were applied, usually worked out to plus or minus a few centimetres. The use of these instruments was confined to long-distance measurements, usually one-half mile or more. Today, on measurements of equal range (up to 40 km), measurements, properly corrected, can be achieved with precisions of 2.5 mm to 15 mm.

In addition to the humble beginnings of the use of the spectrum as a medium for measurement, other parts of the spectrum are now utilized and, although the ranges are somewhat limited by the carrying capacity of higher frequencies, measurements of $\pm$ 1 mm are possible on distances up to 2 km. This type of measurement opens up entire new fields to the professions, such as the crustal studies of the surface of the earth, the movement of dam walls, and rapid measurements of short lines.

In addition to the ability for more precise measurement, the newer methods of operating and the development of new technology have produced work requiring less mental strain on field personnel, greater physical mobility, and, as a result, the capacity for increased work output. Measurements are possible today that were absolutely beyond the capacity of the early electronic surveyor.

Allow me to raise two questions. Until four years ago, whoever could have conceived that measuring to the precision of $\pm$ 1mm was possible? Until three years ago, whoever dreamed of the possibility of measuring 33 km with an instrument weighing only four pounds? Indeed, until recently, whoever thought of measuring an angle on a digitized scale to the precision of 3 seconds and the ability to measure a distance from the same setup - all within a very short period of time!

Thus, in this modern era, although the basic problem of surveying remains the same, the answer became more and more simple. Similarly, despite the new ease associated with the solution of survey problems, the cost of solving them (comparatively studied with the amount of work output) becomes lower and lower.

The following tables show the development of electronic distance-measuring equipment from 1957 through 1976.

From the Tables I and II, it can be seen how the market met the demand of the profession (surveying and engineering) for equipment that met three basic qualification: (1) high precision, (2) modest price, and (3) ease of operation. A special specification for the US market was that the instrument should read in US feet.

A market survey, conducted by Tellurometer Inc in 1967 (4) showed that the instrument market acceptability on the basis of price by the total market (surveying and engineering) was: $10,000 (15%), $7,000 (35%), $6,000 (52%), $5,000 (78%), $4,000 (94%). It can be seen that as the price dimished the demand increased from the $7,000 level down to a rate equal to 50% increase of the available market per $1,000 reduction. Hence, the market price, considering the inflation since 1967, is compatible with the acceptance rate of the current market.

Performance

The major question at this point is whether or not the reduced selling prices of modern instruments from $10,000 per system to $6,000 - has induced a decrease in the quality of the instrument, or in the level of its performance. The answer is an unequivocable "no". The new devices capitalize not only on the technological development of the last five years but also upon the varied use of the media of measurement at higher frequencies. The new systems fall primarily into three categories: those using microwaves, infrared, and light (laser). The advantages and disadvantages of each are shown in Table III.

It is felt that the performance level of these new and modern instruments must be discussed, however before any conclusions can be drawn from this article.

The Premier Diamond Mine is one of the world's largest and is situated at Cullinan in the Transvaal, South Africa. The famous 3,106 carat Cullinan diamond was found there. It is an open cast mine, where shafts are sunk at the sides of the pit, and the actual mining takes place in horizontal tunnels radiating from the vertical shafts to below the floor of the pit. By means of blasting, the diamond-bearing rock is removed and brought up for processing on the surface. As the pit becomes deeper, areas adjacent to the open mine are liable to become unstable and eventually collapse. By measuring absolute ground movement and the rate of ground movement in potentially unstable areas, it is possible to forecast reliably major side-wall collapses, both in extent and in time. By regular measurements all around the mine, it is possible to detect and delineate such unstable or potentially unstable areas. (6)

In the measurements made to detect the movement of the ground, the Tellurometer MA100 was used, and all measurements were made within $\pm$ 3 mm, using cheap plastic reflecting material, permanently mounted. Because of the high precision of the

measurements, the collapse of the areas adjacent to the L mine were detectable. From this particular application, it was considered feasible that the crustal movements of the earth could be measured reliably. Consequently, the MA100 is now one of the instruments being used on the earthquake studies being made in Alaska and those that were made in southern California.

Through a two-and-one-half week period of continuous angle work in the empty east chamber of the Panama Canal, engineers of the Panama Canal Company had determined a 1.5 mm movement of the center wall during ship passages in the west chamber. After setting up the MA100 in conventional fashion, ie., on a tripod, measurements across the empty east chamber to the center wall, during three or four ship transits in the west chamber, gave exactly the same result, in about two hours.

