



(picture: author)

The NIKE Hercules missile system

in service with the 12th (Netherlands) Missile Group during the Cold War.

Ronald Dorenbos

This article aims to provide an overview of the technical and operational specifications of the NIKE Hercules system, as used by the 12th (Netherlands) Missile Group (12GGW) of the Royal Netherlands Air Force (RNLAf) and its predecessors. It discusses the operations and the employment of the system as well as the activities that characterized life on a NIKE squadron.

The following document is compiled on the basis of the author's memory, documentation available from the (Dutch) Historical Collection of Ground-Based Air Defense (HCGLVD) and reliable documentation from the internet. The document concentrates on the NIKE system in the version and as employed during the last years of its operational use by the RNLAf, because that corresponds with the personal experiences of the author.

The author is indebted to 1Lt (ret.) Frank Rappange MSc (former BCO), CWOs (ret.) Hans de la Mar and Pieter Meijn (former LCOs) and LTC (ret.) André Polfliet for their contributions and constructive comments. Gratitude is also due to the Netherlands Institute for Military History (NIMH), Ed Thelen, Greg Brown and Ramiro Carli Ballola for providing pictures and making available documentation. For the sources consulted see the overview at the end of the article.

Note 1: This document describes the NIKE Hercules as employed in the NATO configuration. This configuration differed from that used in continental USA. Also, in continental USA the role of NIKE was to provide point defense for the major cities, whereas in NATO, NIKE was used to provide area defense over the combat zone.

Note 2: A number of aspects of the NIKE system (e.g. the yield of the nuclear warheads used) are still classified information. In those cases, the 'facts & figures' referred to in public sources will be used, without this article confirming those details.

As usual in documents describing military matters, abbreviations are abundant. A list of abbreviations is therefore added at the end of the document.



(Picture: author's archive)

CONTENTS

INTRODUCTION	4
ORGANIZATION	7
SYSTEM DESCRIPTION	9
SEQUENCE OF ENGAGEMENT	36
DOCTRINE, COMMAND & CONTROL AND TACTICAL OPERATIONS	51
EXERCISES AND EVALUATIONS	59
TRAINING AND MAINTENANCE	65
STATUS AND CREW LIFE	67
FINAL REMARKS	72
ABBREVIATIONS	74
SOURCES	76



*NIKE Ajax (front) and 2x NIKE Hercules at 1st (NL) Missile Group, ca. 1963
(picture: NIMH)*

PREFACE

The NIKE weapon system was a Surface-to-Air Missile (SAM), operationally in service with the Royal Netherlands Air Force (RNLAf) between 10 October 1961 and 31 March 1988. All -in the first instance eight- weapon systems were located in the Federal Republic of Germany, roughly in the Nordhorn-Osnabrück-Bielefeld-Wesel area. The weapon system was primarily intended for the defense against enemy aircraft at high and medium altitudes and at a considerable range, with both conventional (high explosive) and nuclear warheads. The weapon system had a limited capability in the defense against aircraft at lower altitudes.

Its secondary task was the employment as nuclear precision artillery against ground targets. In the period from 1967 to 1978, one weapon system was adapted to combat enemy tactical ballistic missiles.

History NIKE Ajax and Hercules. In 1958, the Netherlands decided to make use of the US Mutual Defense Assistance Program offer to provide a NIKE Group (in the US terminology a battalion: here NIKE was part of the US Army), free of charge and to train its staff. That group would then have to be stationed in West Germany. After some discussions between Army and Air Force, the Minister of Defense decided that the NIKE was to be assigned to the RNLAf. At the end of 1958, NATO requested the Netherlands to establish a second group of NIKE. Again, the USA made the systems available, under the same conditions. After the training of the personnel for the 1st Missile Group (1GGW) in the USA in 1958/9, on October 10, 1961, 119 Squadron was the first Dutch (and European) NIKE unit ready for operations and assigned to NATO. The squadrons of 1GGW were equipped with a mix of NIKE Ajax and Hercules missiles. 2GGW was established in April 1963, however, it was equipped with the NIKE Hercules exclusively. The NIKE Ajax missiles had already been phased out at the end of 1964 at 1GGW.

The NIKE Ajax (US designation MIM-3 or NIKE-I) was a two-stage missile against air targets. The first stage (the booster) provided thrust for a few seconds to launch the missile and accelerate the missile to its initial speed. The booster contained solid fuel. After burn-out and booster separation, the second stage (the actual missile) was activated. This contained liquid fuel that had a limited shelf life in the fuel tanks of the missile. Draining and re-fueling the missile was a recurring and high-risk business involving personnel wearing protective clothing and masks. The missile was equipped with three explosive charges that formed a fragmentation pattern that should effectively dispose of the target. The maximum effective range of the NIKE Ajax was 48 km at a maximum altitude of 21 km.

The air threat as perceived in the USA in the early 1960s consisted mainly of large formations of Soviet bombers equipped with nuclear weapons. To counter this threat, there was a need for an improved version of the NIKE. That became the NIKE Hercules (US: MIM-14, initially known as NIKE-B). The NIKE Hercules was designed to be able to carry a nuclear warhead which could annihilate a whole formation of bombers with one shot. The effective range of the NIKE Hercules was (in theory) increased to 170,000 yards (155 km)

¹ BCO's traditional announcement at the start of a crew drill

at a maximum altitude of 100,000 ft (30 km). The NIKE Hercules was a two-stage missile too, with both booster and missile motors burning solid fuel. This enabled the Hercules to maintain readiness for a long time. The fire control and launch equipment for the NIKE Ajax and Hercules were virtually identical so that both types of missiles could be used side by side for some time.

Various improvements have been made to the NIKE Hercules system over the years. The guidance section of the missile was improved (the type designation was now MIM-14B/C), the radars were improved and additional radars were added to better cope with electronic warfare and eventually the radars and the computer were digitized.

The NIKE system was transportable but not mobile in a tactical sense. This means that the system components were partly provided with wheels and could be driven, other components could be moved in other ways. De-assembling, transporting and building up the bulky and heavy system components, however, was so time-consuming and labor-intensive that a relocation under combat conditions was not opportune and therefore was not practiced. In addition, the NIKE system required a well-prepared, hardened location and the alignment requirement of the system components made extremely high demands on the accuracy: the tolerance was 0.5 mil^2 (about 0.03°).

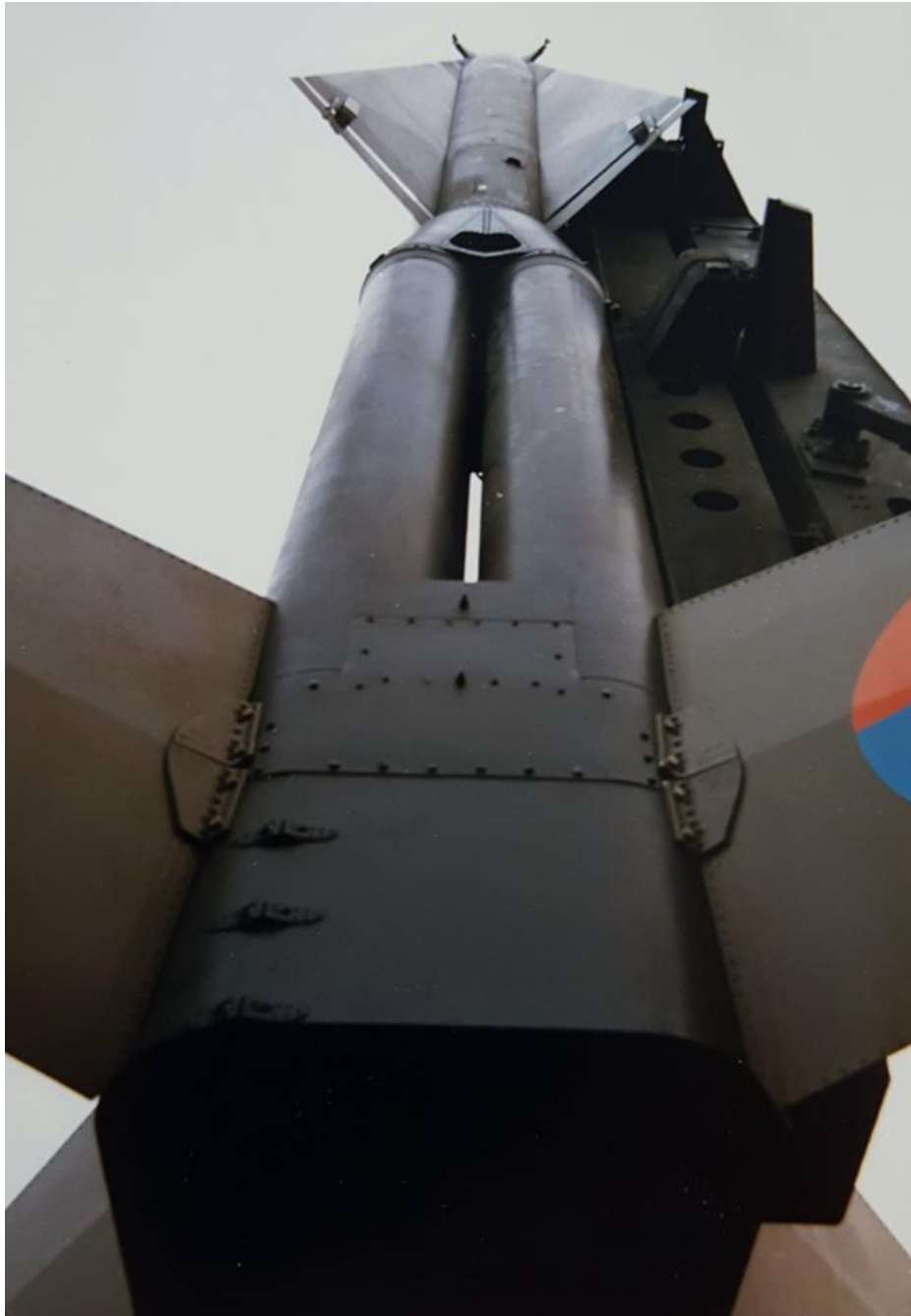
A second tactical limitation of the NIKE system was its low rate of fire and its inability to engage two or more targets at the same time. As will be described later, only one target could be tracked at a time and only one missile could be guided at the same time. Only when this engagement was completed, a next target could be engaged, or a second missile could be fired at the first target if the first intercept had not been successful. In order to be able to cope with an attack of some size, many NIKE systems were therefore required. Around 1975, in the area of the Second Allied Tactical Airforce (2ATAF, the northern half of West Germany) alone, about 36 NIKE systems were employed. A considerable number, but insufficient to be able to counter a concentrated attack over one axis.

The third tactical limitation was that the NIKE system was designed to defend continental USA against high-flying enemy bombers, much as Nazi Germany defended itself against the allied strategic bombers during the Second World War. West Germany, however, bordered on the Warsaw Pact and due to the short flight distances, West Germany could also be reached by low-flying tactical fighters. Against this, the NIKE system was not designed, although it had limited capacity against low-flying targets.

² $360^\circ = 6400 \text{ mils}$; 1 mil is the angle between two points one meter apart as seen from a distance of 1000 meters, or 0.05625°

In 1975, a reorganization of the RNLAF missile units took place and, among other things, the number of NIKE weapon systems was reduced from eight to four, with 1 and 2GGW being merged into the 12th Missile Group (12GGW). Between 1983 and 1988 these last four units were phased out one by one to provide financial and personnel latitude for the introduction of the PATRIOT weapon system in the RNLAF. On 31 March 1988, 118 Sq was deactivated as the last operational Dutch NIKE squadron and 12GGW disbanded.

'Prepare to engage, Red Status'³



(picture: author's archive)

³ BCO's order to prepare for immediate action.

ORGANIZATION

A NIKE weapon system was the core of a squadron (Sq), the basic unit in the RNLAf. A squadron consisted of a commander, a support and administrative flight, a technical flight, a ground-operations flight and an operations flight. Geographically, a squadron was divided into an administrative area, an Integrated Fire Control area (IFC) and a launching area (Launching Control Area/LCA, usually known as the LA). The distance between IFC and LA was between 1000 and 6000 yards (900-5400 m), the administrative area could be located miles from the IFC/LA.

