

Electronic warfare in WWII

by Maj. Richard Riccardelli

The enemy, without information of their movements and not in a condition to reconnoiter, having no resource but in his bayonets and certain of safety only in the concentration of his columns, is like a blind man.¹

—Baron Antoine Henri Jomini

Electronic Warfare (EW) and Signals intelligence have gained immense public notoriety in recent years, resulting initially from the revelations of F.W. Winterbotham's 1974 book, **The Ultra Secret**. The importance of Allied Signals Intelligence on operations in World War II also contributed to EW's popularity;² there is a greater appreciation of Soviet Radio Electronic Combat (REC) and its potential combat destructiveness; and EW's contribution to Israeli successes in the 1967 and 1973 Arab-Israeli wars and recent military actions in Lebanon. Finally, the creation of Military Intelligence (MI), Combat Electronic Warfare and Intelligence (CEWI) battalions and groups at division and corps have combined to stir new interest among US Army officers.

The field of EW is viewed by many as a recent dimension and revolutionary aspect in warfare. In fact, its history dates to World War I when the French Army employed a radio jammer on the Eiffel Tower to disrupt German military radio communications.³ There remain a number of striking and significant lessons that should never be forgotten in this field in mobilization, command and control, technology and research, tactics, and organizational structures. As technology significantly changed the face of war during the era of Sun Tzu with the introduction of the crossbow and cutting weapons of high quality iron, so to may EW prove to be the key technology for success on the airland battlefield.

This article is intended to survey EW and signals intelligence as an element of ground warfare in Europe and North Africa during World War II. Historical studies and articles reporting on the air war and British scientific success in defeating German radars and rockets⁴; the decipherment of Japanese codes⁵; and, Ultra intelligence and codebreaking of German high level communications have focused attention on the overall strategic aspects of Signals Intelligence and Electronic Warfare. Yet, little has been written to



highlight the numerous accomplishments and the importance of battlefield Electronic Warfare and Signals Intelligence units had in support of ground commanders.

As noted by Admiral Thomas H. Moorer, former Chairman of the Joint Chiefs of Staff, "If there is a World War III, the winner will be the side that can best control and manage the electromagnetic spectrum". Electronic Warfare provides ground commanders a tool to disrupt the enemy's strategy and gain time to maneuver forces and employ his firepower.

EW consists of offensive, defensive and "listening in" measures (Figure 1). In the offensive, jamming or Electronic Countermeasures (ECM) are intended to disrupt and deceive enemy communications, radars, and sensors. Defensive measures, or the protection of friendly communications and signals, is known as Electronic Counter-Countermeasures (ECCM). Finally, actions taken to intercept, identify and locate enemy signal transmitters are known as Electronic Support Measures (ESM).

An historical perspective

The Army Signal Corps had the responsibility for EW from World War I to September 1945 when it was transferred to Military Intelligence and the Army Security Agency.⁶ During World War I, Signal Corps

Radio Intelligence units came under the staff supervision, signal intercept, signal intelligence training, research and development, printing, and distribution of and accounting for intelligence material.⁷

From the conclusion of World War I to American participation in World War II, United States Army Signals Intelligence and Electronic Warfare activities were almost nonexistent. Perhaps the efforts of William F. Friedman to sustain a small Signals Intelligence system between the wars provided the principal base for both the Army's tactical and strategic preparations for World War II.⁸ No doubt, Friedman's efforts in solving the Japanese diplomatic code system provided a point of departure for future efforts in solving Japanese military and naval codes.

United States Army indoctrination in the combat value of this field came from the British Eighth Army experience in North Africa; and, then "breaking of the German high command's 'Enigma' code system providing intelligence designated by the code name 'Ultra'". At that time, commanders had to balance jamming

versus listening operations. Often, the decision was to listen and collect intelligence; but, jamming provided an edge in offensive operations.

Perhaps the first Allied effort to use jamming in World War II against ground maneuver units was conducted in November 1941 during the Libyan campaign. Six British Wellington bombers with 50 watt transmitters were used in an effort to jam German panzer communications. Although the immediate effects were not noticeable, reports from German prisoners noted that during the time they were jammed, they were without voice or telegraphic communications. Long term effects would never be determined because after the first two days of battle, Gen. Cunningham's campaign stalled...and of his six jamming aircraft, four were destroyed by the Germans.⁹

With US entry into the war in Europe, the Signals Intelligence partnership with the British blossomed. The British "Y" Service (Signals Intelligence) and the US Signals Intelligence Service (SIS) represented the international interface for this Intelligence. With this marriage, common security regulations to protect this source of intelligence and cover code names were devised to protect against enemy disclosure.¹⁰ For instance, Cryptologic Intelligence was called

