LEGIBILITY NOTICE

A major purpose of the Technical Information Center is to provide the broadest dissemination possible of information contained in DOE's Research and Development Reports to business, industry, the academic community, and federal, state and local governments.

Although a small portion of this report is not reproducible, it is being made available to expedite the availability of information on the research discussed herein.

LA-UR -87-1935

CONF-870778--1

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG 36

LA-UR--87-1935

DE87 011785

TITLE EMP REPRESENTATIONAL TOOLS FOR PERSONAL WORKSTATIONS

AUTHOR(S) R. Allen Riley
Donald F. Shafer

SUBMITTED TO NATO/SHAPE EMP Protection Technical Symposium
Defense Nuclear Agency

DISCLAIMER

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

EMP REPRESENTATIONAL TOOLS FOR PERSONAL WORKSTATIONS

A. Riley, D. Shafer, S-6
Military Systems
Los Alamos National Laboratory
Los Alamos, NM
June 1987

ABSTRACT

The ability to rapidly provide a visual representation of a problem set, its accompanying environment, and the variables that directly impact the analysis is of enormous value to the weapons analyst. Parametric, first-principle tools are directly and immediately usable by the analyst to represent the systems under investigation and the effects on those systems by the weapons under analysis. The three tools described, GEOREP, 3-AXIS, and G_RANGE, provide these visual, analytic tools directly to the analyst on personal computer workstations. The simplicity and rapidity with which these tools may be used are especially beneficial to weapons analysts dealing with complex phenomena such as EMP. The potential flexibility of these representational tools is shown through examples of notional weapons applications. Use of GEOREP, 3-AXIS, and G_RANGE, which augment, rather than supplant, complex weapons effects physics codes, can help provide the necessary, cost-effective guidance for making decisions on detailed case studies.

INTRODUCTION

The analysis of electromagnetic pulse (EMP) effects requires the synthesis of two basic types of information: weapon system characteristics and target environment. The information resides in a variety of formats: published reports, official memoranda, open literature, electronic databases, and maps. Reduction, assimilation, and representation of this material for useful analysis remains a major task. This paper describes three spacially oriented tools for computer personal workstations that were designed to assist analysts in representing EMP effects in the target environment. All tools were developed at Los Alamos National Laboratory by analysts in the Military Systems group. The objectives in their development were not

just to provide tools for usable, hands-on analytical support, but to provide inherent flexibility for rapid iteration through parametric scenario changes.

Personal workstations are becoming more available to all levels of users. The ability to rapidly provide a visual representation of a problem set, its accompanying environment, and the variables that directly impact the analysis is of enormous value to the weapons analyst. His or her efforts are directed at the problem and its solution, not at trying to make the problem fit the available tools. Parametric, first-principle tools are therefore directly and immediately usable by the analyst to represent target systems under investigation and the effects upon those systems by the weapons under analysis. Workstations are providing personal-scale computing to users who previously had to learn obscure computer operating systems working through slow "on-line" terminals.

GEOREP

The first tool, GEOREP, runs on any class of IBM PC or compatible microcomputer. It provides a geocentric projection of a spherical earth with accurate map projection of points, areas, geographic features, and boundaries. Figure 1 shows the GEOREP start-up screen. The user-interactive representation may be actively scaled from greater than 20,000 km to less than 1 km with the same positional accuracy. The view provided the analyst is equivalent to a globe, and the user may move the viewpoint over the surface at will, placing the center of the screen at any desired latitude and longitude.

GEOREP displays provide a 15° latitude and longitude line grid, an outline of continents and major islands, and a suite of icons. Figure 2 shows Europe with the eastern border of the Federal Republic of Germany (represented with small squares); two major NATO military areas of concern, Mons and Heidelberg (rectangles); the western European cities of London and West Berlin (triangles); and the eastern European cities of Budapest, Warsaw, and Moscow (carets; ^). SHAPE Headquarters at Mons is identified. Specific objects, including point and area targets and weapon effects laydowns may be displayed, moved, and placed as desired on the geosphere. The program will accommodate

additional databases as desired (e.g, a detailed road map of West Germany).

3-AXIS

The second tool, 3-AXIS, is built using the DISSPLA graphics subsystem and runs on any personal workstation supporting DISSPLA and FORTRAN. 3-AXIS is designed for three variable combination data, allowing analysts to plot any combination of significant parameters. The data are displayed in a three-dimensional format that permits the user to designate axes' labels and units as required. Within the plotted space, the user can "zoom" in to a portion of the graph or rotate areas of varying viewpoints. This greatly aids the perception of the various parametric combinations. Examples of types of parametric combinations that may be plotted include the following: energy vs frequency range for electromagnetic radiation propagation, altitude vs time vs range for missile performance, and an "x-y" range plot vs altitude for an aircraft's operational envelope.

Figure 3 is a three-dimensional representation of a portion of the information contained in Fig. 11.73, page 538, of The Effects of Nuclear Weapons, 3rd Edition, by Samuel Glasstone and Philip J. Dolan. Computer contours are shown for the maximum peak electric field (E_{max}) and various fractions of E_{max} for varying burst altitudes out to the line-of-sight horizon from the weapon detonation.

G_RANGE

Originally prototyped on a Hewlett-Packard 15C hand-held calculator, this analytical tool calculates line-of-sight ground range from height-of-burst (HOB) to a target. The tool also will calculate a compounded line-of-sight ground range from the detonation point (HOB) to an object at altitude. Figures 4 and 5 show examples of the use of G_RANGE for both earth-based and airborne targets. It calculates ground range for either true line-of-sight or the farther, refraction-induced "radar horizon." An extended version is presently being developed to calculate line-of-sight distance for nontangent phenomena, do multiple unit conversions and be directly accessible by GEOREP.

The remainder of the paper will focus on an example analytical case for the illustration of these tools. Other potential applications areas of interest to NATO analysts will also be described.

EXAMPLE

For our example framework, we will assume a high-altitude nuclear percursor EMP attack on SHAPE Headquarters. GEOREP, 3-AXIS, and G_RANGE representations will be provided for applicable analytical areas, including the following:

- EMP effects environment,
- effects on areas of NATO ground and air C^2/C^3 forces,
- hardness degradation,
- effects of intentional hardening, and
- a simple excursion from the basic example scenario.

It should be noted that this example is notional: it uses generic weapons effects as defined above, and scenario elements are derived from elementary descriptions of NATO assets as included in Zones of Conflict, by John Keegan and Andrew Wheatcroft. With respect to weapons effects phenomena, important characteristics such as field strength (E) and frequency (f) are handled parametrically. For these representations, proportional values (e.g., "0.50 E_{max}" and "E_{max}") are used, the intent here is to illustrate the ability of the tools to describe many potential attributes of weapons effects phenomena and target characteristics with straightforward flexibility. For example purposes, an arbitrary assumption of 0.75 E_{max} has been chosen to represent a "lethal" EMP level on target systems. Actual values are dependent upon complex interaction phenomenology between weapon-induced EMP environments and the response(s) of any target item.