The personnel strength of a nuclear squadron amounted to around 240 people, of which about half were conscripted personnel. The staff of a squadron consisted of the squadron commander, his lieutenant-adjutant as responsible for the administrative and supporting tasks, and the commanders of the operations, technical and ground-operations (security) flights. The operations flight was composed of the Flight Commander and his two Chief NCOs for IFC and LA respectively and three combat crews each led by a Battery Control Officer (BCO), a total strength of about 100 soldiers. A crew consisted of a fire control section at the IFC and a launching section at the LA and was physically separated during operations. The fire control section of a crew consisted of at least nine soldiers and the launching section of at least 20 soldiers. Due to the phased rotation of conscripts, the need for extra personnel for additional duties, filling-in for sick or otherwise absent personnel and the training task of the squadrons for new personnel, in general more soldiers were available than the minimum required. A complete crew consisted of approximately 35 soldiers on average, about half of which were conscripts.

12GGW was composed of the following units:

Group Headquarters in Hesepe (with the Group Operations Center/GOC in Vörden)

- 118 Sq in Vörden (A-Btry)
- 120 Sq in Borgholzhausen (C-Btry)
- 220 Sq in Schöppingen (B-Btry)
- 223 Sq in Rheine (D-Btry)

In NATO terminology, a squadron was designated as a Battery (Btry) and a Group as a Battalion (Bn). For example, 118 Sq within NATO was known as A-Btry, 12 Bn, or '12A' for short.

The fire control equipment, i.e. the radars, radar control equipment, command facilities and supporting systems (e.g. generators for the power supply) was located in the IFC. The IFC hosted the Battery Control Trailer (BCT, also called BC-van) from which the operations were led by the BCO, and the Radar Control Trailer (RCT, also known as RC-van), from which the tracking radars were operated. Here located too was the Maintenance and Supply (M&S) trailer. The M&S was the home of the radar technicians (known as 226's from the US Military Occupational Specialty/MOS-code). Finally, the signals troop was located in the IFC.

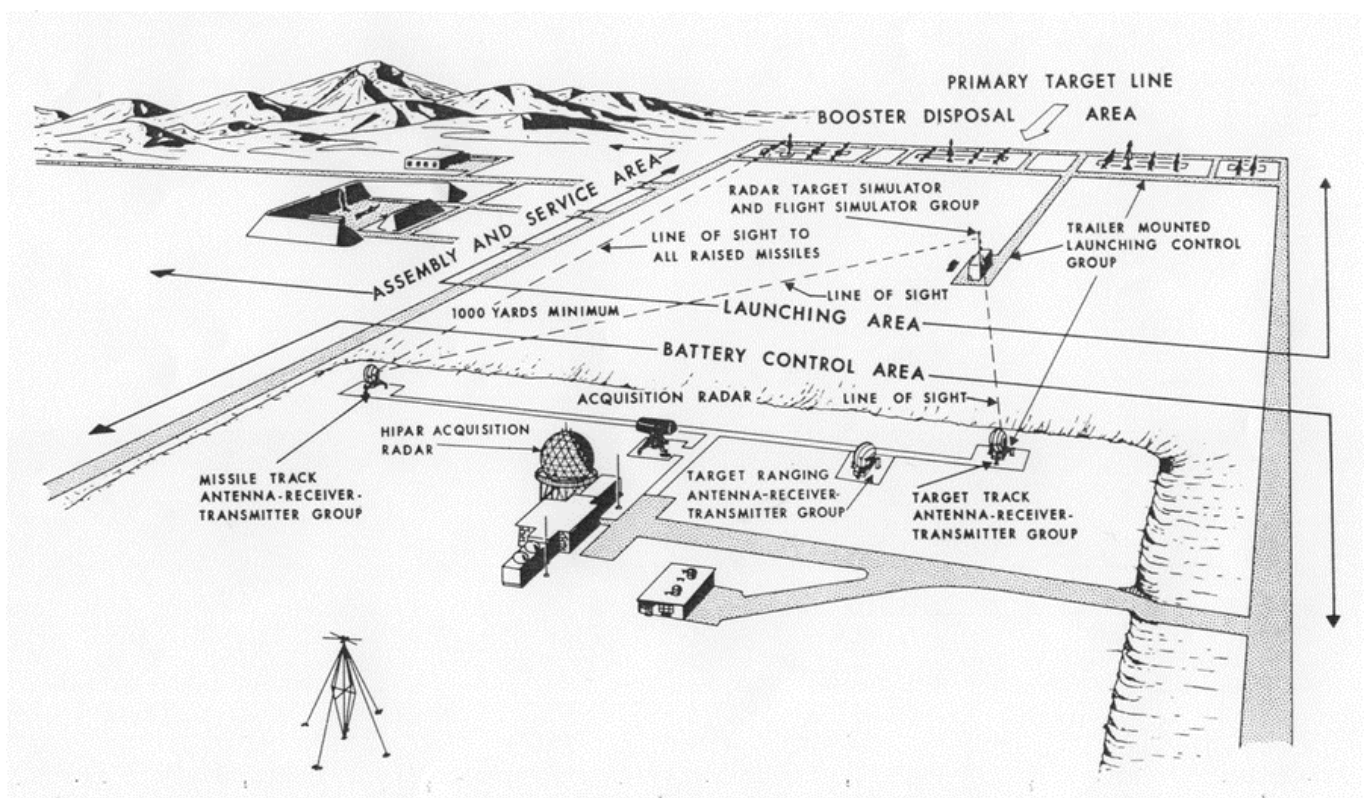
In the LA, the three launching sections with three launchers each were located. The launching operations were led by the Launching Control Officer (LCO), operating from the

Launching Control Trailer (LCT). The LCO commanded the three Section Chiefs in the Alpha, Bravo and Charlie Section. Furthermore, the vast majority of the security flight was stationed here, this in connection with the nuclear task of three of the four NIKE squadrons of 12GGW. In the LA were located the Assembly Building (where the missiles were assembled and checked) and the Warhead Building (where the explosive charge, the rocket engine and the booster were assembled). Furthermore, the LA hosted the launch and missile technicians (225s, for their US MOS) and the Ground Equipment personnel, responsible for the electricity converters and generators.

In peacetime, the NIKE system operated on the electricity from the public grid, which was converted to the correct voltage and frequency. During exercises and actual operations, system power was autonomously provided by diesel generators.

The administrative area included all other facilities such as dining facilities, a medical aid station, the transport unit, sports facilities etc. An exception to this situation was 118 Sq in Vörden, which in terms of facilities was largely dependent on that of the Group Headquarters of 12GGW in nearby Hesepe.

118, 120 and 220 Sq hosted a team of the 509th United States Army Artillery Detachment (USAAD), in connection with the nuclear tasks of these squadrons.



Schematic overview of IFC and LA, not to scale

(DASA)

SYSTEM DESCRIPTION

The NIKE weapon system was based on the 'command guidance' principle. I.e., after launch, the missile was guided from the ground to the target by commands generated by the computer. The computer generated these commands on the basis of a comparison of the position, course, altitude and speed of the target and that of the missile, as determined by a target tracking radar and a missile tracking radar respectively. The computer steered the missile to a point in the airspace where it would meet the target and then give the missile a self-destruct command which would cause the target to be destroyed too.

Radars. The NIKE weapon system used pulse radars. With a pulse radar, the radar emits a high power signal in a narrow beam for a very short time (e.g. 2 microseconds). Then the radar switches to the receiver mode. The radar will be in receiver mode for a relatively long time (e.g. 1 millisecond). Meanwhile, the transmitted pulse travels through the air at the speed of light (300,000 km/s or 186,411 miles/sec) until it hits an aircraft. Part of the radar energy will be reflected back by the aircraft in the direction of the radar. If the radar is still in the receiving mode and the signal is sufficiently strong, this echo can be received, processed and made visible. The distance to the target is half the time between sending and receiving the radar pulse (which has to travel twice the distance between radar and target) times 300,000 km. Tracking a target using radar energy reflected by the target is called skin track.

The maximum range of a radar depends on the transmitted power, the sensitivity of the receiver (Signal/Noise Ratio) and the Pulse Repetition Frequency (PRF: the number of pulses transmitted per second, which in turn determines how long the radar is in receiver mode until the next pulse is transmitted). The power required from the radar is proportional to the fourth power of the distance: to make a radar to detect an identical target at twice the distance, 16 times more power is required, for three times that distance 81 times more power. Furthermore, the size of the reflective surface (Radar Cross Section/RCS) of the target affects the detection range, as well as the atmospheric conditions and the line-of-sight (LoS; unobstructed view: radars can't see through e.g. mountains) between radar and target. To improve the line of sight, all radars, except the HIPAR, were placed on a berm a few meters high. The HIPAR was mounted on a pedestal.

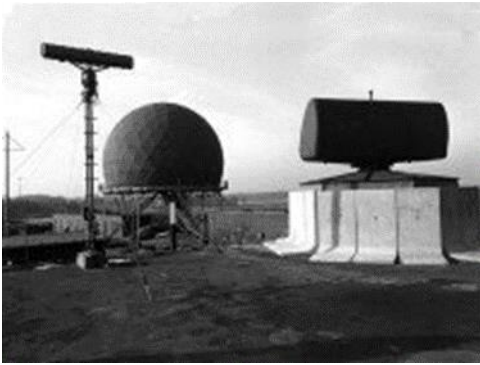
Fire control equipment.

The NIKE system made use of the following radars.

LOPAR (Low Power Acquisition Radar). The LOPAR was a surveillance radar that could detect targets up to a distance of up to 250,000 yards (about 230 km). The radar operated at a variable frequency between 3100-3400 MHz (wavelength approx. 10 cm) with a maximum power of 1 Megawatt and a PRF of 500. The LOPAR was a pulse radar that emitted a radar beam in a narrow azimuth angle (approx. 1° wide) but in a large elevation angle, a so-called cosecant square/CSC² pattern.

The operator could change the elevation of the radar beam from + 2° to a maximum of + 22° to better track targets at different heights. The radar rotated at a set speed of 5, 10 or 15 revolutions per minute. The LOPAR was equipped with a Moving Target Indicator (MTI)

circuit with which targets could be better identified amongst the echoes of static objects, interference of weather and traffic etc. (the so-called clutter). The target echoes detected by the LOPAR were displayed on a radar display scope in front of the BCO, the Plan Position Indicator (PPI).



*Left to right: IFF, HIPAR, LOPAR
(picture: NIMH)*



HIPAR (picture: NIMH)

HIPAR (High Power Acquisition Radar). The HIPAR was a search radar with a maximum range of 350,000 yards (about 320 km) against targets with a 15 m² RCS. This too was a pulse radar that emitted in the frequency band of 1350-1450 MHz (wavelength approx. 23 cm) on one of 10 pre-set selectable frequencies and with a PRF of 400 to 450. The maximum power was 7.5 Megawatts. The HIPAR was equipped with an MTI circuit and was equipped with circuitry to minimize the effects of enemy electronic interference (jamming) as much as possible. The radar antenna could rotate at 6.7 or 10 revolutions per minute. The target echoes detected by the HIPAR were displayed on the PPI too. However, the operator had to select between either HIPAR or LOPAR video, it could not display both simultaneously.

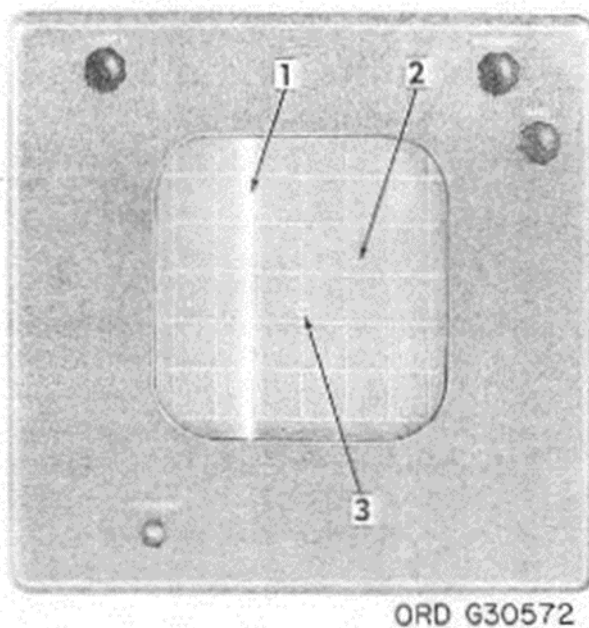
The HIPAR was a later addition to the NIKE weapon system (1967 for GOC/118 Sq, 1980 for the other squadrons) with the primary aim of providing the GOC with organic radar video. However, the extended range also provided more time for detecting, identifying and intercepting tactical ballistic missiles and normal targets, which is why the HIPAR was introduced eventually at all RNLAf NIKE squadrons. LOPAR and HIPAR were operated by the same radar operator. Both a transportable version and a fixed version of the HIPAR existed. 12GGW utilized the fixed version.