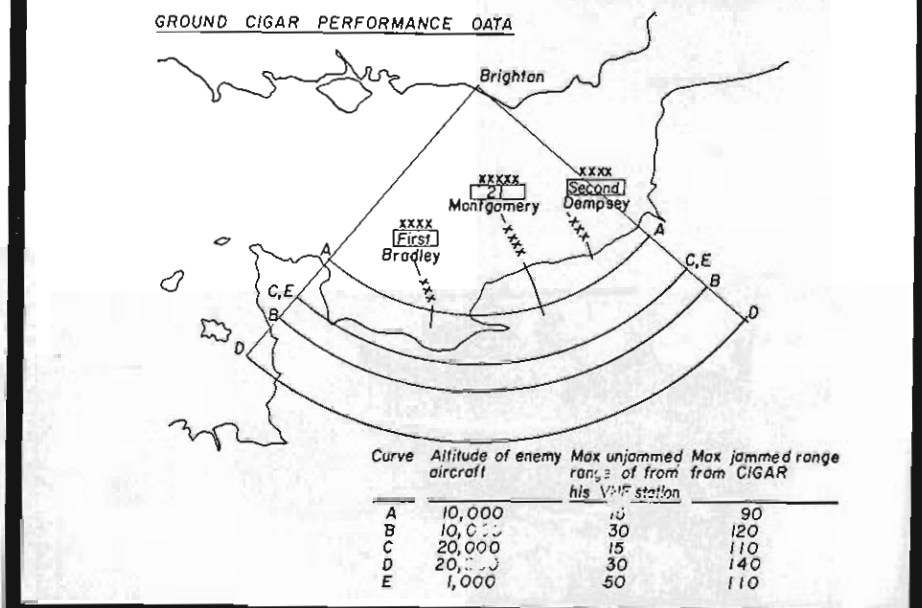


Figure 2. Report of Signal Division, Supreme Headquarters, Allied Expeditionary Force in Operation "Overload", Vol. 1: Prior to the Operation, August 1943 to 'D' Day, 6 Jun 44, p. 104.

"Pearl", traffic analysis of signals and direction finding was called "Thumb"; and "Rabid" was another name for "Ultra" intelligence.¹¹

The United States was quickly indoctrinated into the operational and technical arena by the British. Problems in British signal security in North Africa¹² and German use of communications imitating British signals¹³, led to Army training of communication security in radio schools¹⁴, directives and posters. In part, German field success in North Africa was due to radio intelligence. Col. Bonner Frank Fellers, a US Army Liaison officer to the British Eighth Army, transmitted numerous, comprehensive Eighth Army situation reports to Washington via a compromised code system¹⁵. Gen. Rommel's forces were provided with information from Feller's reports and from British communications carelessness through his highly praised Radio Intelligence Company under a Capt. Alfred Seeborn¹⁶.

With US participation in the North African campaign in November 1942, the Army deployed the 117th, 122nd, 123rd, 128th and 849th Radio Intelligence Companies to support ground operations.¹⁷ North Africa became the Army's radio intelligence classroom in gaining battlefield experience with British assistance. The lessons were applied by these and additional units in Allied operations in Italy and on the continent.

In preparation for the invasion of Europe at Normandy, France, a joint US and British Radio Countermeasures Committee was established. Their mission was to protect the Allied signal frequencies while jamming and deceiving radars and Luftwaffe fighter communications that could find, disrupt and destroy the Allied naval flotilla crossing the English Channel. British naval and air jammers called Ground Cigar, Benjamin, Domino, Aspirin, Ground, Grover and Tuba among others were readied for the invasion.¹⁸ Of note was the British Ground Cigar Jammer (Figure 2) at Brighton, England, which was to be used to jam German fighter communications. On June 6, 1944, the day of the invasion, perhaps the only EW measure employed was by the Royal Air Force. In Operations Taxable and Glimmer, the RAF dropped chaff along the English Channel to simulate a naval task force movement towards the Pas de Calais area of France.¹⁹ Ultra Intelligence revealed that this operation was recognized by the Germans as a chaff deception ploy. In consideration of the 85 reported incidents of jamming, the final D-Day after-action report identified all but three of these incidents as interference caused by Allied use.²¹

For Army ground forces, the first Tactical Radio Intelligence unit, the 113th Signal Radio Intelligence Company, landed at Omaha Beach on June 13, 1944.²² Although an anemic beginning, by the end of the war almost every corps and Army

headquarters had an Organic Radio Intelligence company and Army Group Headquarters had a battalion (Figure 3).

In August 1944, First US Army, under Gen. Bradley, planned to conduct airborne jamming against German panzer radio nets. The mission was to be conducted by the US Eighth Air Force. Operationally, it was to be conducted by four liberator aircraft supported by a fifth plane designed to monitor German radio transmission through the jamming. Apparently this mission was never conducted.²² Yet, in late August, SHAEF sent a directive to subordinate headquarters on the employment of airborne jamming in support of ground operations.²³

As Ultra Intelligence was supplied to the commands on the continent, the Radio and Signal Intelligence companies and battalions also provided invaluable information.²⁴ In fact, all levels of Signals Intelligence were interconnected so that intercepts in the field were fused with high level Intelligence (Figure 4).