The geographical context of the example EMP weapon laydown is illustrated in Fig. 2. Included in this view of Europe, the western Mediterranean, and a portion of the northern Atlantic are the Inner German Border, SHAPE Headquarters at Mons, London, Heidelburg, Berlin, Warsaw, and Budapest. This GEOREP plot is centered to 48°30' N,

12°30′ E, and the scale has been reduced from 13,000 km in the start-up screen to 5,000 km.

This area will have applied to it a high-altitude EMP laydown with a field strength mapping as shown in Fig. 3. This 3-AXIS three-dimensional plot is derived directly from Fig. 11.73, Glasstone and Dolan, and depicts the EMP environment in the area to the east and south of the designated ground zero (DGZ), or detonation point for the attack. This figure represents a nuclear detonation with the following parameters:

- HOB: 100 km
- Weapon yield: 500 kt

The vertical axis is field strength, E, and the base plane represents range values to the east (right) and south (left) in kilometers. (Unless noted otherwise, solid lines are used in this and further 3-AXIS plots to represent the levels of E greater than or equal to 0.75 E_{max}.) The orientation of the south axis is along magnetic south, a point that is significant for accurate geographic mapping of an EMP weapon's DGZ for any specific target. Figure 6 is a view of the same data rotated to look parallel to the vertical axis. The principal target area (within the maximum field) and the offset DGZ may be identified and scaled for further usage.

3-AXIS is readily employed to represent other aspects of EMP phenomena, as is shown in Fig. 7. Here, E is represented on the vertical axis again, with the right-hand axis used for frequency and the left for range along the south magnetic ray. (Note that a similar mapping could be done for other rays as desired.) Such a representation allows the analyst to examine complex interaction of variables from different perspectives as desired. A unique feature of this plot is shown in the lower left: the limited dotted region represents the low-frequency portion of high-altitude EMP which may carry past the line-of-sight horizon (sections 10.92 and 11.72, Glasstone and Dolan).

The basic example problem of a high-altitude laydown on SHAPE Headquarters is displayed geographically in Fig. 8. In this GEOREP

plot, the basic EMP parameters of E_{max} (r_1), 0.75 E_{max} (r_2), and 0.5 E_{max} (r_3) are displayed in circle format. The radii used here are taken directly from Figs. 3 and 7, with the DGZ placed on a north magnetic ray through Mons, Belgium. It should be noted that, for this case, the circularly derived representation (the shaded area, or 120° of the r_1-to-r_2 torus) approximates the "smile" area of high field strength from Fig. 7 to within about 10%. The high field strength areas are shown here using GEOREP's dotted line feature, and the line-of-sight horizon for the HOB is represented by the solid circle. (Horizon radii used throughout this example are line-of-sight; "radar horizon" radii, based upon a four-third's earth curvature approximation, can be obtained from G_RANGE for use instead if appropriate.)

For the example problem, Fig. 8 shows a baseline threat representation to NATO ground C^2/C^3 assets. C_RANGE is used to calculate exposure radii for airborne assets, as is shown in Fig. 9. In this case, total ground ranges are shown for aircraft at 5000 ft (r_4) and 35000 ft (r_5). Figure 10 adds these radii to those previously displayed. EMP line-of-sight exposure to aircraft thus extends significantly the total area of concern for NATO forces.

As can be seen from the foregoing, the potential EMP environment from a single high-altitude laydown could pose significant problems for NATO's efforts to protect its C^2/C^3 assets. GEOREP, 3-AXIS, and G_RANGE were designed to aid the analyst in generating variations on baseline or representative cases readily. Figures 11 and 12 display the result of degradation in hardness that equates to a lethality level lowered to 0.6 E_{max}. Similarly, Figures 13 and 14 represent the result of intentional hardening of NATO systems to the 0.9 E_{max} level. Simple usage of representational aids in this manner assists the analyst in making rapid and distinct discriminations among parametric excursions, while providing a ready format for visual display of key problem elements.

Analysis of complex weapons effects such as EMP often requires modifications to entire scenarios. Since such modifications are usually done in a parametric fashion, the ability to represent an entire suite of parameters together through variations is valuable. Figure 15 is the GEOREP representation of the alteration of one base

parameter in our example, the DGZ. Here the same EMP fields are represented as in the first case (dotted lines represent the initial DGZ; solid lines, the new one). The change in coverage of NATO ground assets can then be contrasted as follows:

- the threat to NATO's Central Europe forces is decreased;
- the exposure of Warsaw Pact and Soviet operating areas is decreased; but
- the new DGZ still maintains "lethal" coverage of SHAPE Headquarters.

OTHER NATO-RELATED APPLICATIONS AREAS

The base example discussed here has concentrated on NATO's principal area of interest for EMP hardening. However, there are other major NATO operational areas in which EMP targeting by Soviet Union/Warsaw Pact forces may be a critical concern; in all, GEOREP, 3-AXIS, and G_RANGE are useful analytical tools. Figure 16 encapsulates four such areas of interest for NATO operations, showing line-of-sight horizons for representative threat scenarios (HOB equals 100 km):

- UK Air,
- Mediterranean C^2,
- far north operations areas (e.g., the Norwegian Sea; Northern Canada), and
- attack warning/attack assessment.

CONCLUSIONS

As stated initially, the intent here has been to display the potential flexibility of representational tools designed for use by weapons analysts. Since one does not have the freedom to perform lengthy and expensive physics calculations without reasonable justification, the simplicity, and rapidity with which such tools may be used is especially beneficial to weapons analysts dealing with complex phenomena such as EMP. The use of GEOREP, 3-AXIS, and G_RANGE, which augment, rather than supplant, complex weapons effects physics codes,

can help provide the necessary, cost-effective guidance for making decisions on detailed case studies.

REFERENCES

1. The Effects of Nuclear Weapons, Glasstone, Samuel and Philip J. Dolan; U.S. Department of Defense and U.S. Energy Research and Development Administration, Third Edition, 1977.