The target echoes of both LOPAR and HIPAR could be displayed in more detail and slightly enlarged on a Precision Indicator/PI next to the PPI. Thus, it was possible to recognize whether the target echo involved one or more targets that were close to each other.

TTR (Target Tracking Radar). The TTR was a pulse radar with a narrow-focused radar beam of 1.4° diameter (a so-called pencil beam). The radar operated at a variable frequency in the band of 8500-9600 MHz (wavelength approx. 3 cm) with a maximum range of 200,000 yards (about 180 km) and a PRF equal to that of HIPAR or LOPAR, depending on which search radar was selected. The TTR could operate in both short pulse (pulse duration 0.25 microsecond) and long pulse (pulse duration 2.5 microsecond) mode. In short pulse

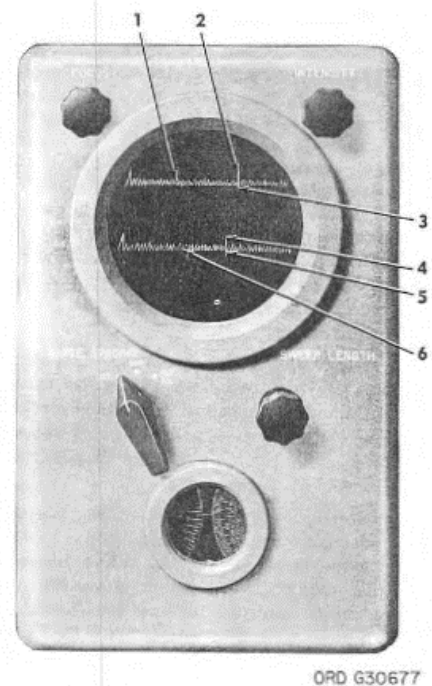
mode the maximum power was 201 kW, in long pulse mode 142 kW. The TTR was equipped with a multi-pulse mode. This option was sealed in peacetime and could only be used after permission under wartime conditions. The multi-pulse mode was in fact an excellent tool against enemy jamming and it had to be kept as a surprise for the enemy as long as possible.

The TTR was operated by three operators for azimuth, elevation and range respectively, each with a so-called A-scope in front of him/her. When the BCO selected a target on the PPI and 'designated' this target electronically to the TTR operators, a small cut-out of the PPI image around the target was presented on a B-scope in front of the TTR operators. This image gave the global azimuth and the range of the target.



1. Vertical sweep
2. Return signal (designated target)
3. Target track antenna position circle

B-scope (TM 9-1400-250-10/2)



1. Upper trace (target track radar)
2. Target pip (target track radar)
3. Range notch (target track radar)
4. Target pip (target range radar)
5. Range notch (target range radar)
6. Lower trace (target range radar)

A-Scope (TM 9-1400-250-10/2)

The TTR slewed automatically to this azimuth and global range, but in elevation the operator had to search manually for the target. Once the target was visible and centered on the three A-scopes, the target could be locked. This means that (in the absence of jamming) the TTR automatically tracked the target. This was possible because the receiver of the TTR consisted of four parts, arranged two by two. Here, the received signal in the two left-hand side receivers and the two upper receivers was continuously compared with that of the two on the right-hand side/two lower receivers. The TTR adjusted itself in azimuth and elevation continuously in order to keep the signals in each of the four receiving channels equally strong and thus to remain exactly aligned with the target. For range, there was a system where the target echo was automatically held in the middle of the range gate. Manual tracking of the target was also possible, as well as tracking in semi-automatic mode by setting an angular speed ('aided tracking'). Both of these options were widely used in case of electronic interference against the radar.

MTR (Missile Tracking Radar). The MTR was a pulse radar with the same pencil beam as the TTR. The radar operated at a variable frequency in the band of 8500-9600 MHz (wavelength approx. 3 cm) with a maximum range of 200,000 yards (about 180 km) and a PRF equal to that of HIPAR or LOPAR, depending on which search radar was selected. The maximum power was 158 kW. The MTR was operated by one operator. The MTR automatically followed the selected missile by means of so-called beacon tracking: after receiving a radar pulse from the MTR, the missile sent back a signal to the MTR. The MTR automatically centered on this signal.

The MTR sent out a pulse train consisting of four pulses to the missile as determined by the computer. The distances between certain pulses formed the battery code and coded a steering command for the missile. This steering command was converted into a movement of the missile's control surfaces. The distance between other pulses was a hold-off signal and prevented a fail-safe of the missile. Should the MTR lose track of the missile in excess of three seconds, a self-destruct (fail safe burst) of the missile would automatically occur and the MTR would lock on the next selected missile.

Such a loss of missile track could be caused when the angular velocity of the missile as seen from the MTR exceeded 700 mils (39°) per second because this was the maximum rotation rate of the MTR antenna in azimuth and elevation. Therefore, the distance between MTR (and therefore IFC) and LA had to be at least 1000 yards (900 m). A final pulse combination signified the burst command for the missile.

To prevent a missile from responding to a radar pulse from a neighboring unit's MTR, both the MTR pulse and the missile signal were encoded with a unique battery code. Because the MTR focused on a signal from the missile itself, less transmitter power was needed: the MTR had to emit just enough energy to reach the missile, the return signal was produced by the missile itself. The MTR could also work in skin track mode, but this was only used for certain tests.

Within the MTR operating console, a maximum of 16 positions (in azimuth, elevation and range) of launchers were stored, plus one for the position of the flight simulator on top of the LCT. As soon as the LCO in the LA selected a launcher for firing, the MTR automatically slewed to the position of this launcher, locked on this missile and continued to follow the missile during the flight until the moment of detonation.

TRR (Target Ranging Radar). The TRR was a later addition to the NIKE Hercules system. The TRR was slaved to the TTR and followed it exactly in azimuth and elevation. The TRR itself did not provide azimuth and elevation information, but only information on the distance to the target. This was necessary in case of certain forms of electronic interference when the distance to the target could no longer be determined by the TTR. The TRR had two transmitter/receiver channels (A and B), which could alternately be switched on manually, or automatically changed channel up to 400 times per second. By selecting a frequency that was not or less disturbed, the range to the target could still be determined. The TRR operated in a frequency band of 15.7-17.5 GHz (1.8 cm) and could transmit in both long and short pulses on both channels. The maximum power of the TRR was 125 kW. The TRR was operated by one operator. Because TTR and TRR were linked together in azimuth and elevation, the distance between these two radars should not exceed 82 yards,

otherwise the parallax between the two radars could no longer be compensated.

TTR, MTR and TRR were externally identical. The antenna's themselves were covered by a pressurized spherical protection. This offered the antenna protection against wind, weather, dust, etc.



TTR without protective cover (picture: NIMH)



TTR and TRR

(picture: NIMH)

IFF (Identification Friend or Foe). The IFF was an antenna that emitted a coded signal. Aircraft carrying the same code sent back a signal that produced a symbol on the PPI in front of the BCO. The IFF interrogation signal ('challenge') is transmitted at 1030 MHz and the aircraft's automatic response was at 1090 MHz. The IFF antenna was synchronized with the LOPAR or HIPAR (depending on which radar the operator had selected), so it was clear to which LOPAR/HIPAR target echo the IFF response belonged. If an IFF signal was received from the aircraft, it had to be assumed that this was a friendly aircraft that should not be intercepted.

Different types of IFF were in use: the modes 1, 2, 3 and later also 4. The IFF code was entered in the BCT and had to be changed every half hour (for mode 1 and 3) within a margin of 2 minutes. Mode 4 was a so-called crypto mode that remained valid for 24 hours.

Other fire control equipment.

BCT. The operation of the surveillance radar and the fire control within the squadron took place from within the Battery Control Trailer. The manning consisted of:

- Battery Control Officer (BCO) (2nd/1st Lieutenant), who had overall control of the crew's actions and was specifically responsible for the identification and engagement of targets.
- Acquisition operator (Sergeant), who operated the LOPAR, HIPAR and IFF.
- Computer operator (Corporal), who operated the computer.
- Switchboard operator (conscripted soldier), who was responsible for the internal communication systems.
- Early Warning Plotting Board Operator, who had to plot the received early warning on targets and pass it on to the BCO. This function was deleted after the introduction of the Automatic Data Link (ADL).

A cabinet on the left-hand side in the BCT contained the computer (analogue to approx. 1984), including the Multi-Channel Data Recorder (MCDR) which recorded data of the engagement for later analysis. The analogue computer worked on the basis of voltages (e.g. 1 V equaled a distance of 1000 yards) and used servo-driven potentiometers. After circa 1984, the computer was digitized and consisted of a monitor, keyboard, printer and 2 (8 inch) floppy disk drives. One floppy was used for data recording, the other contained either the tactical operations program or the diagnostic program.



BCT

(picture: Ramiro Ballola)

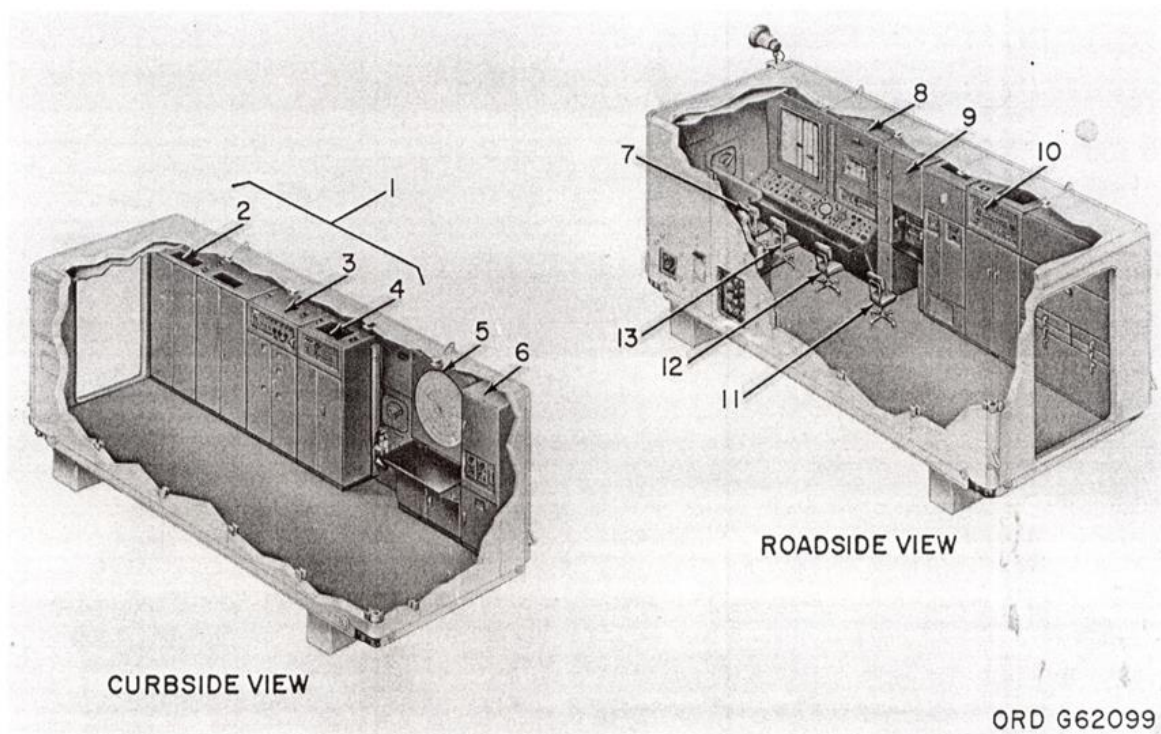
The right-hand side in the BCT provided the positions for (back to front) the acquisition operator, the BCO, the computer operator and the switchboard operator. Against the side wall in front of the BCO, the horizontal plotting board was situated on the left and the vertical plotting board on the right. On the horizontal plotting board the position of the tracked target, in azimuth and range, was plotted by computer controlled plot pens, displaying the position and course of the target. Before launch, the other plot pen represented the position of the Predicted Kill Point (PKP, otherwise known as the Predicted Intercept Point/PIP or Predicted Burst Point/PBP), after launch it gave the position and course of the missile. On the vertical plotting board, the altitude of the target was shown as well as the calculated time to interception, after launch the second plot pen showed the vertical course of the missile plotted against the time to intercept.