In December 1944, and prior to the German winter offensive (Battle of the Bulge), Ninth Army requested airborne jamming of 6th Army Panzer radio nets. With 6th Panzer Army suspected in the zone between British forces and First Army, Ninth Army sought to break up a potential panzer attack. Ninth Army's request was rejected by Eighth Air Force

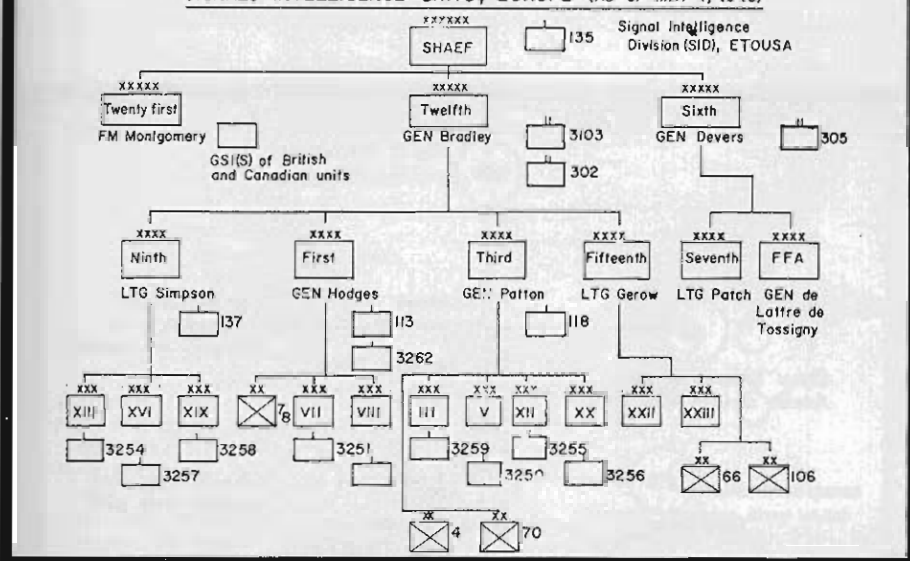


Figure 3. Unlocated: 116th Signal Radio Intelligence Company; 114th Signal Radio Intelligence Company (this unit provided Ultra Intelligence liaison personnel to US Army units); for 21st Army Gp, British Forces were supported by the First Signal Intelligence Gp (See: Report Signal Section, 12th Army Gp, 6 Sep 44 for 24 Aug 44).

because in order to effectively jam these signals, the aircraft would have to be flown in an area of heavy flak and known heavy fighter aircraft concentration.²⁵ However, from December 29, 1944 to January 7, 1945, Third Army received airborne jamming support at the Battle of the Bulge. Twelfth Army Group reported inconclusive findings on the effectiveness of this jamming²⁶, but German prisoners of war in another report indicate that the jamming was very effective.²⁷

Mission

The missions of Radio Intelligence units can be divided into three echelons. At corps level, the primary missions were the intercept, direction finding and traffic analysis of low grade communications, plain text and low grade ciphers with a secondary mission of exploiting medium grade signals. At Army, exploitation was directed against medium grade communications traffic.²⁸ At theater level, emphasis was on the interpretation and dissemination of Ultra Intelligence provided from England. Ultra Intelligence was sent to Army units through the Signals Intelligence Service to Signal Security Det "Ds". These "security" detachments were a cover organization within the G-2 staff. They processed Ultra Intelligence, provided Signals Intelligence technical guidance and fused Signals Intelligence collected by Corps, Army and Army Group units

with Ultra. The cover mission description of a security Det was:

*...specialized officers from the Combat Intelligence subsection for research into German organizations, such as government, civil service, Schutzstaffel, Sturmabteilung, Bund Deutsche Madel, Hitler Jugend, the school system, and organizations of teachers, industrialists, and technicians.*²⁹

Because the Security Dets were the focal point for Signals Intelligence, the initial Radio Intelligence companies deployed to Europe came under the command and control of these detachments.³⁰

Mobilization

Perhaps the most significant factor in US mobilization in support of the Signals Intelligence field was the lack of language-qualified personnel. This was emphasized often as a serious shortcoming.³¹ Additionally, Army requirements to activate units with highly skilled technicians and linguists failed to keep up with the requirements from field commands. For example, 12th Army Group repeatedly requested, but never received, 14 additional companies.³²

The industrial production of communications equipment and Signals Intelligence devices called for astronomical quantities of equipment. For instance, for the Normandy invasion, 30,000 high frequency transceivers, 10,000 very high frequency radios, 3,000 radars and 100 radar ECM systems were used.³³ By the end of the war, 4,100 jammers and intercept receivers of various

types were in use. SHAEF's Radio Countermeasures Division's total requirement was for almost 10,000 ground and airborne jammers and for nearly 1,500 tons of chaff.³⁴

Command and control

Signals Intelligence units came under three separate organizations for command and control. First, these units were assigned to the Signal Corps and under Signal Corps command. Next, these Intelligence units were under the technical control of the Signal Intelligence Service. Technical information was fused with all levels of Signals Intelligence both vertically and laterally.³⁵ The radio and communications nets to support this flow of information (Figures 4 and 5) indicate how this flow worked. Finally, the units came under Intelligence requirements direction of the G-2. For instance, with G-2 Intelligence collection requirements, Radio Intelligence units met the Intelligence needs through a daily activity report. The report consisted of six sections:

- An Intelligence Summary
- Decodes and Translations
- Technical Summary of Nets Heard
- Direction Finding Bearings
- Message Count and Set Allocation
- Code Identifications and Cipher Values³⁶

The companies provided this activity report along with signals intercepts in

TYPICAL SIGNAL INTELLIGENCE MESSENGER SYSTEM

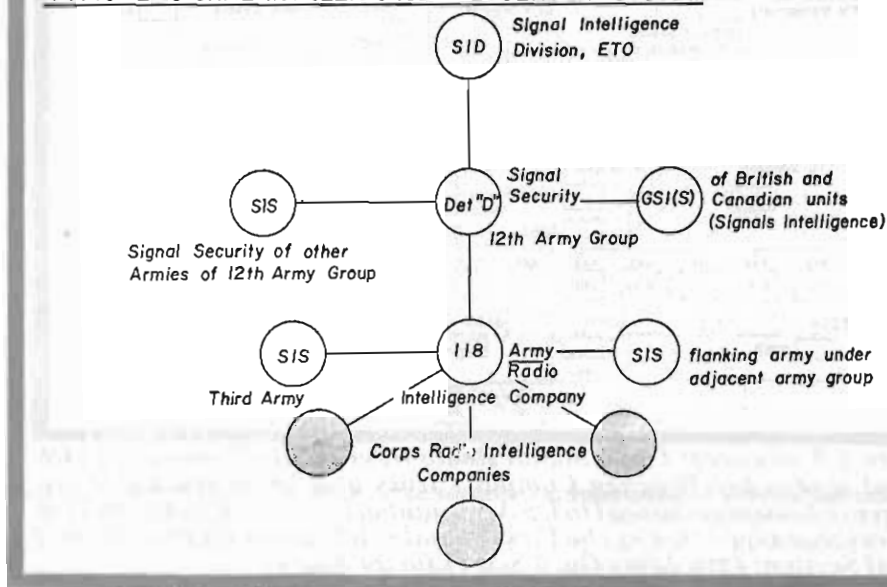


Figure 4. "Third Army Radio Intelligence History in Campaign of Western Europe," prepared by Signal Intelligence Service of Headquarters Third US Army, declassified 1979, SRH-042, p. 18a Annex 3.

both German and English translation "as soon after daylight as possible". In addition, a high priority was given to current combat information or spot reports that could be quickly responded to by maneuver or artillery units.

These reports, along with Ultra Intelligence, were fused together and compared to other Intelligence. An illustration best shows how this reached the commander:

At 12th Army Group Hdqtrs (sic), Gen. Bradley was briefed daily at a small private session. Present were: CG, C/S, G-2, 3 & 4 and usually three Asst G-2s. The situation was developed and the G-2 views stated. Questions by the CG then brought out any additional points of interest to him. (Thus) capabilities and their priorities (or in effect "enemy intentions") were fully developed.

In addition to this there was an open session daily with about forty officers present, at which the G-2 and G-3 general situations were developed. Certain Sensitive information was not brought out at these meetings. Capabilities and priorities were not discussed.

G-2, 12th AG, also put out a weekly *Intelligence Summary* which listed capabilities and discussed priorities. This did not discuss information from most Sensitive sources but did reflect that information wherever safe to do so.³⁷

The operational and technical internal control in these units for ECM and direction finding is illustrated at Figures 6 and 7.

Technology

Victory in these techniques would ultimately go to the Nation that best utilized its brains, that produced suddenly needed equipment faster, that played the game with greater ingenuity. It became a strange combat of Intelligence, of science, of production, of planned integrated tactics behind the men who fired the guns, flew the planes, and dropped the bombs.³⁸

Technological surprise is the most ominous aspect in this field of warfare. It was vital that Signals Intelligence/EW equipment be produced and fielded to cover the electromagnetic spectrum of known and anticipated enemy signals; be designed to the technological standards of the time; and be flexible in design.

In 1942, to meet this challenge, the Army Communication and Equipment Coordination Board completed studies on US Army requirements for

signals, radio intercept and jamming equipment needs for the war.³⁹ As the Wedemeyer Victory Plan was to projecting the wartime personnel and unit mobilization needs for war in 1941, this plan was to signals and Intelligence needs.