The foregoing applications demonstrate the advantage of the high precision of the new instruments in that the measurements in question probably could never have been made if the high sensitivity of an instrument, such as the MA100, were not available. In passing it must be noted that this instrument uses the infrared section of the spectrum.

In Alaska the National Geodetic Survey has utilized the MRA5, an instrument originally designed for the British Army, in the establishment of a trilateration network. Distances in excess of 50 km were measured successfully (8). The key to these successful measurements is that the antennas for the MRA5 are separable from the instruments and could be mounted atop telescoping masts 13 m tall, thus increasing the range. Again, advantage is taken of the advancing technology in speed of operation and increased capability. The instrument utilizing microwaves and digitized automatic readout simplefied the operation.

Insofar as the new formats are concerned, ie, the relatively small size and the light weight of the new instruments, the flexibility offered by the new configurations must be considered a viable part of the EDM (electronic distance measuring) of the future.

The advantage of lightweight equipment has been mentioned by Dr Robert Thomas of the University of Nebraska on the Ross Ice Shelf Project in his discussions on measurements with a CA1000 in Antartica (7). Since, particularly for those surveyors who still climb the sides of mountains to do their work, the weight of the equipment is a vital factor, it stands to reason that the smaller and lighter the manufacturer can produce their equipment, the more acceptable it will become.

The four-pound weight, for example, of the CA1000 was a definite factor in the rapid movement that Dr Thomas required on the tundra of Antartica to shoot 300 lines in a two-month period under the worst ambient conditions.

The capability of being able to mount an instrument directly on a theodolite or a range pole is surely a factor in time costs in making surveys, since setup time of modern EDM's is the greatest part of the work, so that now a single setup for angles and distance becomes a cost factor.

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TABLE 1

Instrument Introduction Date 1957-1976

Year	Model
1957	Tellurometer MRA 1
	Geodimeter 4
1960	Tellurometer MRA 2
	Tellurometer MRB 2
	Tellurometer MRC 2
1962	Electrotape, Hydrodist
1963	Tellurometer MRA 3
	Fairchild MC8 (military)
1965	Tellurometer MRA101
	Geodimeter 6
	Autotape
1967	Tellurometer MRA301 (military)
	Geodimeter 8
	Wild DI-50
1969	Tellurometer MRB201
	Tellurometer MRB301
	Tellurometer MA100
	Wild DI 10
	Laseranger
1971	Ranger I
1972	Tellurometer CA1000
1973	Cubitape DM 60
	A.G.A. Model 76
	Micro Ranger
1974	Tellurometer CD6
	Tellurometer MRA5
	Beetle 500
	Kern DKM 500
	Kern DKM 1000
	Wild D13
	H.P. 3805
1975	Tellurometer CA1000-D
	Kern DKM 2000
	A.G.A. Model 12
	H.P. 3810
	Micro Ranger II
1976	A.G.A. Model 78
	Wild D135
	Cubitape HDM 70
	Auto Ranger