Between BCT and GOC, a direct voice connection (the hot loop) existed, which was used for alert messages and voice fire control commands. The BCT contained the Automatic Data Link (ADL). This allowed the higher echelons to assign targets to the squadron, give fire orders and follow the course of the interception, all without the need for voice commands. The BCT was connected to the LA and the RCT by two internal voice connections. These were the 'Command Loop' (mainly for coordination between BCO and RCT) and the 'Tech Loop' (for coordination between the computer operator and the LA). The BCO could switch between the two.

The BCT was always manned by a 'system watch', even when the duty crew was off site. The system watch's main duty was to receive alert messages distributed from the GOC via the 'hot loop' and to alert the duty crew. When the crew was 'on site' this was done by sounding the siren at the IFC and switching the system to 'blue status', which activated the sirens on the LA. When the duty crew was consigned at home, the system watch initiated the crew recall. The system watch's secondary duty was to keep an eye on the system with regards to temperature, fire, short-circuits, etc. The system watch was usually performed by conscripted soldiers from both IFC and LA.



*Vertical part from left to right: horizontal plotting board and vertical plotting board with Battery Status Indicator Panel underneath. Horizontal part from left to right: acquisition operator panel with PI, PPI, BCO control console and computer operator console.
(picture: Ramiro Ballola)*



- 1—Computer group
- 2—Computer amplifier relay group
- 3—Servo computer assembly
- 4—Computer power supply group
- 5—Early warning plotting board
- 6—Auxiliary acquisition control interconnecting group
- 7—Acquisition radar operator's position

- 8—Battery control console
- 9—Recorder group
- 10—Director station group
- 11—Switchboard operator's position
- 12—Computer operator's position
- 13—Battery control officer's position

BCT (TM 9-1400-250-10/2)

RCT. TTR, MTR and TRR were operated from within the Radar Control Trailer. The manning consisted of:

- Tracking Supervisor (Sergeant-Major), who was in charge of the RCT and operated the TRR.
- TTR-Azimuth operator (Sergeant), who was responsible for the operation of the TTR and in particular for positioning the TTR in azimuth.
- TTR-Elevation operator (Corporal or conscripted soldier), who operated the elevation channel of the TTR.
- TTR-Range operator (Corporal or conscripted soldier), who operated the range channel of the TTR.



Lower section: the TTR console; from left to right elevation and azimuth A-scope, B-scope and range A-scope. Upper section the TRR console. (picture: Ed Thelen)

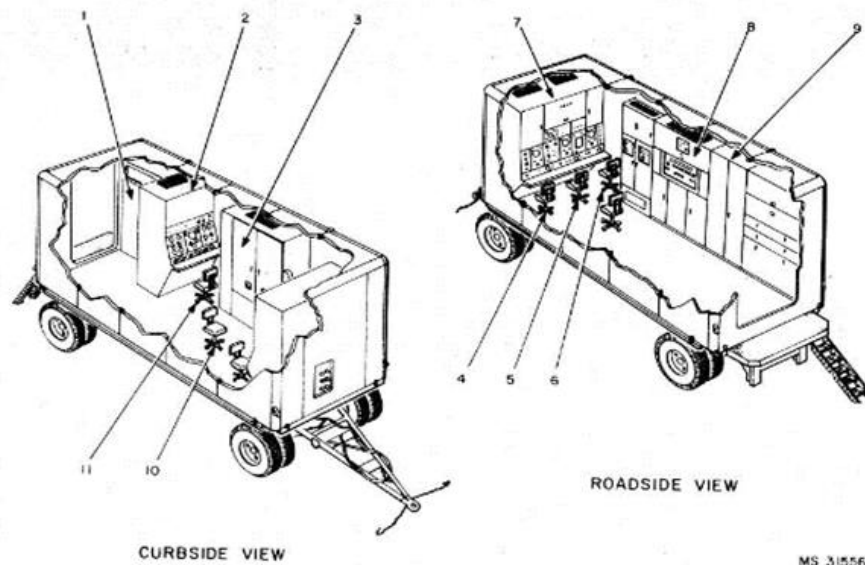
- MTR operator (Sergeant), who operated the MTR.



MTR console

(picture: Ed Thelen)

Against the backside of the RCT the operator stations for (from left to right) the TTR elevation, azimuth and range operators were located. In front of them the Tracking Supervisor, who operated the TRR, was situated. On the left-hand side in the RCT the MTR console with the MTR operator was located.



MS 315568

- 1—Target ranging radar control
- 2—Missile radar control console
- 3—Radar set group
- 4—Elevation operator's position
- 5—Azimuth operator's position
- 6—Target range operator's position

- 7—Target radar control console
- 8—Radar power supply group
- 9—Radar coder - TDP
- 10—Tracking supervisor's position
- 11—Missile tracking operator's position

RCT (TM 9-1400-250-10/2)

Interconnecting Building. The Interconnecting Building was a building that contained the office of the radar engineers (commonly known as '226' after their US Army MOS-code). At the four sides of the building the BCT, RCT, M&S Van and the Local Air Defense Command Post (LADCP) were situated. The LADCP was a trailer in which during exercises messages were decoded, calculations for the Surface-to-Surface mission were made and the Airspace Control overlay for the horizontal plotting board was drawn.



Interconnection building (archive F.E. Rappange)

RTSG (Radar Test Set Group). The RTSG was used to check the operations of TTR, TRR and MTR and for the collimation of these antennas (i.e. the alignment of the mechanical and optical axis with the electrical axis of the antenna, necessary for the alignment of MTR, TTR and TRR). The RTSG consisted of a mast with receivers for radar signals and a Radar Test Set Cabinet for the control of the RTSG.

T-1. The T-1 was a training tool for the fire control crews. The T-1 consisted of a trailer containing equipment which could simulate the radar echoes of aircraft, clutter (radar echoes of static objects such as mountains and rain showers), electronic interference (jamming) and mechanical interference (chaff) and display them for the operators without the radars being activated. Up to six simulated targets could be presented simultaneously with associated electronic or mechanical interference. In addition, the T-1 generated a virtual missile with which engagements could be executed. By using the T-1, the fire control crew was independent of the availability of live flying targets for training. The targets generated by the T-1 could achieve a performance (speed, altitude, maneuverability) that real aircraft could not or could rarely equal. The crew of the T-1 was provided by the Group Staff and the T-1 visited the squadrons of 12GWW successively for training weeks.



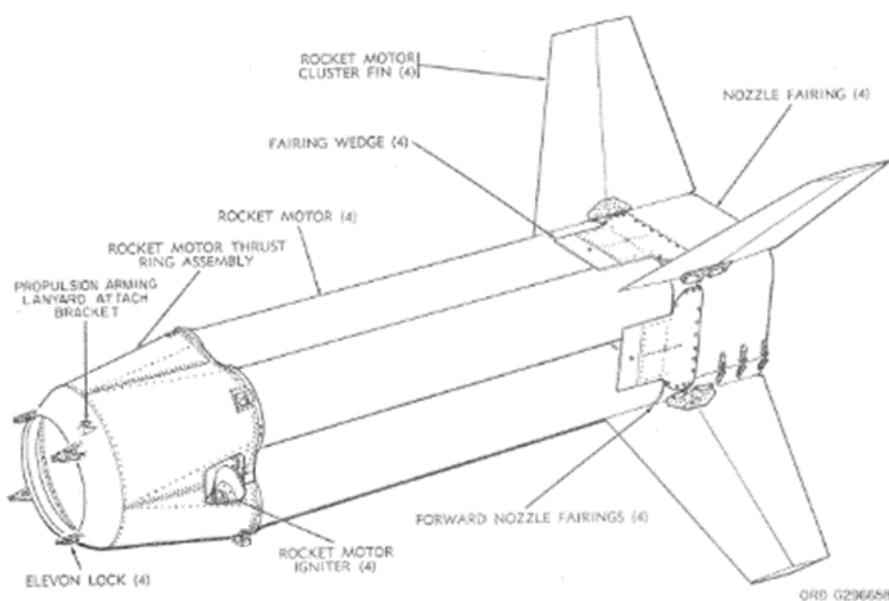
IFC 118Sq: the big sphere is the HIPAR with next to it the GOC. On the radar berm behind, from left to right TTR and TRR, LOPAR with IFF and MTR. Center in the picture the Interconnection Building with BCT, RCT, M & S and LADCP. Right center the RTSG. (picture: NIMH)

Launching equipment

Missile/booster combination. The NIKE Hercules missile consisted of a booster and the actual missile. The total length of this combination was 41.6 ft (12.65 m) and weighed 10,700 pounds (4853 kg). Booster and missile were mounted together on a firing rail (launching handling rail). The combination of missile, booster and launching handling rail was called the missile round. The missile was slid into the booster in a wooden ring (impact cushion). This should prevent the missile to get stuck in the booster during the acceleration during take-off, and facilitate an easy separation of missile and booster after booster burn-out. Circa 25,000 NIKE Hercules missiles were produced.

Booster. The booster consisted of four solid fuel rocket engines, which were mounted two-by-two. The booster was equipped with four stabilizing fins and four fold-out clips (elevator locks) that mechanically prevented movements of the control surfaces of the missile. The electric ignition cable (booster ignition cable) was not connected to the firing circuit in the launcher but to a shorting plug, which prevented inadvertent ignition by stray electric currents. Before the booster ignition cable could be connected to the launcher, a 'stray voltage & continuity check' had to be performed first. This was to ensure that no stray voltages were present in the ignition circuit and the ignition circuit was not interrupted.

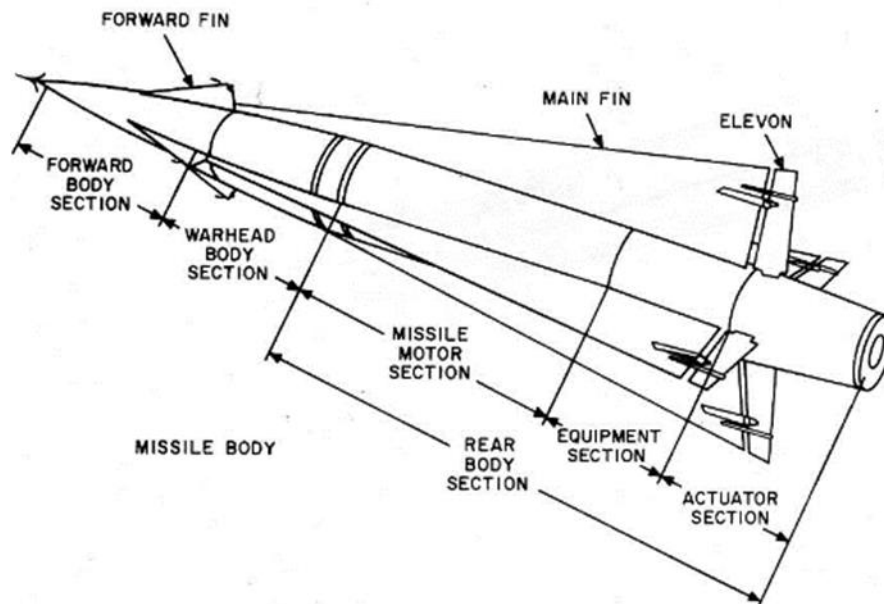
The booster had a burn time of 3.4 seconds and produced 173,600 pounds (772,211 N) of thrust. The booster had a length of 14.5 ft (4.42 m) and a weight of 5,304 lbs. (approx. 2,400 kg). The ratio between thrust and launch weight (thrust/weight ratio) resulted in a tremendous acceleration of approx. 150 m/s^2 or more than 15G (15x gravitational acceleration) when launching the booster/missile combination. By burning fuel, the booster/missile combination became lighter so the acceleration increased even further to more than 20G. At booster burn-out after 3.4 seconds, the missile was at an altitude of over one kilometer (3000 ft) and had already reached a speed of more than 2000 km/h (1242 mph) or almost Mach 2.



Booster (TM 9-1410-250-12/2)

Holes in the front of the booster in the booster thrust structure caused the air resistance of the booster itself to be greater than that of the missile. When the boost pressure of the booster was lost at burn out, the booster was drawn away from the missile due to difference in air resistance. The lagging booster pulled a pin with a cable (the propulsion arming lanyard) from the missile, thereby activating two thermal batteries (squib batteries). These ignited (about 0.75 seconds after booster separation) the rocket engine. A nuclear missile had two extra squib batteries for the power supply for the nuclear detonation circuit. The burned-out booster fell back to earth and impacted almost two minutes after launch in the booster impact area: a vacant or vacated area right next to the LA.