The National Defense Research Council (NDRC) had overall responsibility for technological research, and development of systems. Divisions 13 (communications), 14 (radar), and 15 (countermeasures) were the contributing agencies for equipment and research in the Signals Intelligence and Electronic Warfare field.⁴⁰ Their research was conducted at the Camp Evans Signals Laboratories, Camp Coles Signal Laboratories, the aircraft radio research laboratories, and the Radio Research Laboratories (RRL) at Harvard University.⁴¹

These scientists developed a variety of equipment for the rapidly expanding Signals Intelligence field. Several unique items planned and/or produced included multi-van intercept and direction finding systems;⁴² portable direction finding equipment like the SCR 206;⁴³ and, an expendable parachute delivered

TYPICAL SIGNALS INTELLIGENCE RADIO NETS

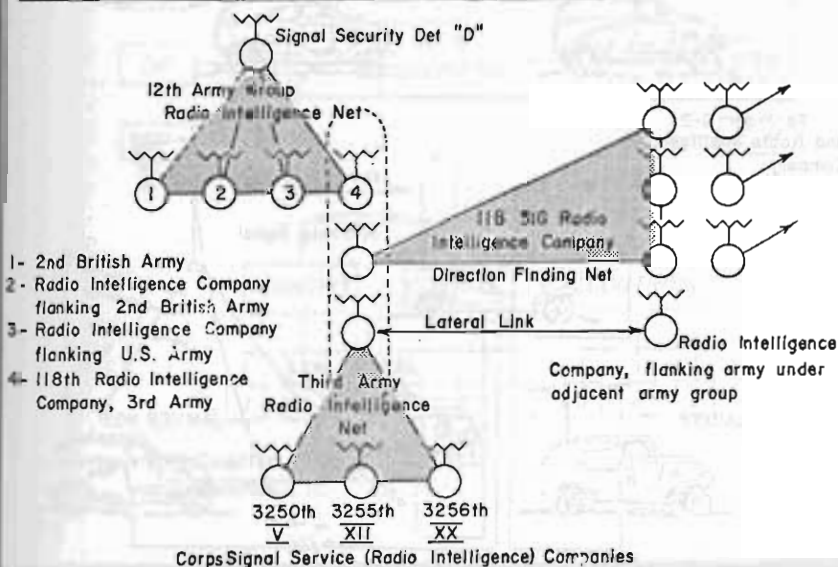


Figure 5.

jammer known as CHICK (AN/CRT-2) and an expendable radar jammer (RADAR CHICK (AN/CPT-1) which would produce a low power jamming signal.⁴⁴ Additionally, improvements were designed into existing equipment. For instance, the PIMPERNEL jammer was improved so that it would skip the frequencies used by our own forces and operate in a multi-scan role.

In early May 1944, a team of these scientists from Division 15, were sent to England to form the American-British Laboratory Division 15 (ABL-15). Stationed at Great Malvern, Worcs, England, they provided technical advice and assistance in the Signals Intelligence and ECM field.

Tactics

Corps and Army Radio Intelligence units worked for their assigned command under the staff supervision of the G-2. As a result, corps companies were concerned with the communications of opposing divisions with emphasis on unencrypted voice signals; Army units concentrated in the high frequency (long distance communications) spectrum with emphasis on the morse code signals of all units opposing the Army.⁴⁷

Often, the companies were divided into forward and rear echelon units and located on the battlefield where the signals could best be heard.⁴⁸

Communications jamming on a large scale was avoided and only the selective use of jamming communications was preferred. This procedure was desired because it was expected that when jammed, the enemy would fall back on fixed wire and cable communications. As noted in one text "...Intelligence to be obtained...was considered to be of more importance than the benefits derived from jamming. Selective jamming was considered to require excessive personnel and equipment."⁴⁹

In anticipation of their deployment across the English Channel, units trained and were tested in their technical and linguistic abilities. The units trained against German units across the channel in work shifts. For example, units at Wincham Hall, England organized into three shifts to conduct Signals Intelligence:

Shift (hours)	Receiving sets used
0001 to 0800	8
0800 to 1800	15
1800 to 2400	15

Operators working at these receiving sets were given a priority search list of communications stations to find along with master listings of communications as an aid. This master listing provided information on fixed station communication systems, call signs, and the peculiarities of the stations noted.⁵⁰

Because these units operated in a sensitive Intelligence field, they had to be selective in the location of their field positions. In order to acquire the strongest signals, they had to be located "well forward"; conversely, they had to be "well screened and secured from enemy action, especially capture".⁵¹ This meant that direction finding baselines were established by the Radio Intelligence companies with the direction finding sets seldom positioned forward of division command posts.⁵² However, the direction finding capabilities of the equipment used often cited as poor in accuracy.

Force structure

The organizational makeup of Radio Intelligence companies varied considerably from their Table of Organization and Equipment (TOE). The original companies were organized under TOE 11-77 published in 1939. Corps' companies consisted of four officers and 100 enlisted men