2. Zones of Conflict, Keegan, John and Andrew Wheatcroft, Simon and Schuster; 1986.

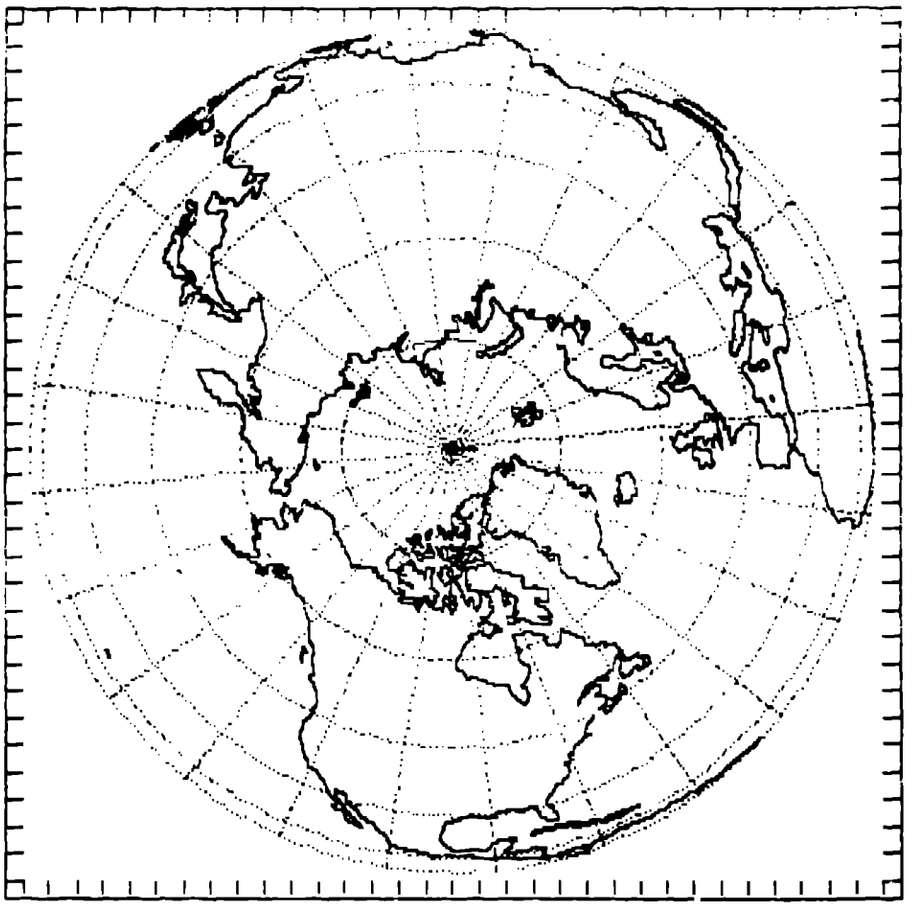


Fig. 1.
GEOREP Start-Up Screen.

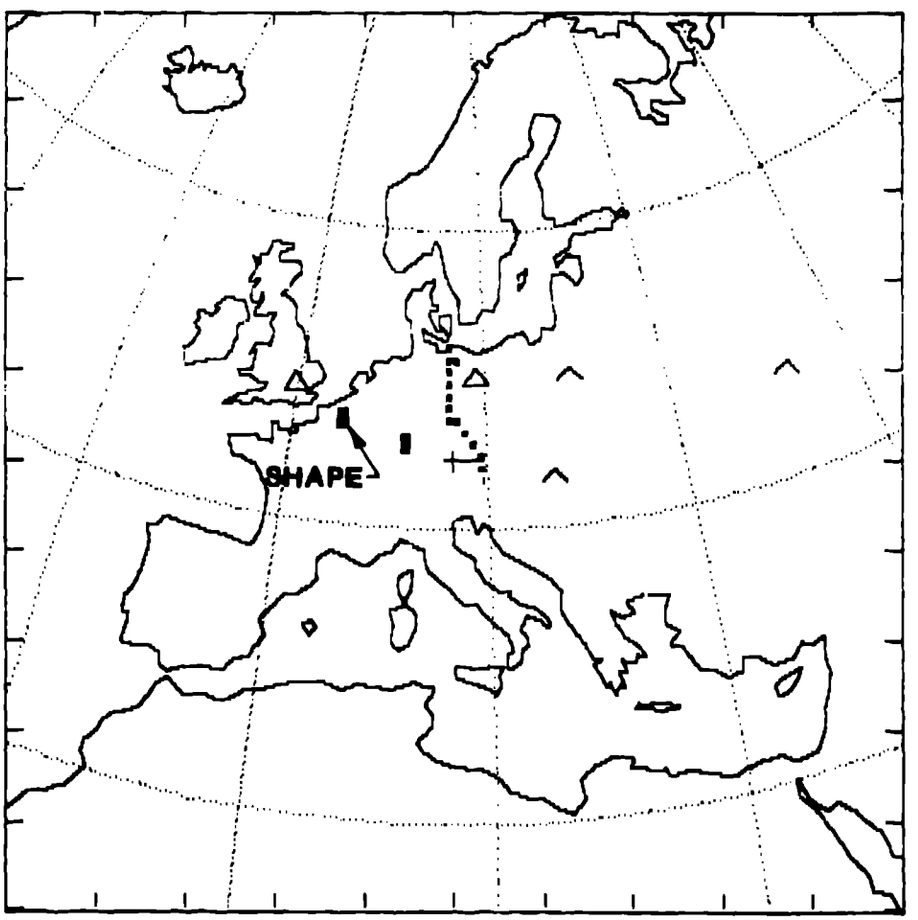


Fig. 2.
NATO Area of Interest.

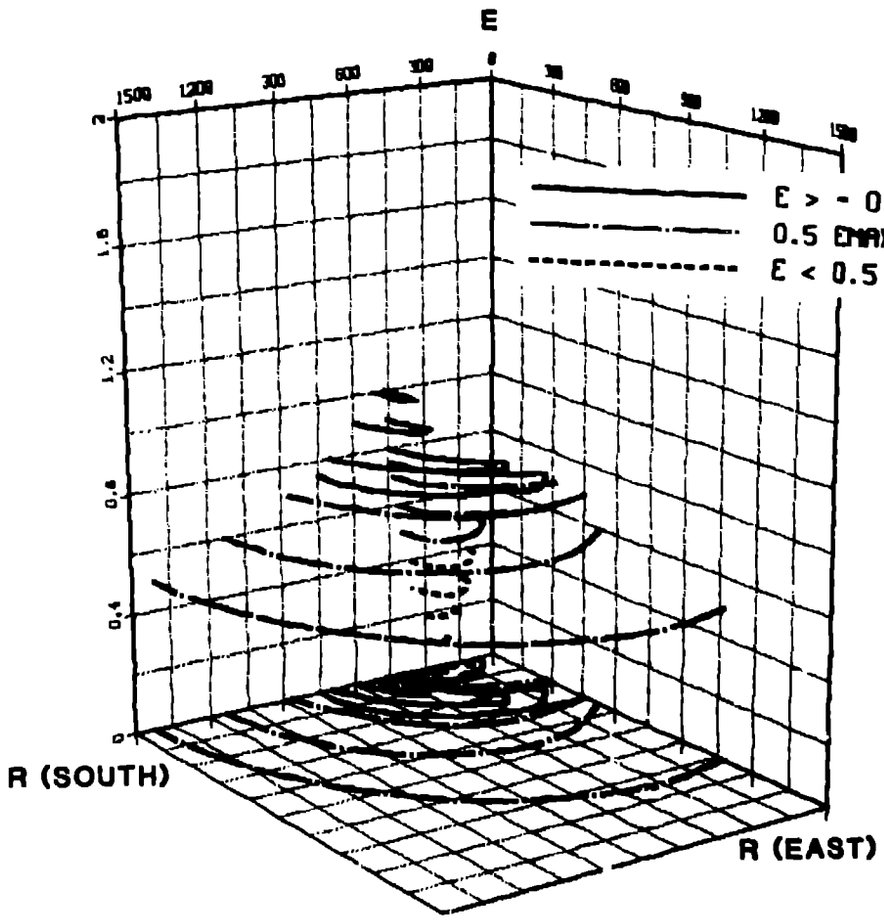


Fig. 3.
EMP Environments: Field Strength Plot

Assumed Lethality: 0.75 E_{max}.