Missile. The missile had a length of 27 ft (8.23 m) with a diameter of 31.5 inches (0.8 m) and a weight of 5342 lbs. (2422 kg). The missile consisted of the following parts, front to rear:



Missile (TM 9-1410-250-12/2)

Nose Cone: the aerodynamic tip of the missile. Missiles equipped with a nuclear warhead were equipped with a 'self-aligning static tube' (also known as 'barometric probe') instead of a nose cone. This was a static pressure measuring device, stabilized in the direction of flight by four small fins, which was needed for the barometric ignition of the nuclear warhead in a 'Surface-to-Surface air burst', or to prevent a nuclear detonation below a minimum altitude in the Surface-to-Air mode. The self-aligning static tube (usually encased in a red protective cap) was the only external distinction between a conventional and nuclear missile. However, there is evidence that in the very early days a few conventional missiles were nevertheless equipped with a static tube.

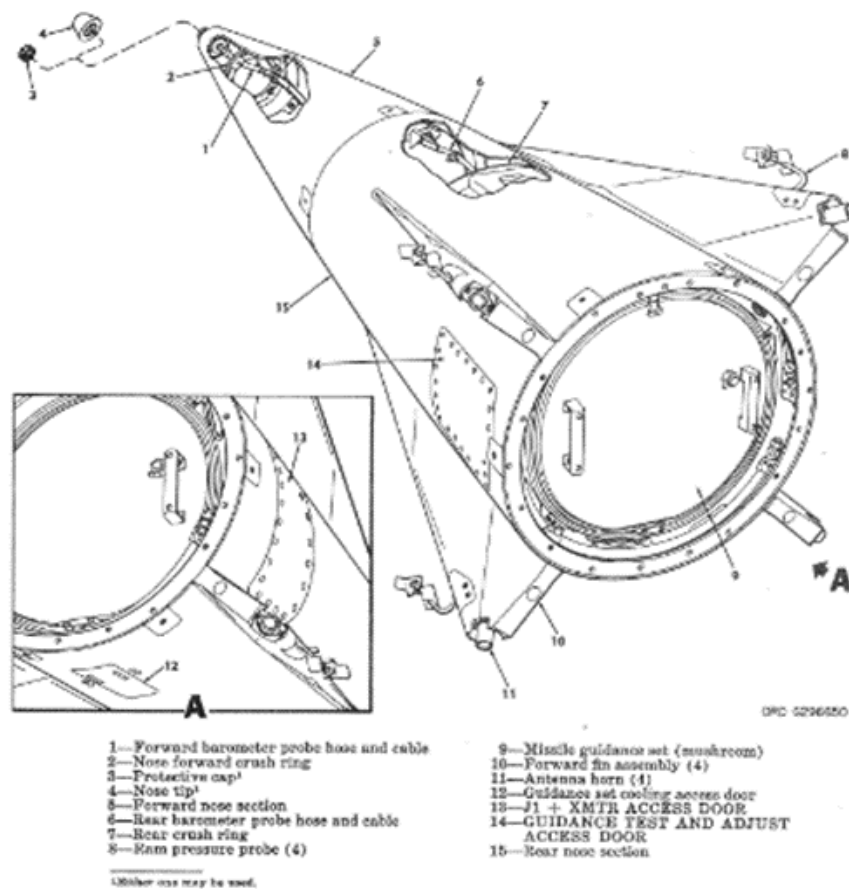


Self-aligning static tube on a 'special weapon'
(picture: website Ed Thelen)



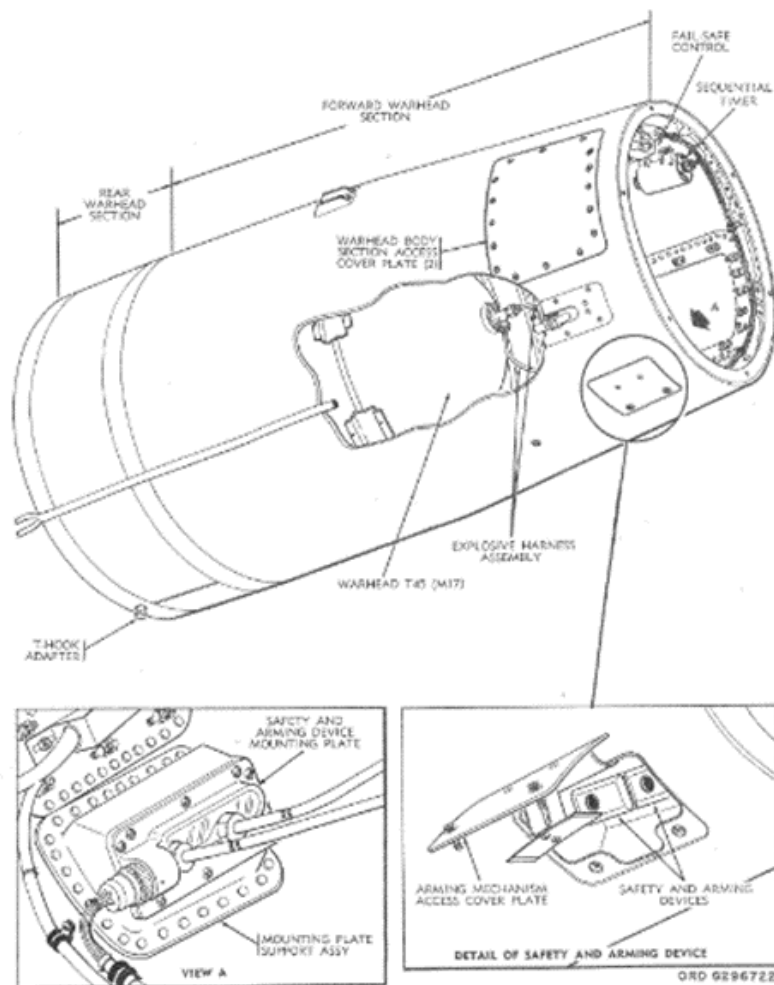
Self-aligning static tube in protective cover
(picture: website FAS)

Guidance section: here, the signals received from the MTR were decoded and converted into movement instructions for the hydraulically operated control surfaces (elevons) at the rear of the missile. The guidance section had four small fins on the outside. These contained the two transmitting and two receiving antennas for the exchange of signals with the MTR and were mounted crosswise so that in each position of the missile one transmitting and one receiving antenna were in visual contact with the MTR. At the front of each fin was a ram pressure probe to measure the dynamic air pressure. This determined how much movement of the elevons was required to comply with the ordered steering command at varying barometric altitudes and speed. A hose between the guidance section and launching handling rail ensured the cooling of the guidance section until launch.



Guidance section (TM 9-1410-250-12/2)

Warhead section: here the warhead, either nuclear or conventional, was accommodated, as well as two Safety & Arming Devices (SAD). The conventional warhead (T45) consisted of 525 lbs. (238 kg) of explosives encased in 20,000 pre-fragmented (approximately 1 cm³) metal cubes. Upon detonation, the cubes were ejected in a spherical pattern with a conical dead zone to the rear of the missile. Air pressure and blast pattern would eliminate the target within a radius of several tens of meters. The two identical SADs mechanically interrupted the warhead's electrical ignition circuit. Only an acceleration of at least 11G for at least two seconds in the direction of flight, i.e. during launch, could arm the SADs. A missile with a high explosive charge was designated as 'BHE' (NIKE type B (= Hercules), High Explosive).



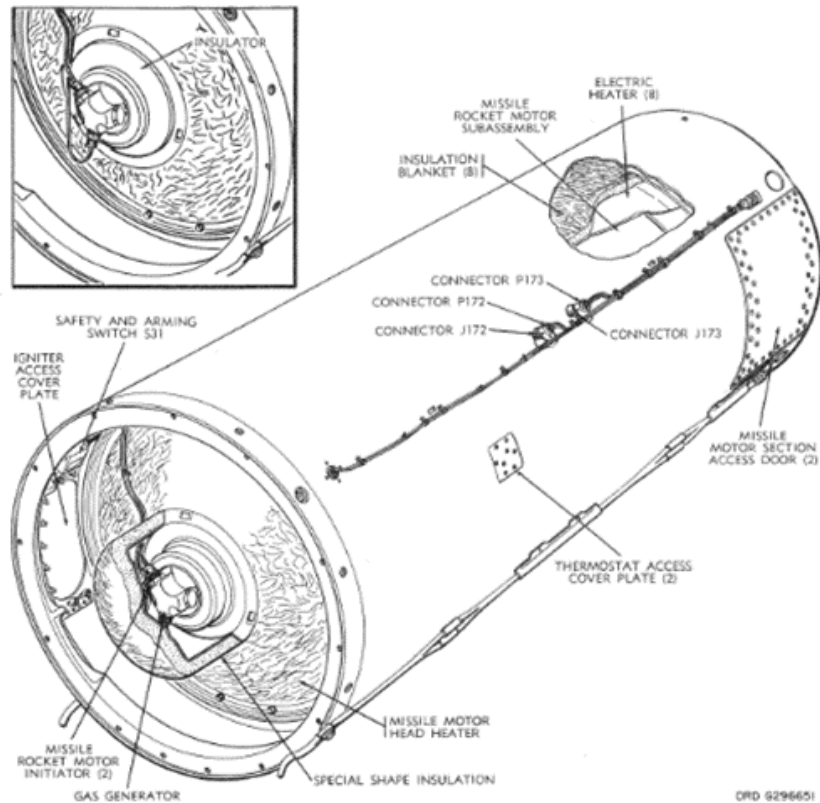
Warhead section (TM 9-1410-250-12/2)

From 1967 onwards, part of the NIKE Hercules missiles in the RNLAf inventory were equipped with a nuclear warhead. This was the W31 nuclear warhead that was used in various versions and yields. The versions were the 'BXS' (NIKE type B, Special, Small) and 'BXL' (Special, Large), of which the yields (according to public sources) ultimately amounted to 2 and 20 kilotons (kt) of TNT respectively⁴. The BXL version was already phased out by 1981. The nuclear warhead was equipped with a Permissive Action Link (PAL). Only when this was removed, the arming plug be could installed. The code for removal of the PAL was provided in wartime after authorization by the National Command Authority through the US national channels. A fail safe circuit prevented a nuclear

⁴ For an animation of the effects of an air or ground burst see <http://nuclearsecrecy.com/nukemap/>

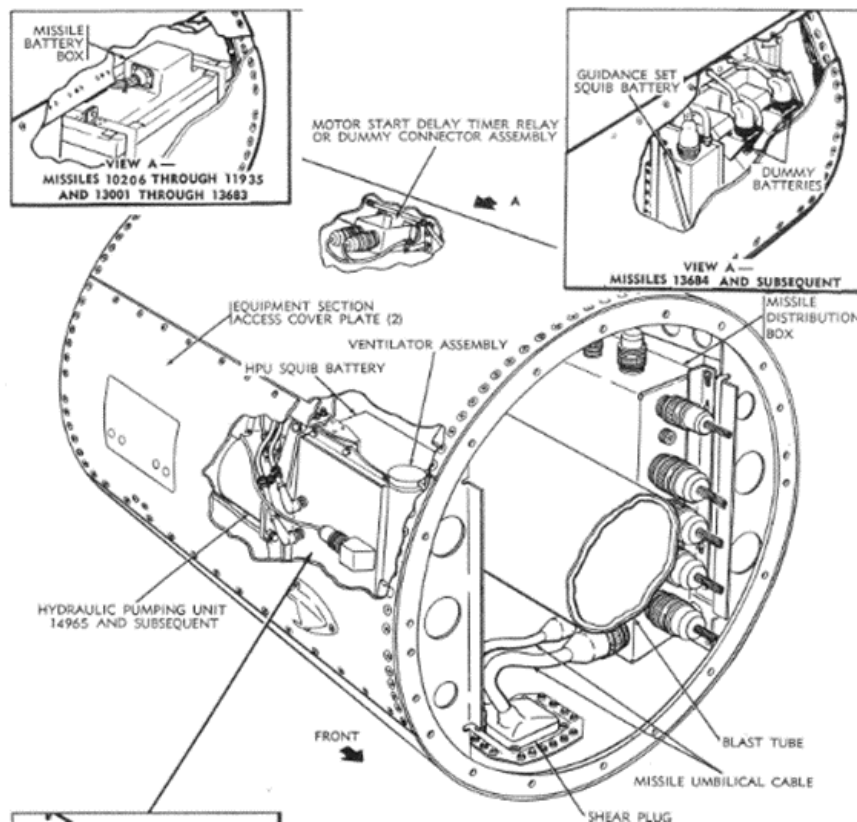
detonation until just before the burst command.