A CONCEPTUAL EW SYSTEM: 12th ARMY GROUP

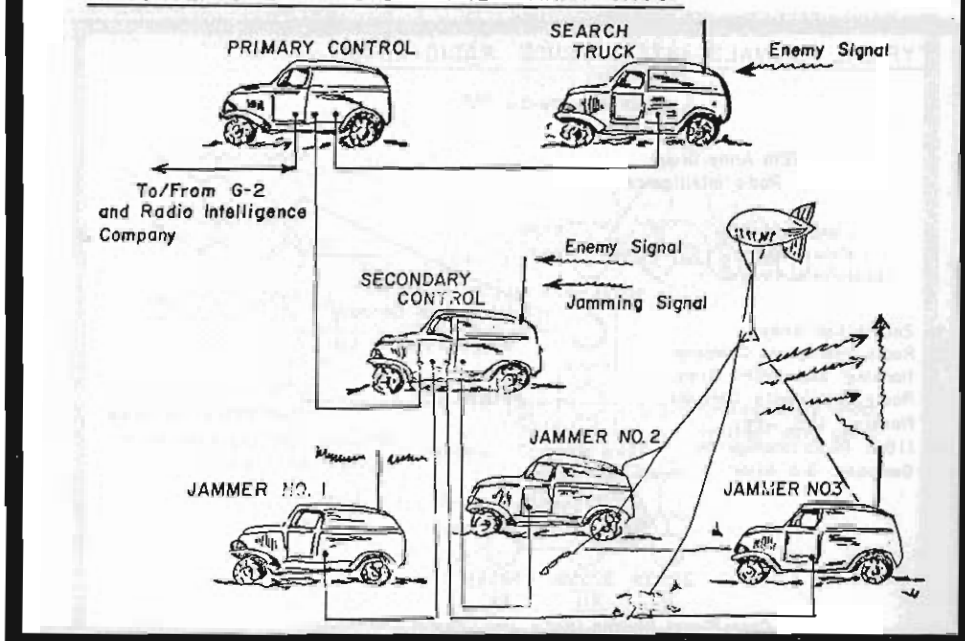


Figure 6. Notes of Col. William A. Beasley, Chief Signal Officer, 12th Army Group, 27 July 1943, "Organization and Operation of a Jamming Unit," RCM-350.

responsible for manning eight to ten communications intercept positions and one direction finding position. At Army level, the organization consisted of eight officers, 150 enlisted personnel, 12 to 15 intercept positions, and up to three direction finding systems.⁵³

Throughout the War, the structure was adjusted to meet field requirements. For instance, the TOE was found lacking in security guards, and this had a direct impact on how far forward the intercept positions could be employed.⁵⁴ By manning equipment and exceeding authorization levels, units expanded upon their capabilities. The 113th Radio Intelligence Company, assigned to First US Army in England, used up to 24 intercept positions and six direction finding stations.⁵⁵

The US Army Signals Intelligence Service, ETOUSA, which was responsible for providing Ultra Intelligence liaison personnel to Army field commanders, consisted of 46 officers and 207 enlisted personnel.

Modifications to equipment and personnel structures in field operations were characteristic of Electronic Warfare operations. For

instance, the Radio Set SCR-596 was modified by a unit to jam in the radio bands used by panzer units. Using this equipment, a corps radio intelligence company established ECM teams of approximately four officers and 37 enlisted personnel.⁵⁶

Conclusion

*Therefore determine the enemy's plans and you will know which strategy will be successful and which will not; agitate him and ascertain the pattern of his movement... probe him and learn where his strength is abundant and where deficient.*⁵⁷ —Sun Tzu

Military leaders throughout history have always placed great emphasis upon the lessons of military history. The principles, tactics, mobilization issues, technological demands and command and control principles in World War II show striking similarities with EW issues today.

Current notoriety in this field of warfare and the development of Military Intelligence (MI), Combat Electronic Warfare Intelligence (CEWI) units represents a renaissance with roots to United States Army employment of Radio Intelligence units in North Africa, Italy, and Northern Europe.

Several similarities exist between US Army World War II experiences

and the present. Of those of particular note, the most crucial is the requirement for linguists. Throughout World War II, the Army was hard-pressed to provide linguists to tactical radio intelligence units. The highest attendance percentage of students in US modern-language study was just prior to World War II. In the main, this situation has deteriorated. Nationally, only 3,500 high school students are studying Russian beyond their Sophomore year; 197 are in their third or fourth year of Chinese language studies; and, only 81 high school students are taking Polish beyond the second year. The civilian manpower base to support and sustain future defense needs is diminishing rapidly.⁵⁸ Although efforts to automate work and phrase recognition as demonstrated by International Telephone and Telegraph and Bell Laboratories may help, linguists will still be required to go beyond machine or phrase recognition.⁵⁹

Second, mobilization and the reserve forces influx of officer and enlisted linguists, analysts and technicians were the principal source of both initial and sustaining personnel and units in Signals Intelligence