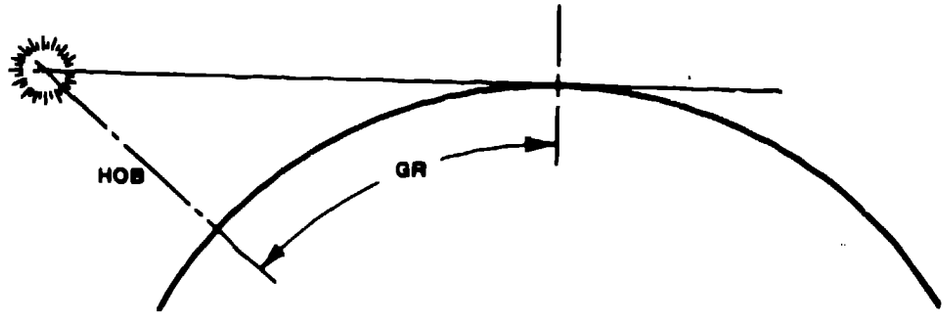


Fig. 4.
Line-of-Sight Ground Range (GR): Detonation to Earth Tangent

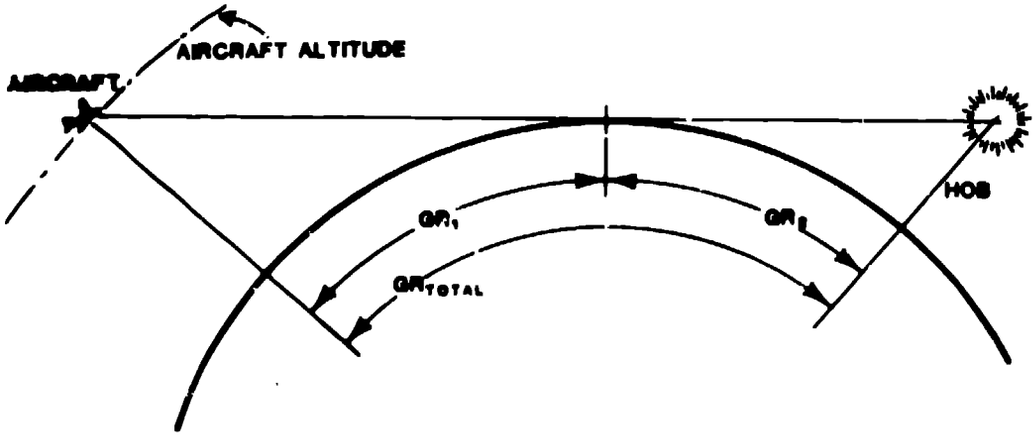


Fig. 5.
Total Line-of-Sight Ground Range: Detonation to Exposed Aircraft

GR_1 = Ground Range to Earth Tangent for Aircraft

GR_2 = Ground Range to Earth Tangent for HOB

$GR_{Total} = GR_1 + GR_2$

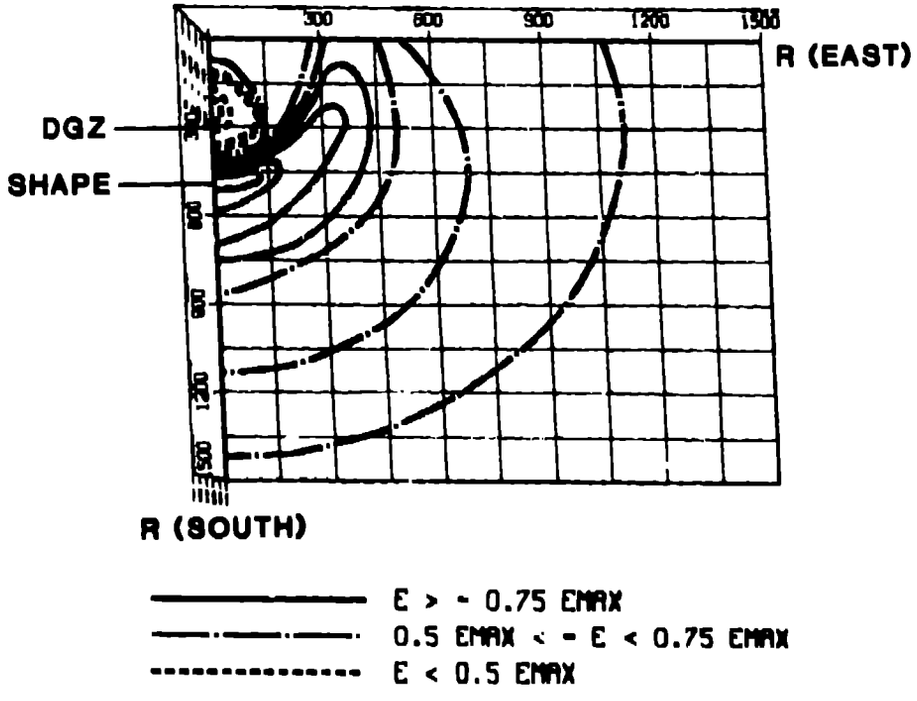


Fig. 6.
EMP Field Strength Plot, Rotated (0.75 E_{max} Lethality).