Motor section: here the solid fuel rocket engine was located. Via a nozzle, the combustion gases were fed under great pressure and velocity to the exhaust pipe at the rear of the missile. Connected to the rocket engine, a missile motor safe and arm switch was installed which prevented unintended ignition. This safety was armed only by an acceleration in the direction of flight for a number of seconds. The rocket engine had a burn time of 29 seconds providing a thrust of 13,500 lbs. (60,050 N). During this time rocket engine propelled the missile to a maximum speed of Mach 3.65 (approx. 4200 km/h / 2600 mph) and up to a maximum altitude of 100.000ft (30.5 km).



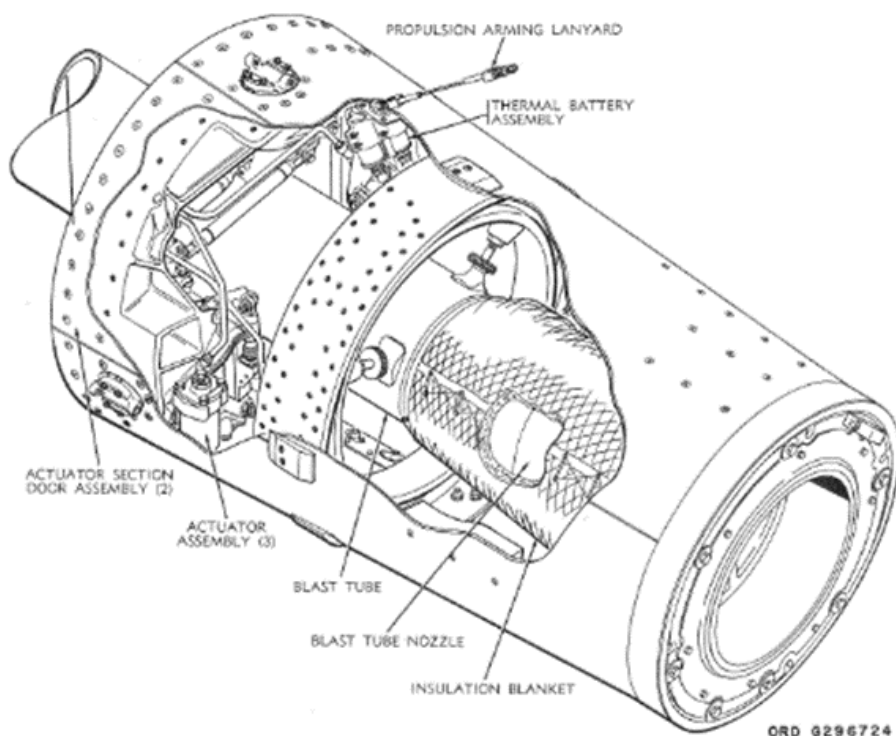
Motor section (TM 9-1410-250-12/2)

Equipment section: the hydraulic and electrical system equipment was installed in the free space around the nozzle. This included the umbilical connector: via the umbilical cable, the missile was supplied with electrical current and data prior to launch from the launcher through the missile umbilical connector.



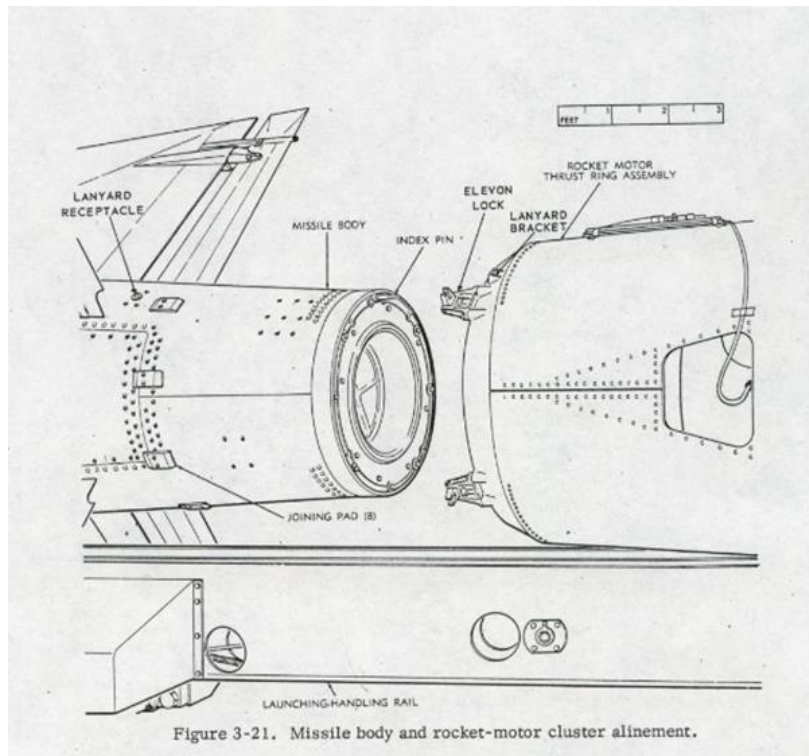
Equipment section (TM 9-1410-250-12/2)

Actuator section: these were the elevons at the rear of the stabilization fins of the missile and their associated hydraulic actuators. The elevons caused movements of the missile in the longitudinal axis (roll), up/down (pitch) or left /right (yaw). The missile could maneuver in turns up to 10G.



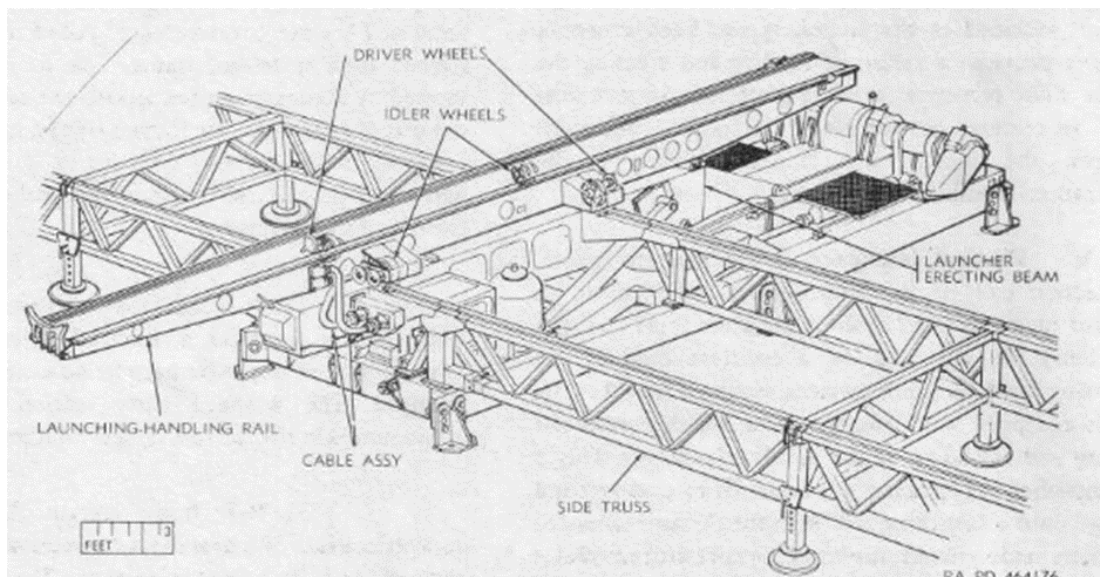
Actuator section (TM 9-1410-250-12/2)

Stabilizing fins (missile wings): the missile was equipped with four missile wings along nearly the entire length to maintain the correct position during the flight.



Missile, booster and launching handling rail (MMS-900)

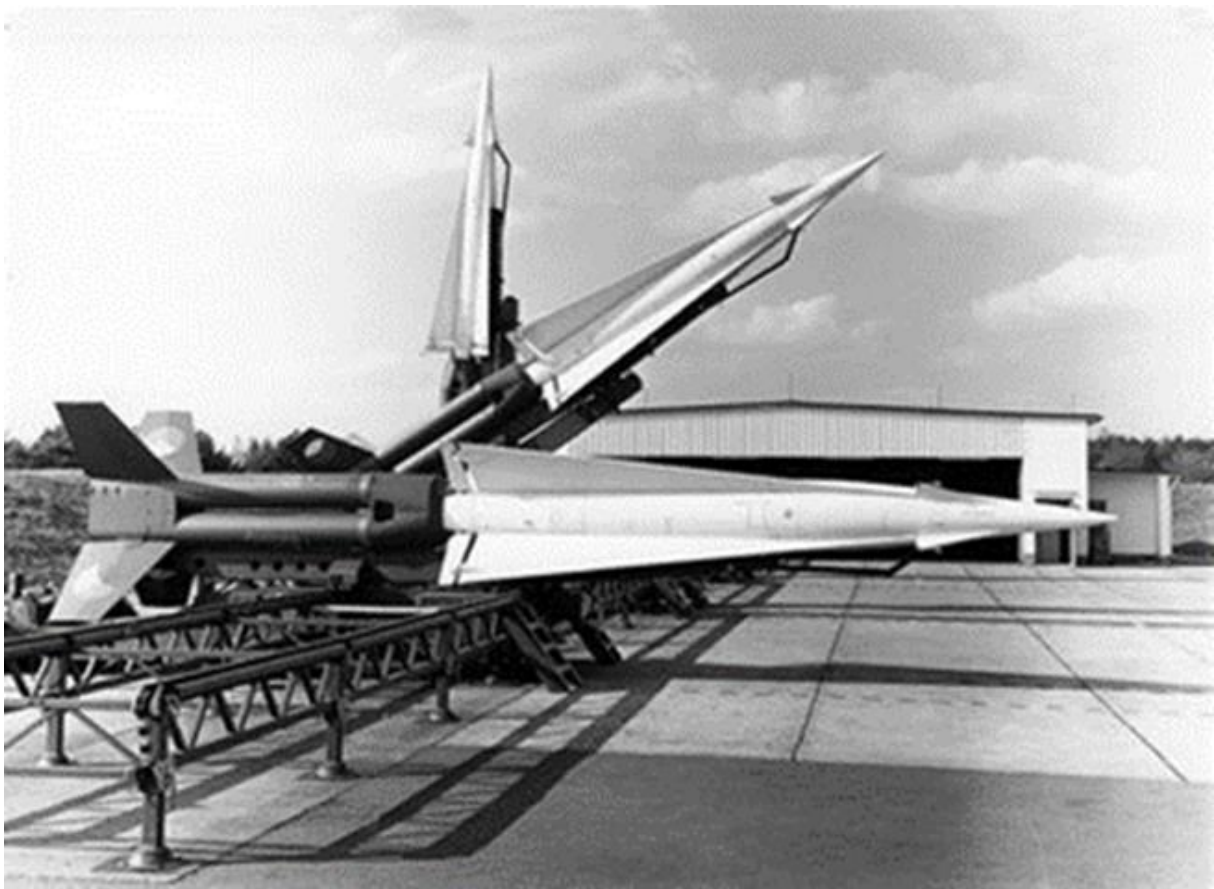
Launching handling rail. Booster and missile were mounted together on a launching handling rail by the assembly technicians. The three elements together formed the missile round up to launch. The launching handling rail was moved by manpower from the Missile Storage Building to the launcher.