Patton's 118th Radio Intelligence Company EW System

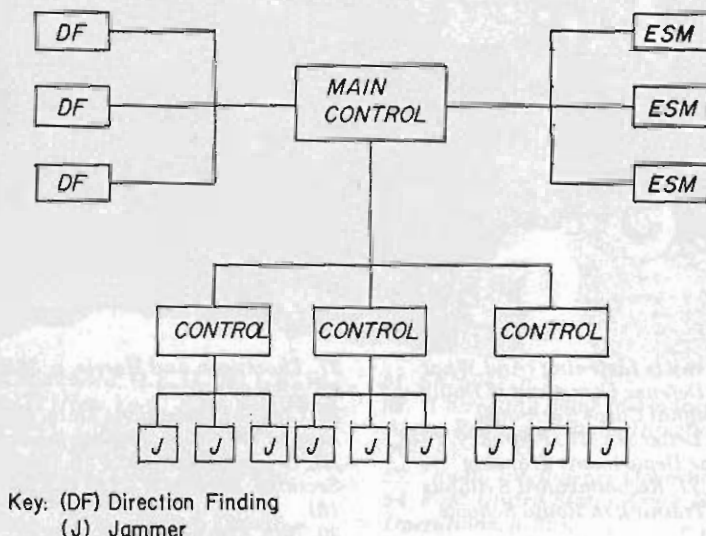


Figure 7. Notes of Col. William A. Beasley, RCM-350.

and Electronic Warfare. To fight the First World War, 58 divisions were activated and 42 went overseas. In World War II, 89 divisions and supporting troops were raised and deployed. The reserve forces Electronic Warfare community in the past and on the airland battlefield will be a significant element in meeting and sustaining operations.⁶⁰

Next, and in the field of tactics during World War II, the G-2 and G-3 had to balance the advantages of jamming, against the benefits of remaining silent and listening to the enemy. If jamming was employed, it was used to disorganize an enemy attack; to strain existing and supplemental communications; and, to force him to expend materials, manpower and time to overcome our jamming strategy. US Army ECM strategy today parallels the principles of 40 years ago.

Finally, the backbone of World War II radio intelligence units was the junior non-commissioned officer. The resourceful, often ingenuous field developments and sophistication of these units can be attributed to their leadership. The parallel between World War II and today is evident.⁶¹

Maj. Riccardelli is Chief of the Military Intelligence Team, Readiness Group Sheridan, Ft. Sheridan, Ill. He received a BA from Seton Hall University and a MS from Ohio University. He is a graduate of USACGSC, class of 1983. He is also a graduate of the Infantry Officer Basic, EW/Cryptologic Officer, Tactical Surveillance and MI Officer Advance Courses. He has commanded EW units in both CONUS and in USAREUR.

Endnotes

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3. M. T. Thurbon, "The Origins of Electronic Warfare," *RUSI*, September, 1977, p. 57, as cited in R.F.H. Nallder, *Royal Corps of Signals*, Royal Signals Institution, 1958. The jamming was used against German radio logistics communications during the first battle of the Marne in 1914.

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5. Ronald Lewin, *The American MAGIC: Codes, Ciphers and the Defeat of Japan* (New York: Farrar Straus Giroux, 1982).

6. See: *The Origin and Development of the Army Security Agency, 1917-1947* (Laguna Hills, California: Aegean Park Press, 1978).

7. George R. Thompson, Dixie R. Harris, Pauline M. Oakes, and Dulaney Terrett, *The Signal Corps: The Test (December 1941 to July 1943)* (Washington, D.C.: Office of the Chief of Military History, 1957), pp. 328-329; also, *Regulations for the Intelligence Section of the General Staff* (Paris: Headquarters, American Expeditionary Forces, August 31, 1917), p. 36 notes "...the wireless Intelligence Officer at Army Headquarters receives the reports and analyzes and disseminates the information from them, while the technical supervision and maintenance of the equipment rests upon the proper officer of the Signal Corps."



8. See: "A Brief History of the Signal Intelligence Service" by William F. Friedman, June 29, 1942, declassified 1979, SRH-029; and, "Expansion of the Signal Intelligence Service from 1930-7 December 1941" by William F. Friedman, declassified 1981, SRH-134; there were at least seven fixed intercept sites in existence on December 7, 1941. These were at Ft Hancock, New Jersey; Ft Scott, Presidio of San Francisco; Ft Sam Houston, Texas; Post of Cororal, Panama Canal; Ft Shafter, Hawaii; Ft McKinley, Puerto Rico; and Fort Hunt, Virginia.

9. "Handbook for RCM Officers," NDOA-53, n.p., n.d., notes from the Chief Signal Officer, 12th Army Group, Colonel William A. Beasley; hereafter referred to as "Handbook for RCM Officers".

10. "War Department Regulations Governing the Dissemination and Security of Communication Intelligence 1943-1945," declassified 1979, SRH-044; hereafter referred to as SRH-044.

11. Ibid., "Security of Special Intelligence within European, North African and Middle East Theater of Operations," 15 March 1944, pp.28-38.

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15. David Kahn, **The Codebreakers** (New York: The MacMillan Company, 1967), p. 473

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19. Thurbon, op. cit., p. 33, as cited from Alfred Price, **Instruments of Darkness** (William Kimber, 1967). Taxable was a simulated assault on Fe' comp, and Glimmer an assault on Boulogne; contrary to notes on the successful deception of these operations in the **Instruments of Darkness** (pp. 199-211), the Germans were aware that this was a deception operation (Figure 6)."

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21. First U.S. Army. Report of Operations, 20 October 1943 to 1 August 1944, Annex No. 14, Operations Plan "NEPTUNE," Signal Communications Plan, p. 97.