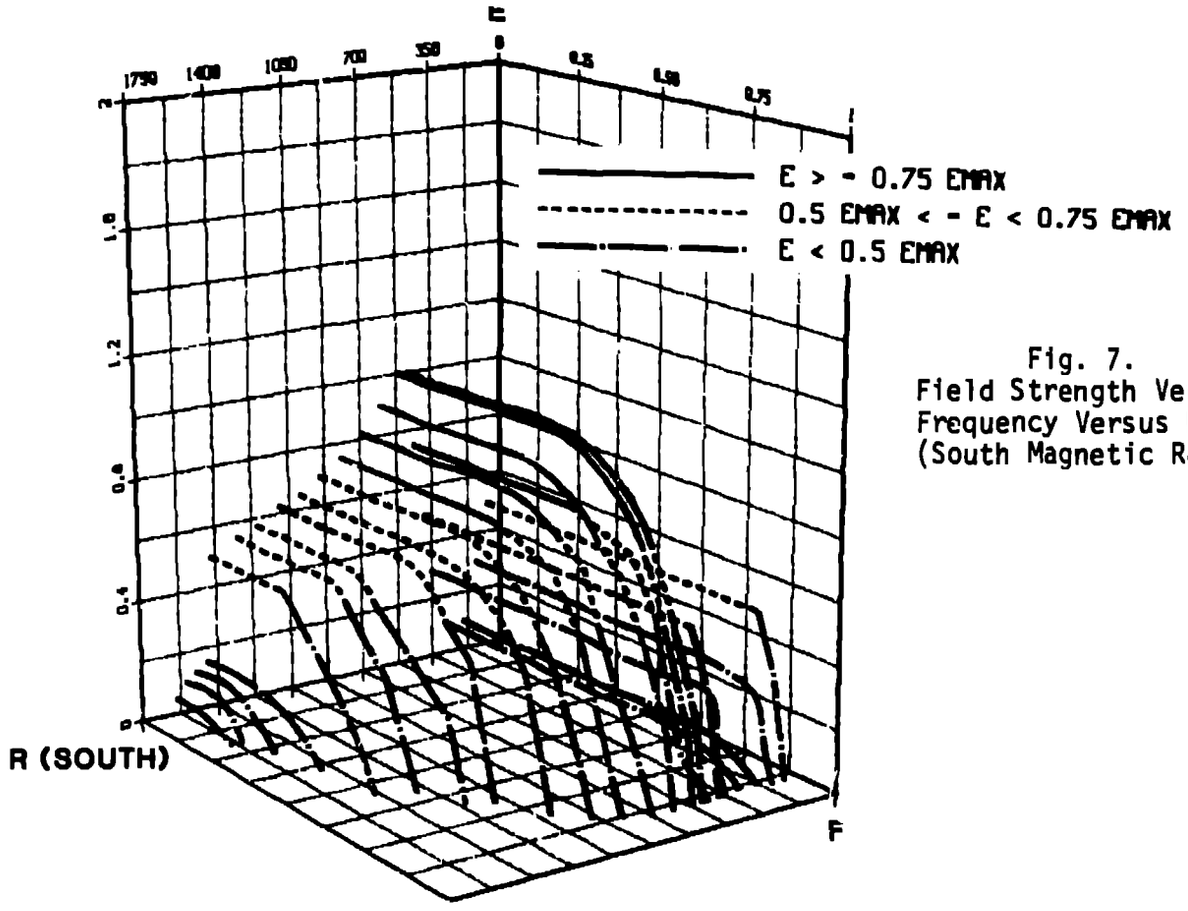


Fig. 7.
Field Strength Versus Frequency Versus Range (South Magnetic Ray).

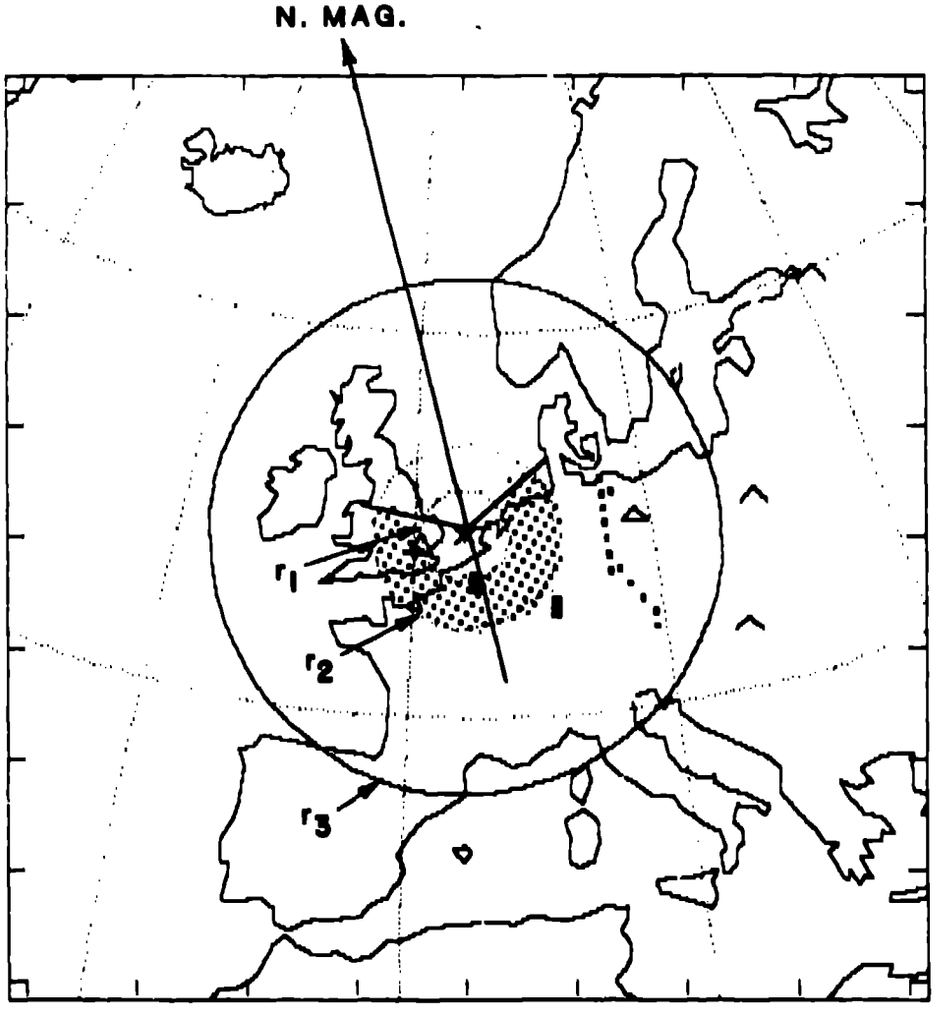


Fig. 8.
EMP Attack on SHAPE Headquarters.