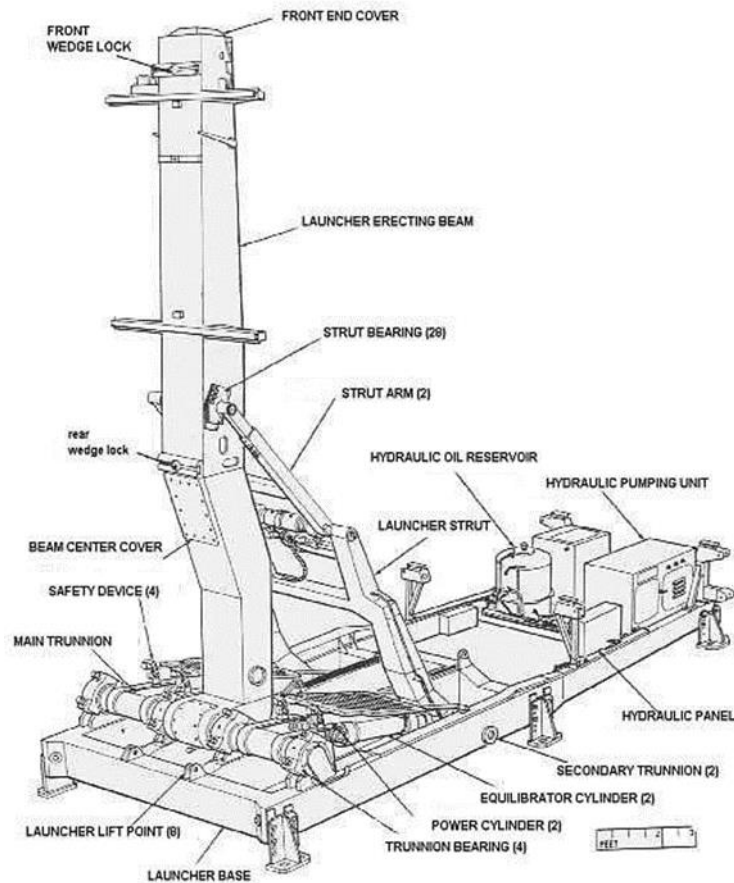
Launcher, launching handling rail and 'rail tracks' (TM 9-1400-250-10/2)

Launcher. The launcher put the missile in the firing position and provided the missile before launching with electrical power. The launcher also provided the electrical connection between the booster ignition cable and the firing circuit. During exercises, the booster was not actually connected but a Firing Simulator was used. This simulator provided options to select either a nuclear or conventional missile in either the Surface-to-Air or Surface-to-Surface mode.

Per launcher, one missile could be loaded. The three launchers per launching section were connected by a kind of rail tracks. The rails ran on one side until past the last launcher in order to park used launching handling rails. On the other side, the rails ran into the Missile Storage Building where the reload missiles were stored. When all three missiles on the launchers were fired, the launching handling rails were moved to the end of the rails and the launchers were reloaded with missiles from the Missile Storage Building.



*Launcher Section with 3 launchers and
Missile Storage Building (picture: NIMH)*



Launcher in 'up' position (MMS-151)

The launcher erecting beam could mechanically be adjusted for a vertical firing angle of 85, 87.5 or 90°. Within 12GGW, the default setting was 87.5° degrees. This prevented the burnt-out booster from falling back onto the LA, but still within the booster impact area near the LA. Both wedge locks ensured that the launcher handling rail with its missile were secured to the launcher erecting beam as soon as this was elevated.

Launching Section. A Launching Section included three launchers, a Missile Storage Building, a Section Panel and a number of missiles. The Launching Sections were surrounded by an earthen berm. In this berm the concrete shelter for the launching crew and the Section Panel was located. Each Launching Section was equipped with a maximum of 11 missiles; three on the launchers and up to eight in the Missile Storage Building. The nuclear missiles were stored within the Missile Storage Building and were only moved outside once a week for the 'acquire & command' checks with the MTR.

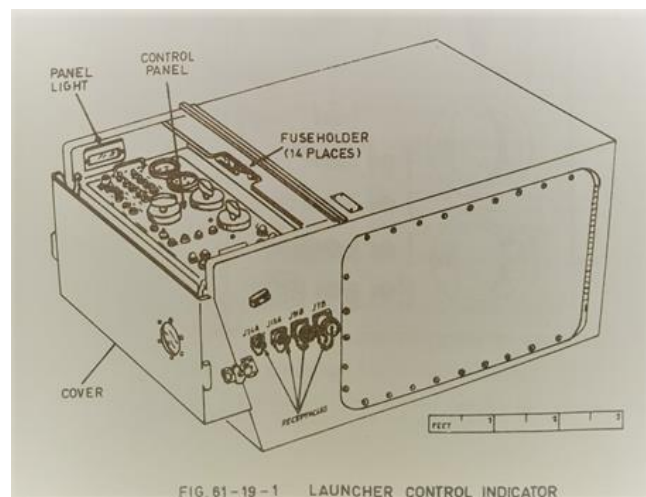
There were three Launching Sections per squadron: Alpha, Bravo and Charlie. The nuclear missiles were situated in the Alpha and Bravo sections of the LA, within an inner ring of the LA permanently guarded by the Dutch security troops. Access to the special weapons was strictly regulated: there was a special access roster for the inner ring, a permanent 'two man rule' (nobody was allowed to pass markers on the ground near the special weapons singly) and there had to be direct supervision on foreign personnel by a US soldier at all times. In the event of violation of these rules, the US personnel were under instruction to open fire immediately. Alpha and Bravo Sections were each equipped with five nuclear (BXS)

missiles and six conventional missiles (BHE), Charlie Section was equipped with 11 conventional missiles.

The three launchers could be operated remotely from the Section Panel. During the preparation of the Launching Section for operations and during checks, the launching crew was on the launch pad, except for the Section Panel Operator. The Section Chief was in contact with the Section Panel Operator in the bunker by means of a two-way speaker system. During operations, all personnel would be in the concrete shelter, separated from the launching platform by double, heavy metal doors. Being on the launch pad whilst a missile was fired was not recommendable.

On the Section Panel, a launcher was selected, allowing the launch command from the BCT to run via the LCT and Section Panel to the selected launcher and missile. If necessary, the Section Panel Operator could manually fire the selected missile from the Section Panel. While on duty, the Section Chief would permanently wear a chain around his neck on which were the four keys to close the firing circuit of the launchers ('crew safety keys'). Only when there was the intention to actually firing the missiles (or simulating this), the Section Chief activated the firing circuit by placing and turning the keys in the Section Panel. Continental-USA NIKE systems were equipped with four launchers per Section and four Sections per LA, hence the four crew safety keys and the four selection options for launcher and Section on the control panels of Section respectively LCT.

To test launchers and missiles, each launcher was connected to a Launcher Control Indicator (LCI). This was located in the Missile Storage Building.



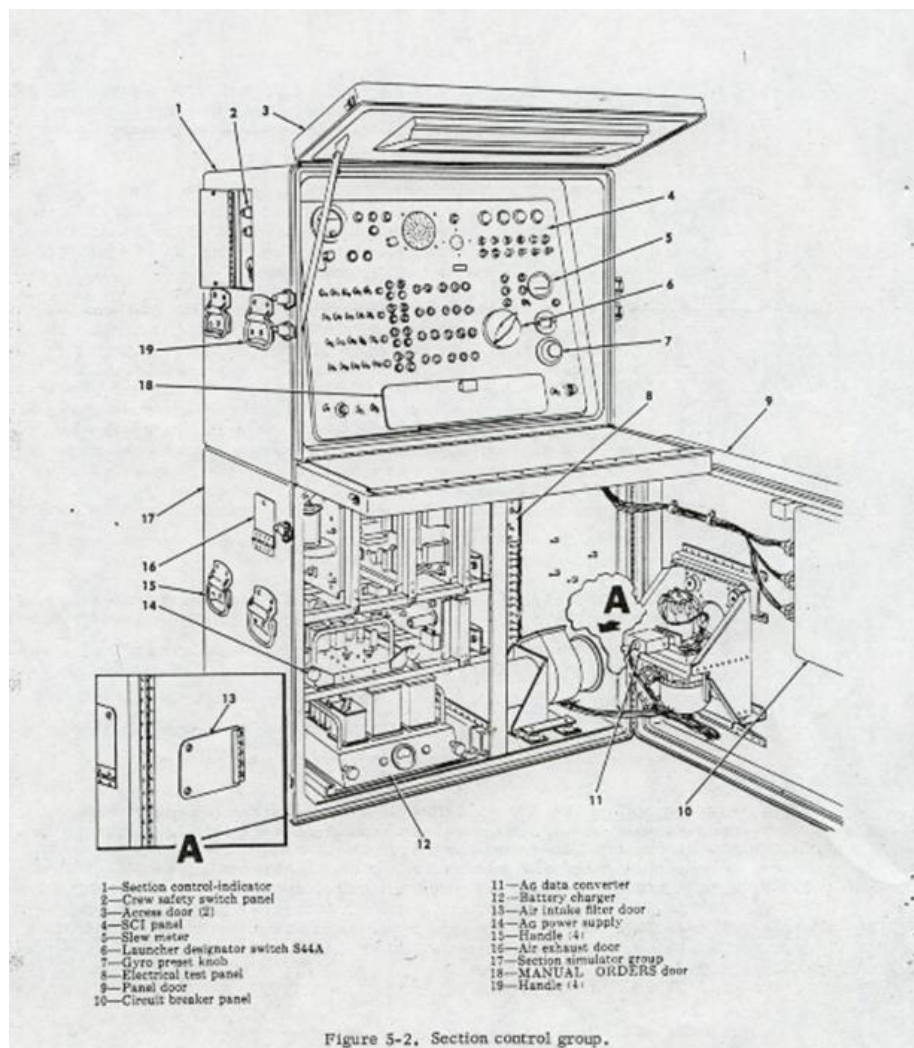
Launcher Control Indicator (OL152/3)

The Launching Section was manned by:

- Section Chief (Sergeant), who led the launch personnel of the section.
- Section Panel Operator (Corporal), who operated the Section Panel.
- Four Launcher Crew Members (conscripted soldier), who operated the launchers and generator and prepared the missiles, each one with a specific set of tasks.
- In the nuclear sections, the launch crew was supplemented with US custodian personnel.



*Section Panel. At the bottom of the console, normally behind a lid, the switches to fire a missile during 'emergency procedures-LCT out of action'.
(Picture: Ed Thelen)*



Section Panel (MMS-151)

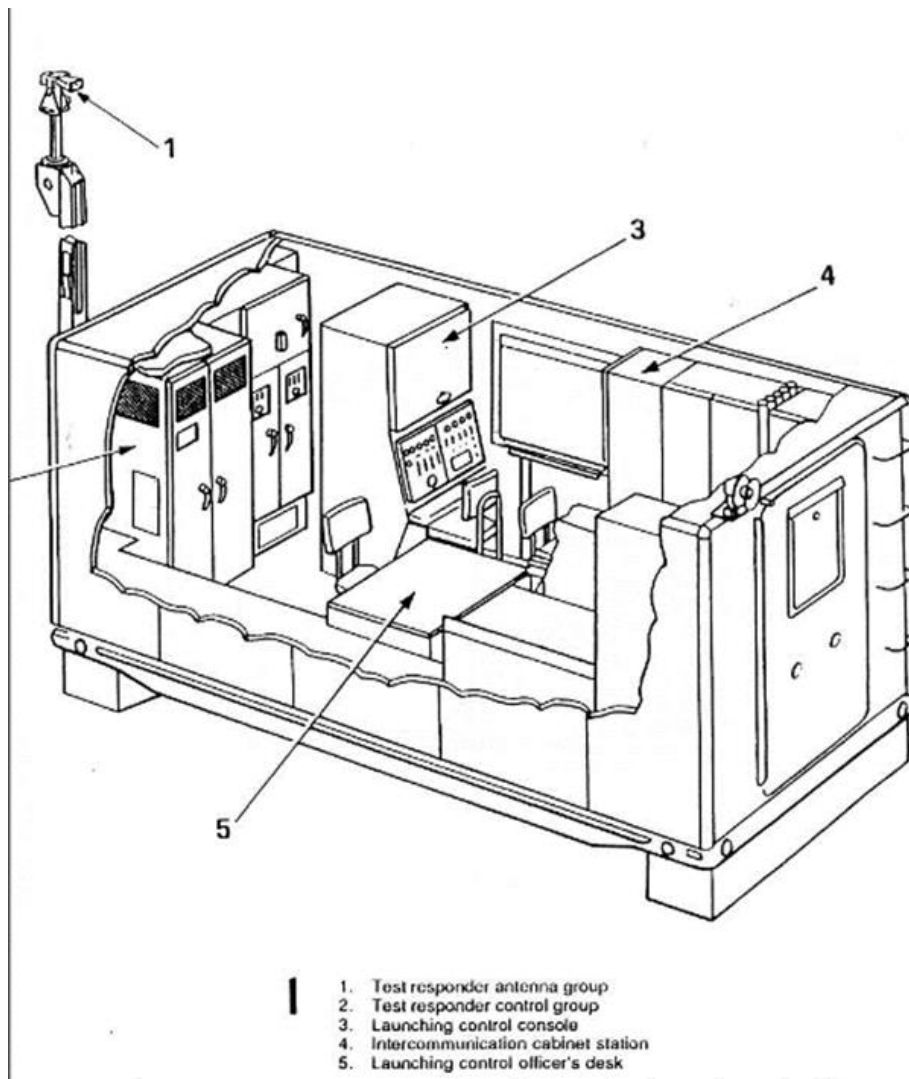
LCT. From the Launching Control Trailer, the actions on the three Launching Sections were commanded and contact with the IFC was maintained. The crew of the LCT consisted of:

- Launching Control Officer/LCO (Sergeant-Major or Sergeant). He coordinated the actions on the launching sections.
- Launching Control Console Operator/LCCO (Corporal), who operated the Launching Control Console/LCC in the LCT.
- Switchboard Operator (conscripted soldier), optional.
- On nuclear squadrons, the US custodian officer would be in the LCT during operations.