22. 12th Army Group. Report of Operations (Final After Action Report). Vol. XI, Section V, Signal, pp. 156-157, hereafter referred to as 12th Army Group. Report of Operations; the Liberator aircraft used jammers known as Jackal (AN/ARQ-2) and referred to by the British as Jostle. The jammer was located in the gun turret.

23. Ibid., p. 196.

24. "Examples of Intelligence Obtained from Cryptanalysis, 1 August 1946," declassified 1980, SRH-066; SRH-042; Kahn, op. cit.

25. 12th Army Group. Report of Operations, p. 232.

26. Ibid.

27. Thompson and Harris, p. 324.

28. SRH-042, p. 52.

29. Combat Operations Data, First Army, Europe 1944-1945, 18 November 1946, Part III: Organization and Functions, The Staff Sections, Section B—The G-2 Section, p. 161.

30. 12th Army Group, Report of Operations, p. 178.

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32. 12th Army Group. Report of Operations, p. 153.

33. Richard W. Pryor, "Electronics Production and Procurement, 1939-1945 Compared to Today," **Signal**, May-June, 1981, pp. 89-92, 95.

34. Letter, "Status of Countermeasures Equipment as of 1 December 1943," HQ, SOS ETOUSA, Office of Chief Signal Officer, RCM Division, C-4 Branch, December 11, 1943.

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36. SRH-042, pp. 11-12.

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38. Thompson and Harris, p. 302.



39. John E. Burchard, **Q.E.D., M. I. T. in World War II** (New York: John Wiley and Sons, Inc., 1948); Lincoln R. Thiesmeyer and John E. Burchard, **Combat Scientists** (Boston: Little, Brown and Company, 1947), p. 259.

40. Thompson, Harris, Oakes, Terrett, p. 306.; the counterpart British organization was the Telecommunications Research Establishment (TRE) at Malvern. See: Seymour Reit, **Masquerade: The Amazing Deceptions of World War II** (New York: Hawthorn Books, Inc., 1978), p. 217.

41. Handbook for RCM Officers, p. 5. For a listing of the Signal Corps Engineering and Technical Service branches and activities see Army Service Forces Manual M301, "Army Service Forces Organization," HQ, ASF, 15 January 1944. (Washington, D.C.: US Government Printing Office, 194), p. 11.

42. "Radio Direction Finder Central TC-8 and Radio Intercept. Central TC-9," Signal Corps Technical Information Letter, March 1944, pp. 49-55; "Radio Intercept Central TC-9," Signal Corps Technical Information Letter, April 1944, pp. 52-54.

43. "Direction Finders," Signal Corps Technical Information Letter, December 1944, pp. 7-10; it is of interest that the SCR-206 was described as portable but weighed 300 pounds. Tactical direction finding equipment throughout World War II generally lacked the sensitivity to provide accurate bearings to target communications systems. See also: "Correcting Some Misconceptions about Radio and Radio Direction Finders," **Tactical and Technical Trends**, December 1944, pp. 66-69.

44. Handbook for RCM Officers, p. 51.

45. Ibid., p. 50.

46. 12th Army Group. Report of Operations, p. 155.

47. "Radio Intelligence Operations," Signal Corps Technical Information Letter, September 194, pp. 9-10, 23.

48. Ibid.

49. 12th Army Group. Report of Operations, p. 155.

50. First United States Army. Report of Operations: 20 October 1943, 1 August 1944, Annex No. 2, n.d., p. 97.

51. SRH-042, p. 8.

52. "Correcting Some Misconceptions About Radio and Radio Directions Finders," p. 68.

53. "Radio Intelligence Operations," p. 9.

54. First United States Army. Report of Operations, p. 225.

55. Ibid., pp. 124-125.

56. Joint Communications Plan, European Theater of Operations, Army Communications Requirements, Annex 2 to Appendix C, 14 October 1945.

57. Samuel B. Griffith (Trans.), **Sun Tzu, The Art of War** (New York: Oxford University Press, 1962), p. 100.

58. Fred M. Hechinger, "US Said to Stand Alone in Neglect of Languages," **The New York Times**, January 9, 1979, pp. C1, C6; Flora Lewis, "Speaking in Tongues," **The New York Times**, February 4, 1982, p. A23; James Barron, "Teaching Foreign Tongues Continues to Decline," **The New York Times**, June 17, 1979, p. 20; Robert Rheinhold, "Panel Urges Stress on Foreign Tongues," **The New York Times**, November 8, 1979, p. B7.

59. See for examples: "Briefs: International Telephonic and Telegraph Corp.," **The New York Times**, July 22, 1982, p. D4; "Systems Developed for speech Recognition," **The New York Times**, June 2, 1979, p. 35.

60. US Army Field Forces. "Report of Army Ground Force Activities," 10 January 1946, pp. 3-4, 11.

61. An excellent leadership reference for electronic warfare unit leaders is Thomas J. Peters and Robert H. Waterman, Jr., **In Search of Excellence, Lessons from America's Best-Run Companies** (New York: Harper and Row, 1982).