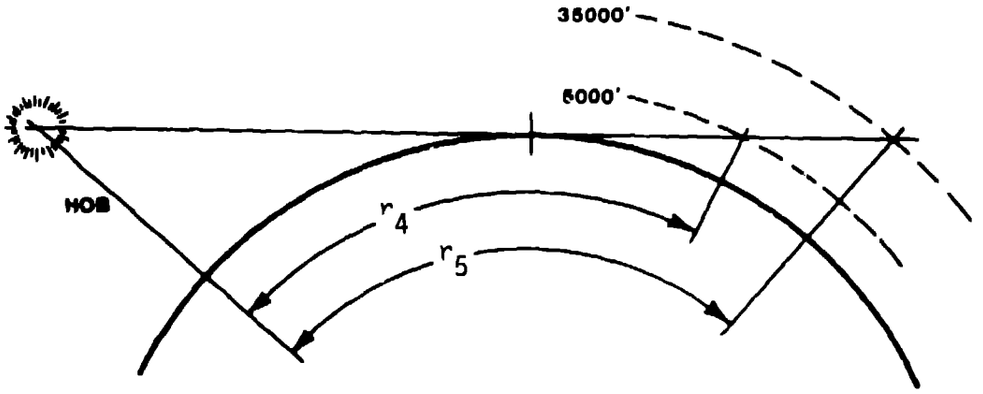


Fig. 9.
Direct Exposure to
Aircraft at Altitude

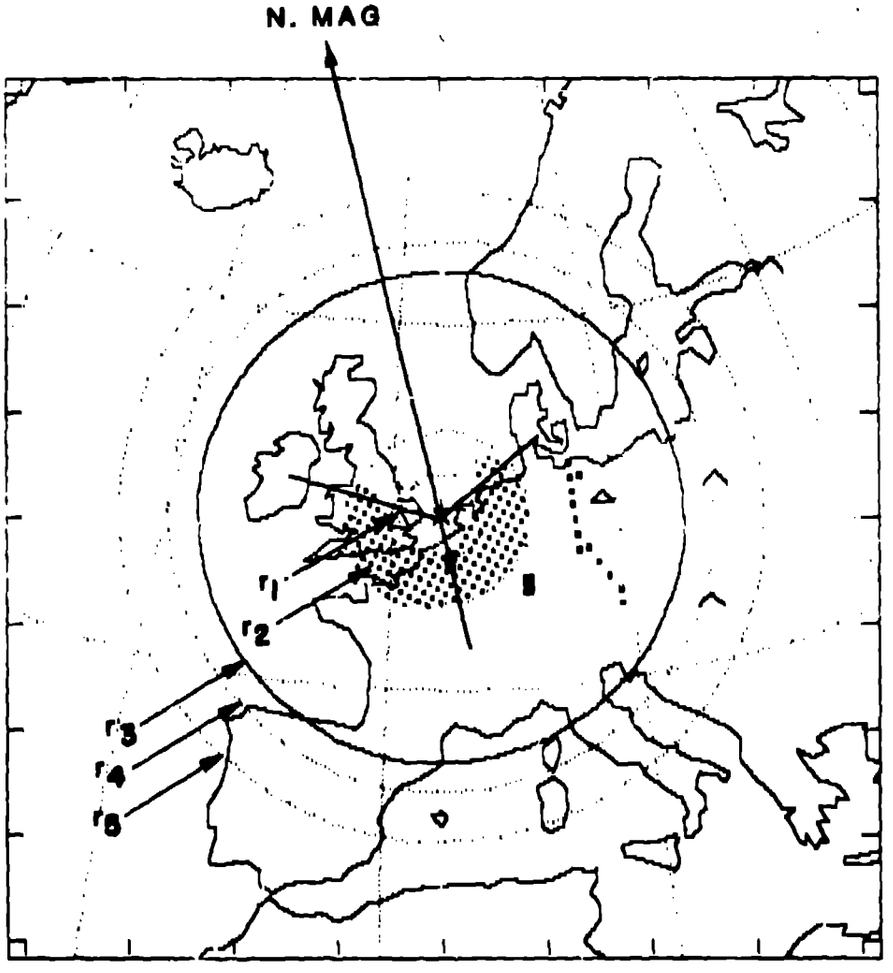


Fig. 10.
EMP Attack, Including
Aircraft Exposure.

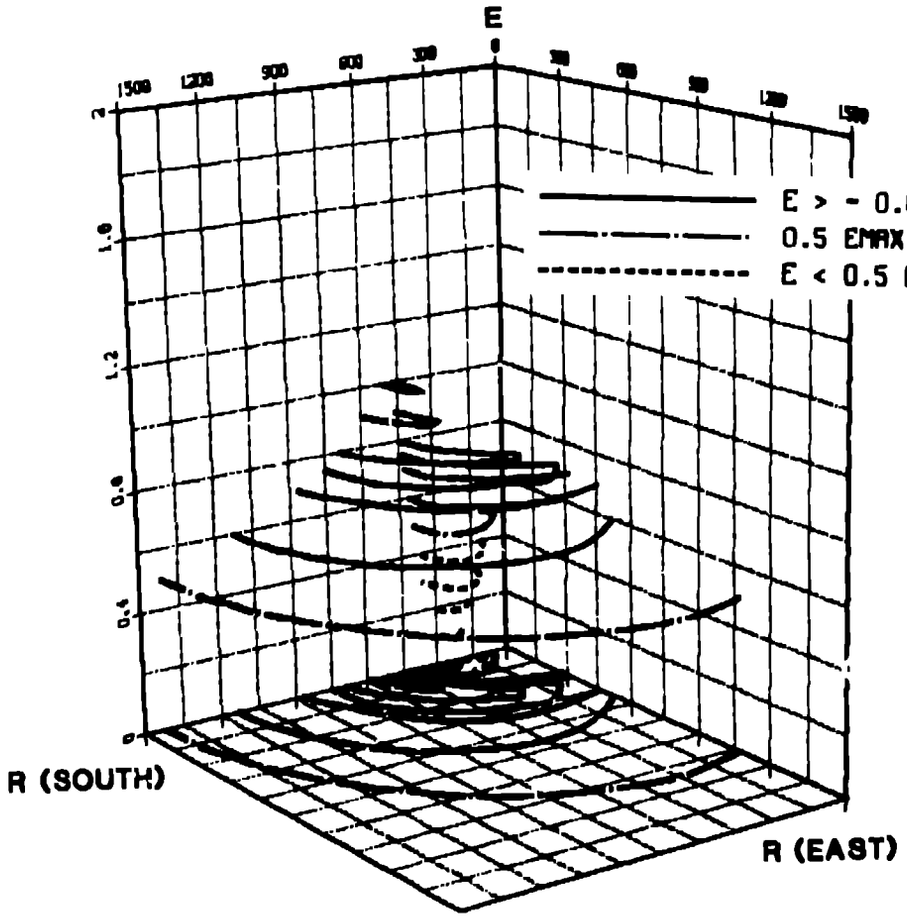


Fig. 11.
Field Strength Versus Range

Assumed Lethality: 0.6 E_{max}.

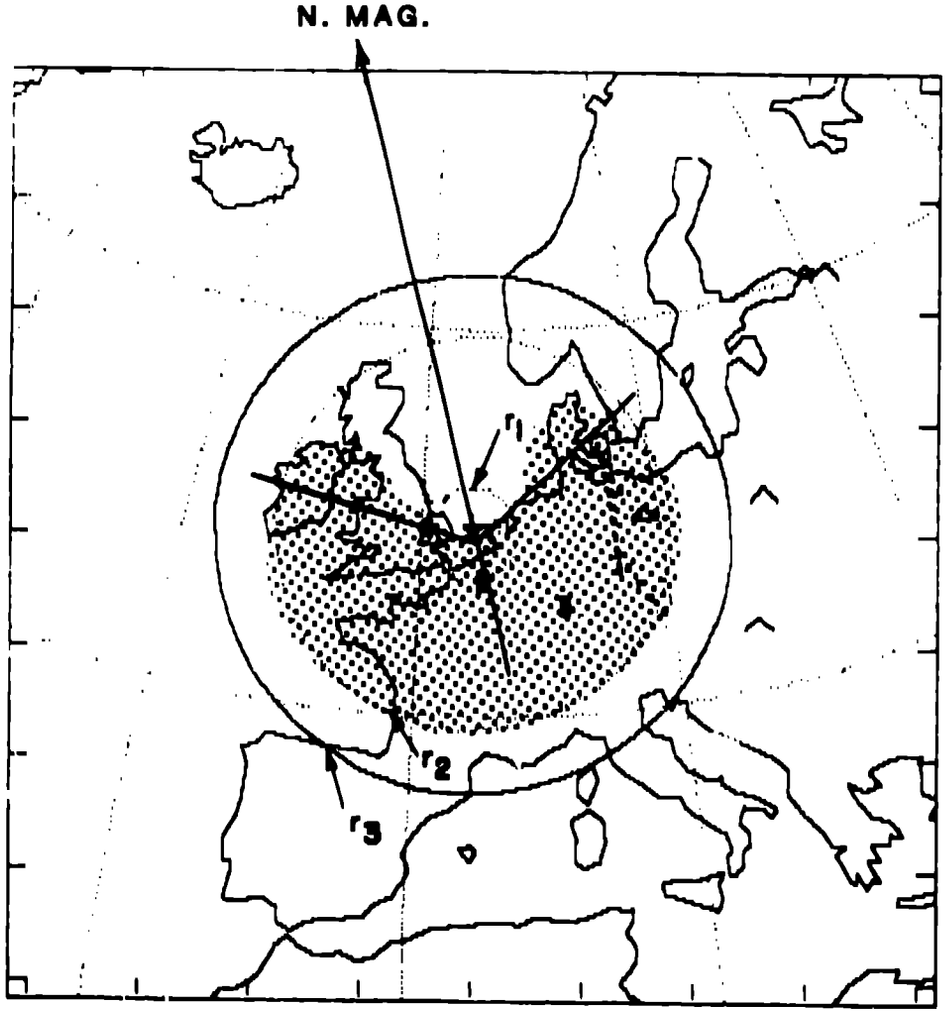


Fig. 12.
Effect of Hardness Degradation to NATO's Ground-Based Assets.