TABLE II

Statistical Data for Electronic Distance-Measuring Instrumentation 1976

Instrument	Manufacturer	Range (Metres)	Accuracy	Foot/Metre Readout	Weight less batteries (Kg
Microwave				A feet	
CA1000 A/B	Tellurometer - USA	30 m to 30.5 km	≠ 10 mm + 5 ppm	B metres	1.8
CA1000-D A/B	Tellurometer - USA	30 m to 24 km	≠ 0.6 mm + 5 ppm	A feet, B metres	2.5
MRA3	Tellurometer - USA	60 m to 50 km	≠ 15 mm + 3 ppm	metres	14.9
MRB201	Tellurometer - USA	200 m to 250 km	≠ 0.5 mm + 3 ppm	metres	14.9
MRA5	Tellurometer - USA	100 m to 80 km	≠ 10 mm + 3 ppm	metres	18.1
DM-20	Cubic Corp	50 m to 50 km	≠ 10 mm + 3 ppm	metres	15.0
DM 40A	Cubic Corp	100 m to 150 km	≠ 0.5 m + 3 ppm	metres	29.0
Infrared					
Autoranger	Keuffel & Esser	0 to 1.5 km	≠ 5 mm + 5 ppm	both	3.6
Beetle 500	Precision International	0 to 500 m	≠ 10 mm	both	2.5
CD6	Tellurometer - USA	0 to 2.5 km	≠ 3 mm ≠ 5 ppm	metres	3.4
DI-35	Wild Heerbrugg	0 to 2 km	≠ 5 mm ≠ 5 ppm	both	5.9
DI-10	Wild Heerbrugg	0 to 2 km	≠ 10 mm + 5 ppm	metres	17.7
DM-500	Kern	0 to 500 m	≠ 6 mm + 5 ppm	metres	1.6
DM-1000	Kern	0 to 3 km	≠ 4 mm per 1000 m	metres	9.9
DM-60	Cubic Corp	1 to 2 km	≠ 5 mm + 10 ppm	both	6.8
3800 A/B	Hewlett-Packard	0 to 3 km	≠ 5 mm + 7 mm/km	A feet, B metres	13.2
3805	Hewlett-Packard	0 to 1.6 km	≠ 7 mm + 10 mm/km	both	7.7
3810	Hewlett-Packard	0 to 1.6 km	≠ 5 mm + 10 mm/km	both	11.8
MA100	Tellurometer - USA	0 to 2 km	≠ 1.5 mm + 2 ppm	metres	17.2
ME 3000	Kern	0 to 3 km	≠ 0.2 mm + 1 ppm	metres	17.2
Micro Ranger	Keuffel & Esser	1 m to 1.6 km	≠ 5 mm + 2 ppm	both	3.2
Micro Ranger II	Keuffel & Esser	1 m to 2 km	≠ 10 mm + 5 ppm	both	3.2
Regelta	Zeiss	0.3 m to 1.9 km	≠ 12 mm + 5 ppm	metres	29.9
SM 11	Zeiss	0.3 m to 1.9 km	≠ 12 mm + 5 ppm	metres	20.0
Model 12 A/B	A.G.A.Geodimeter	0 to 2 km	≠ 5 mm + 10 ppm	A feet, B metres	3.2
HDM-70	Cubic Western	0 to 1 km	≠ 5 mm + 10 ppm	both	4.5

Instrument	Manufacturer	Range (Metres)	Accuracy	Foot/Metre Readout	Weight less batteries (Kg)
Laser					
Model 76	A.G.A. Geodimeter	1 m to 3 km	≠ 10 mm + 1 mm/km	both	8.2
Model 78	A.G.A. Geodimeter	1 m to 9.6 km	≠ 10 mm + 1 mm/km	both	8.2
Model 710	A.G.A. Geodimeter	1 m to 5 km	≠ 5 mm + 1 mm/km	metres	24.9
Ranger	Keuffel & Esser	1 m to 12 km	≠ 5 mm + 2 ppm	both	16.3
Range Master	Keuffel & Esser	1 m to 60 km	≠ 5 mm + 1 ppm	both	29.5

TABLE III

Methods of EDM Currently Available Using Media Specified with Advantages and Disadvantages (5)

(1) Microwave	(2) Laser	(3) Infrared
	(a) Functional Advantages	
Accuracy: ≠ 1.5 cm Range: from 50 m to 50 km	Accuracy: ≠ 1 cm Range: from 10 m to 5 km (day): from 10 m to 50 km* (night)	From ≠ 1 mm to ≠ 1 cm Range: from 5 m to 3 km
	(b) Physical Advantages	
Day or Night use	Short range	High accuracy for short range
Will work with imperfect line-of-sight	One skilled operator and one assistant needed	One skilled operator and one assistant needed
Self-checking system, unaffected by fog or smog		Direct readout
	(c) Physical Disadvantages	
One skilled and one unskilled operator	Requires perfect line-of-sight	Requires perfect line-of-sight
Accuracy affected by relative humidity but correctable	Frequent necessity for night work, due to smog	Short range
	Affected by light rays and heat	Accuracy affected by heat

* High powered heavy instrument only.

NOTICES

Contributions to the 'AUSTRALIAN GUNNER'

The Editor of AUSTRALIAN GUNNER seeks, welcomes and indeed would demand if he were in a position to do so, contributions from all walks of Artillery life for this Magazine. In particular the following types of contributions are needed:

a. Technical ideas.

b. Units activities including photographs.

c. Copies of battery newsletters.

d. Humorous stories.

e. Photographs of people, social events, courses, equipment, etc.

f. Regimental feature. Our premier Regiment, 1 Fd Regt, will be featuring in our first Edition. 2/15 Fd Regt Take Post as you are next in line. Then regimental features in regimental numerical order.

Please send contributions to:

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