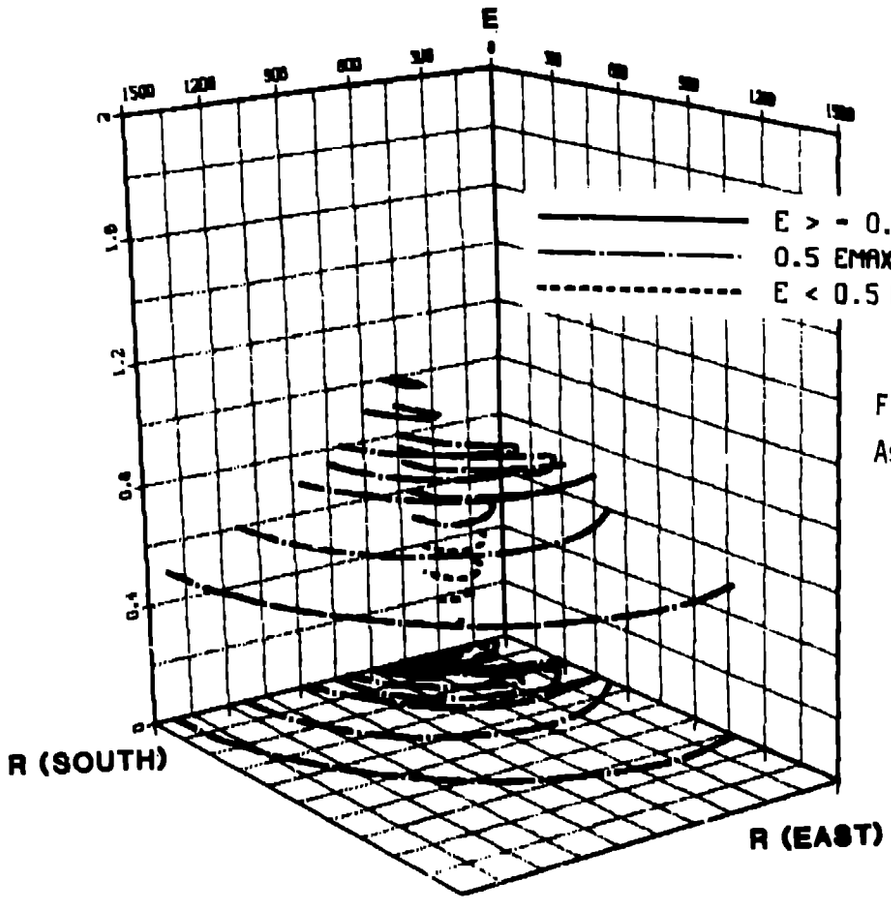


Fig. 13.
Field Strength Versus Range
Assumed Lethality: 0.9 E_{max}.

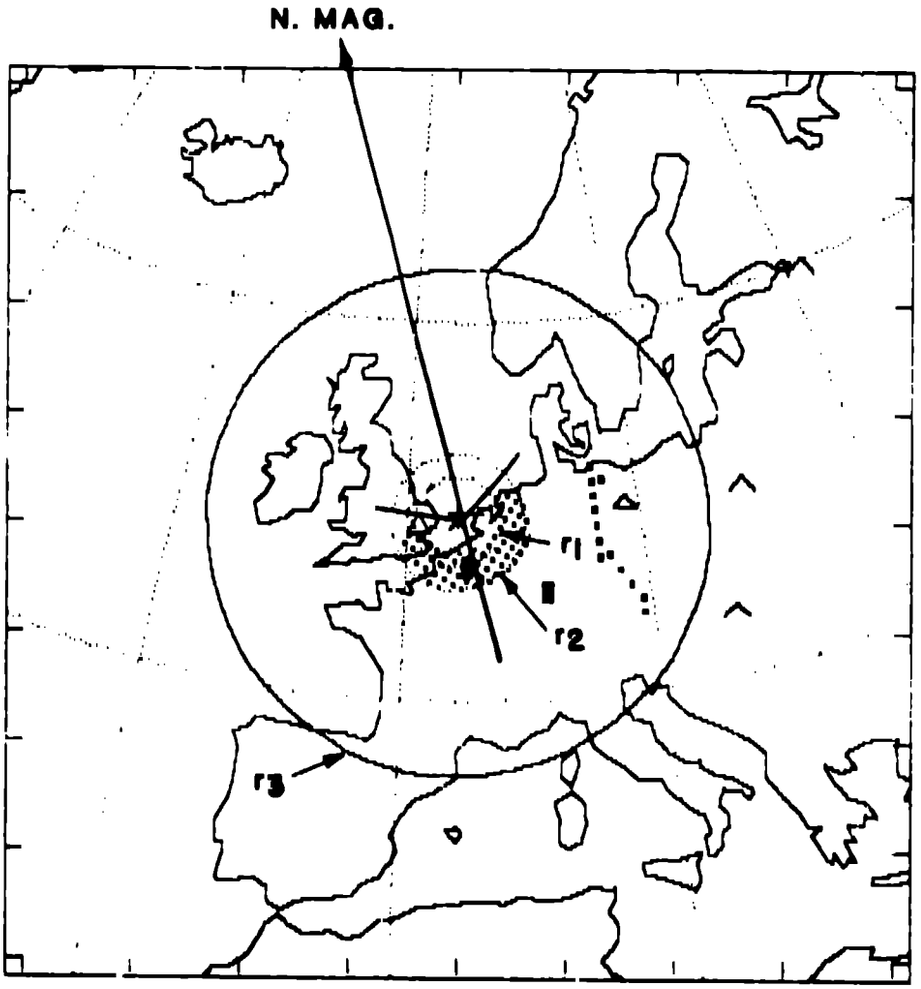


Fig. 14.
Effect of Hardening on NATO's
Ground-Based Assets.

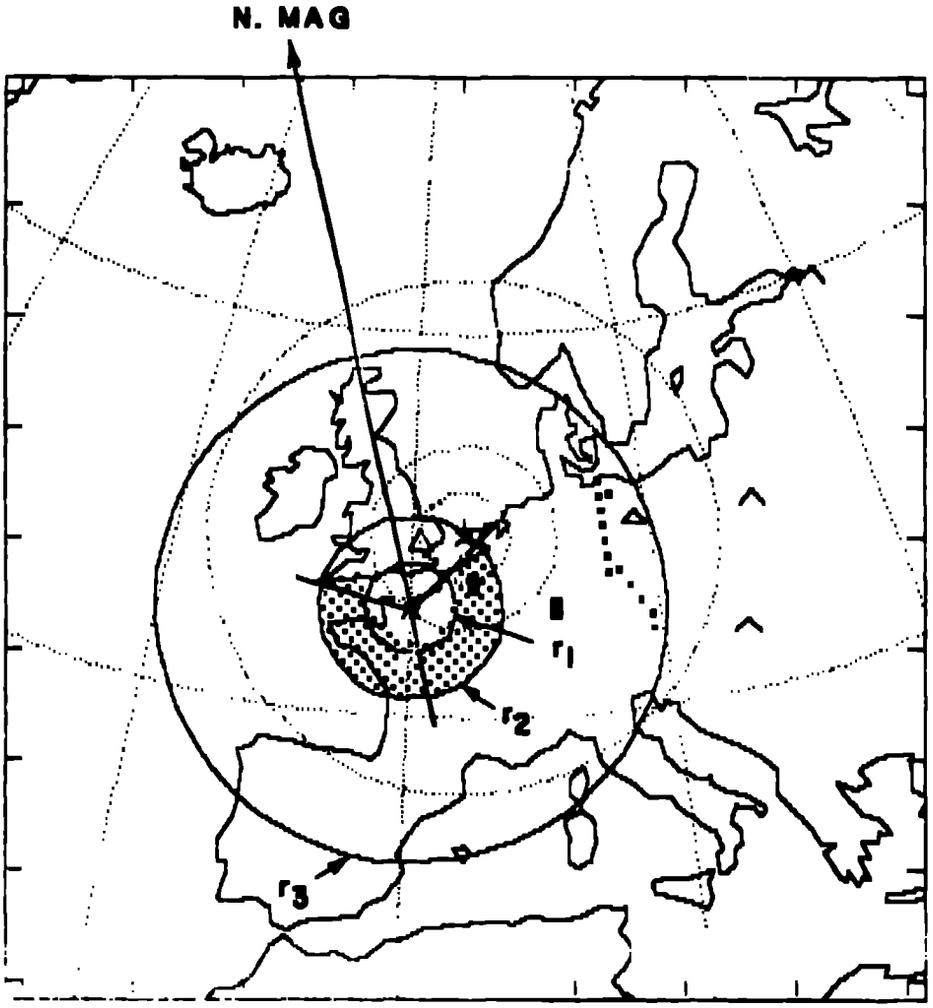
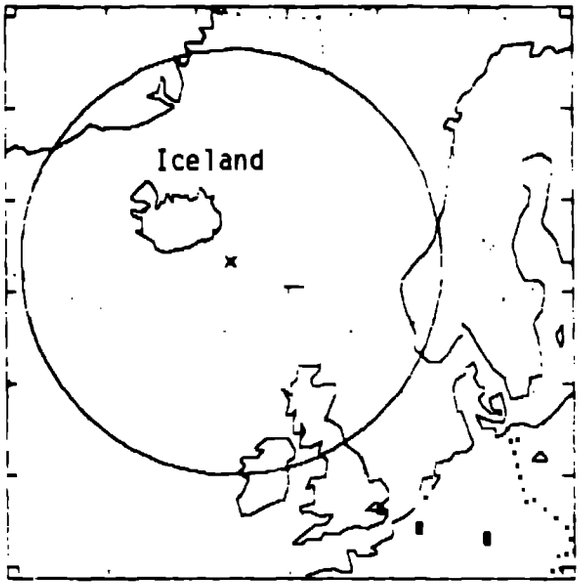
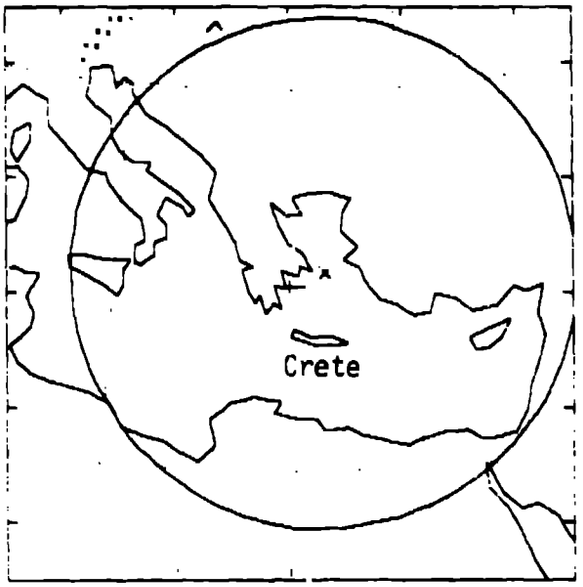


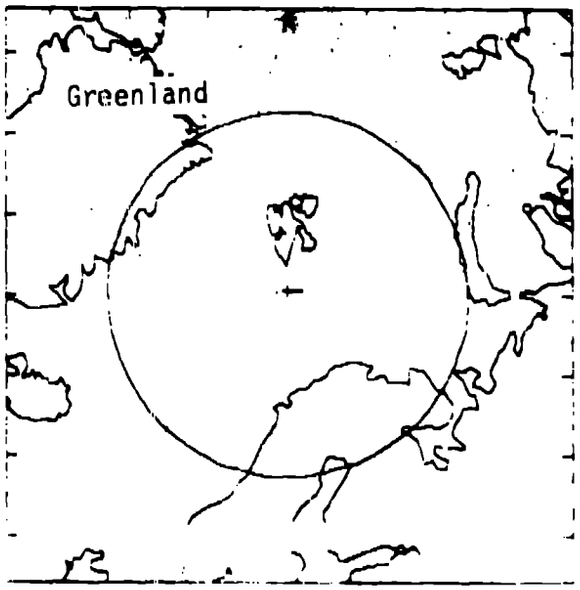
Fig. 15.
Alteration to the Weapon Detonation Point.



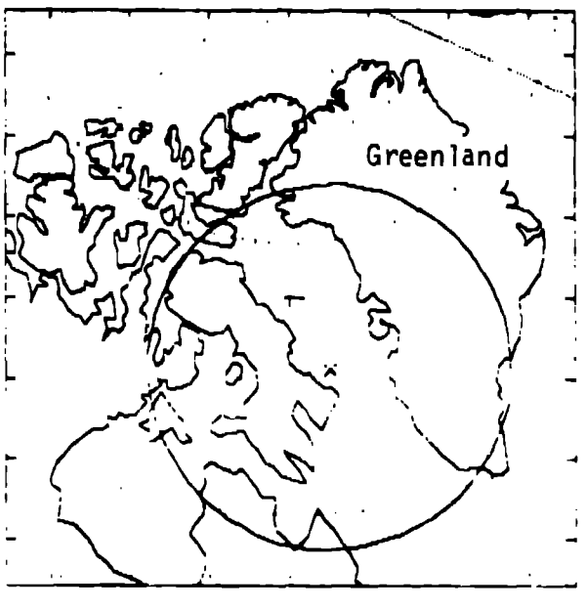
UK Air



Mediterranean C^2



Far North Operations



Attack Warning/Attack Assessment

Fig. 16.
Other NATO-Related Applications Areas.