Launching Control Console

(Picture: Ramiro Ballola)



LCT (TM 9-1400-259-10/2)

In the LCT, on order of the LCO, the LCCO selected the Launching Section for the next engagement. The LCO would ensure that a Launching Section was available at all times, even if a reload was in progress in the other sections. The LCO informed the computer operator in the BCT on the current situation on the LA (which missile on which launcher, which launcher selected, etc.) to The LCCO communicated with the BCO and MTR operator in the IFC. The LCT was equipped with a test responder (also known as flight simulator). This was used for certain tests with the MTR.

A data and voice cable connected the LCT and each of the launch sections. BCT and LCT were connected by a data and voice cable; the interarea connection cable. This cable had a length of up to 6000 yards (5400 m) and this determined the maximum distance between IFC and LA. The firing command would travel from the BCT via the interarea connection cable to the LCT, from there to the Launching Section selected on the LCC and from there via the Section Panel to the selected launcher. If one of these cables was inoperative, Emergency Procedures were available to enable continued mission execution.



Launching Area 118 Sq. In the rear, the A and B section, surrounded by the inner ring with watchtowers. To the left the US Entry Control Post and the LCT. On the extreme left the Assembly and Warhead Building. Left center the C-Section. The white building on the right is the squadron staff building. The WWII German runway system, including filled-in bomb craters, is still clearly visible. (picture: author's archive)

Built-in safeties. To prevent unintentional launches and detonations of the warhead, a number of safety devices were built into the system. A fire command from the BCT could only be sent to the LCT and Section if the system was in 'red status' and the relevant Launching Section was selected in the LCT. The fire command, even during Emergency Procedures, could only reach the launcher if the relevant launcher had been selected and the four crew safety keys had been inserted and turned. The launcher could only pass the fire command to the booster if the launcher erecting beam was locked in the (almost) vertical position and the booster ignition cable was connected. The rocket engine could only ignite when the propulsion arming lanyard had activated the thermal batteries and the missile motor safe & arm switch of the rocket motor had been armed. For both, an acceleration in the direction of flight during a few seconds was required. The same applied for the detonation of the warhead: the two SADs could only detonate if the two SADs were armed by an acceleration in the direction of flight.

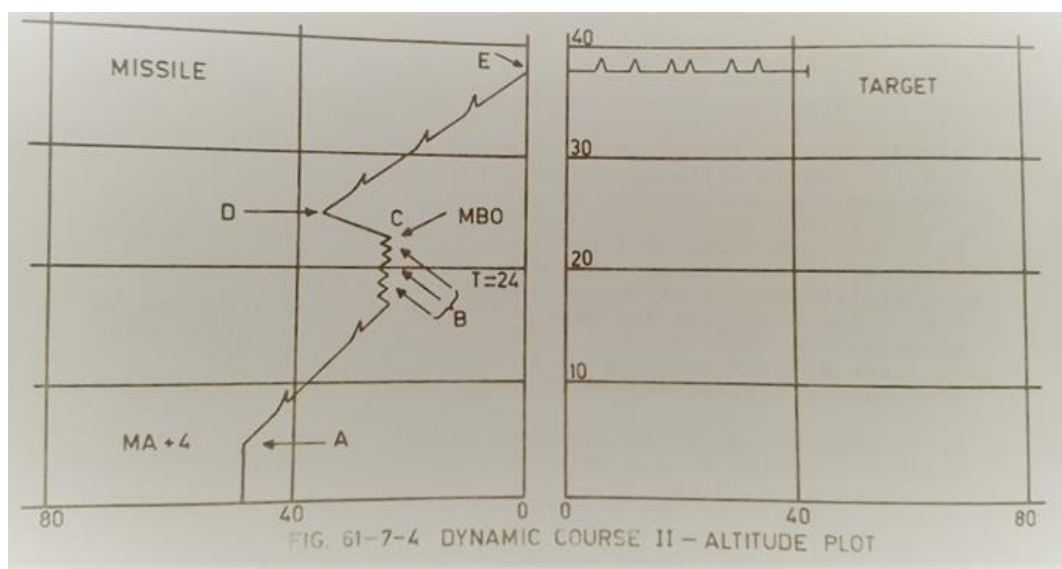
On the other hand, if the missile lost the MTR signal for more than three seconds after launch, this resulted in a failsafe burst of the missile. This prevented an armed warhead from a missile that had lost its guidance to travel uncontrolled to an unintended destination. If the thermal batteries were not activated after booster separation (e.g. when the propulsion arming lanyard was broken), this would lead to a failsafe burst too. A fail safe burst would always be a conventional detonation, even in the case of nuclear missiles.

System checks.

Because of the high readiness posture during the Cold War, it was essential that the weapon system was frequently checked for correct functioning. This involved a strict regime of daily, weekly, monthly, annual and multi-year checks: the system checks. The correct operation of the system was regularly checked during evaluations by external bodies, e.g. the Group's Operational Readiness and Evaluation (ORE) team or the NATO Tactical Evaluation (TACEVAL) team.

During system checks, firstly the correct functioning of the individual system components was checked and corrected where necessary. When all individual checks were completed, the operation of the weapon system as a whole had to be tested. The main integrated system checks were:

- Acquire & Command check. In this test, the automatic lock of the MTR on the missile on the selected launcher was checked. Furthermore, it was checked whether steering commands from the MTR resulted in corresponding movements of the elevons of the missile. Finally, a test burst command passed by the MTR needed to be received by the missile. The Acquire & Command check was performed on each missile every week. Because the nuclear missiles had to be tested as well, the participation of US and Dutch security personnel was necessary.
- Automatic AG test. In this test, it was checked whether the lead angle for the missile (azimuth of gyro; AG) to the intercept point, as calculated by the computer, was correctly transmitted to the missile. The SPO verified this on the A.G. Data Convertor on the Section Panel.
- Automatic fire & launch test: In this test, the correct functioning of the entire firing circuit between BCT and missile was tested.
- Dynamic course test. In this test, the computer simulated the intercept of a virtual target. The test results had to be within the prescribed tolerances.



Vertical plot Dynamic Course No. 2 (OL152/3)

- Simultaneous Tracking test. Because of the 'Command Guidance' principle, the accurate alignment of TTR, TRR and MTR was crucial for a successful engagement. The whole alignment procedure was known as LOCOS because it consisted of the parts Leveling, Optical Alignment, Collimation (aligning the electrical, mechanical and optical axes of the radar), Orientation (direction to the North) and Synchronization (the Simultaneous Tracking test). To perform this last test, the TTR and the TRR would establish a lock on an aircraft on a regular course, e.g. a commercial airliner, at a range of 50-100 km.

Then the MTR was switched to skin track mode and locked on the same aircraft. This situation simulated the moment of intercept of the target by the missile, when the distance between missile and target would be minimal. The computer received the target and missile positions from TTR/TRR and MTR and calculated the absolute difference in distance between these positions. This was done for each of the pulse modes of TTR (long and short pulse) and TRR (A /short and long pulse, B/short and long pulse). The allowed tolerance was half a meter per 1000 meters range, which corresponds to an alignment accuracy of 0.5 mil (0.03°). At a target distance of, for example, 80 km, the system tolerance was a maximum difference of 40 m between the positions indicated by the MTR on the one hand and the TTR or TRR on the other. With a deviation of 1 mil or more (i.e. 1 meter or more per 1000m range), the system was considered to be non-operational (non-ops) and the entire LOCOS procedure between TTR, TRR and MTR had to be performed again.

- ADL check. The Automatic Data Link system made it possible that target allocation, fire commands, etc. could be transmitted electronically between higher echelons and BCT, even without voice commands. The ADL check could be held with either the GOC or higher echelons. The aim was to check whether the electronic orders arrived correctly in the BCT, the target position as indicated by the higher echelon corresponded with the actual radar echo and that the reports back from the squadron were sent correctly.



(picture: author's archive)

SEQUENCE OF ENGAGEMENT

The BCO would command the computer through a selector switch to execute one of three missions: Surface-to-Air Low Altitude (not in use), Surface-to-Air or Surface-to-Surface. Through a second switch he selected the type of warhead: I-HE (NIKE Ajax conventional, no longer in use since 1964), BHE (NIKE Hercules conventional), BXS (NIKE Hercules nuclear small) or BXL (nuclear large). The default choice was Surface-to-Air, BHE. The sequence of engagement associated with this setting is discussed below.

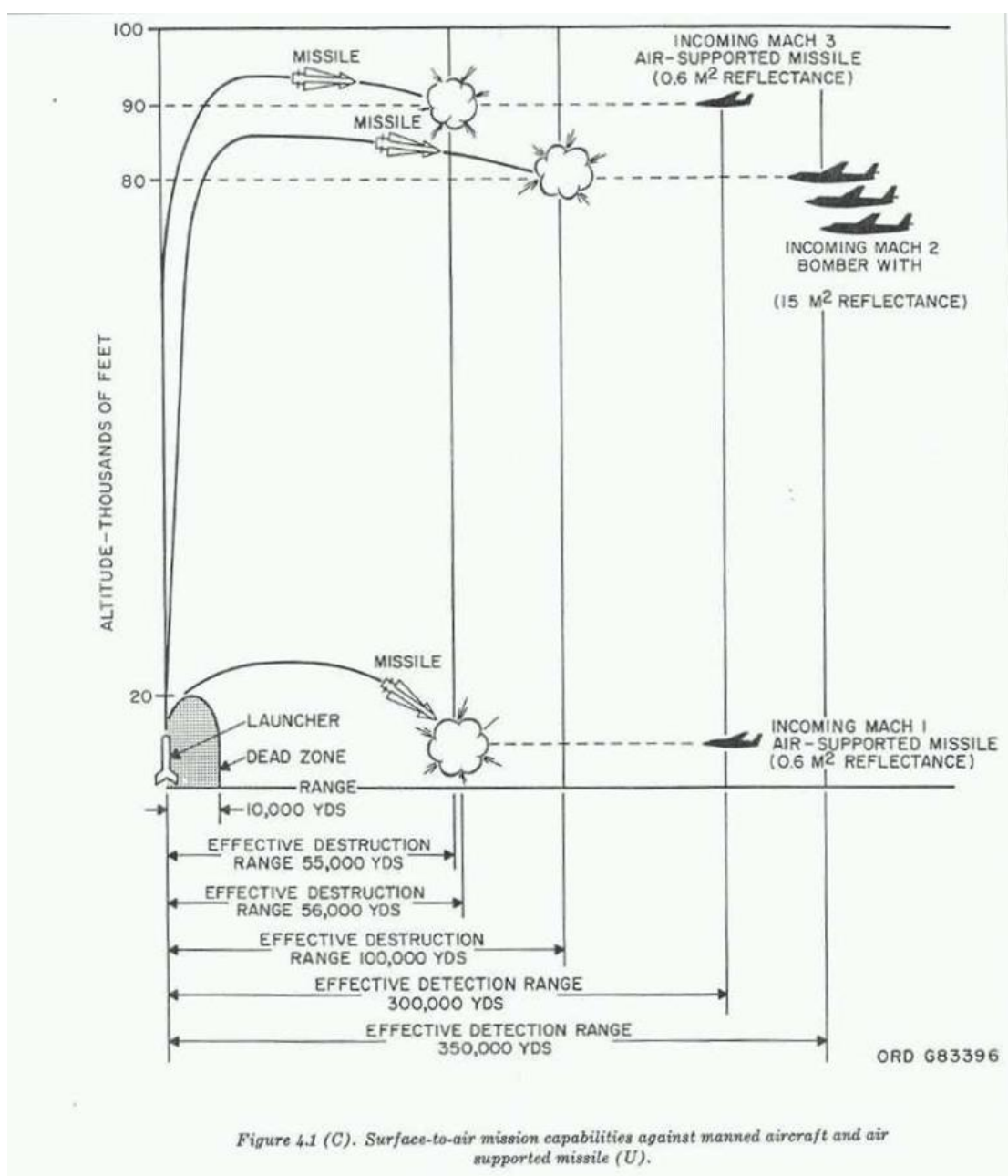
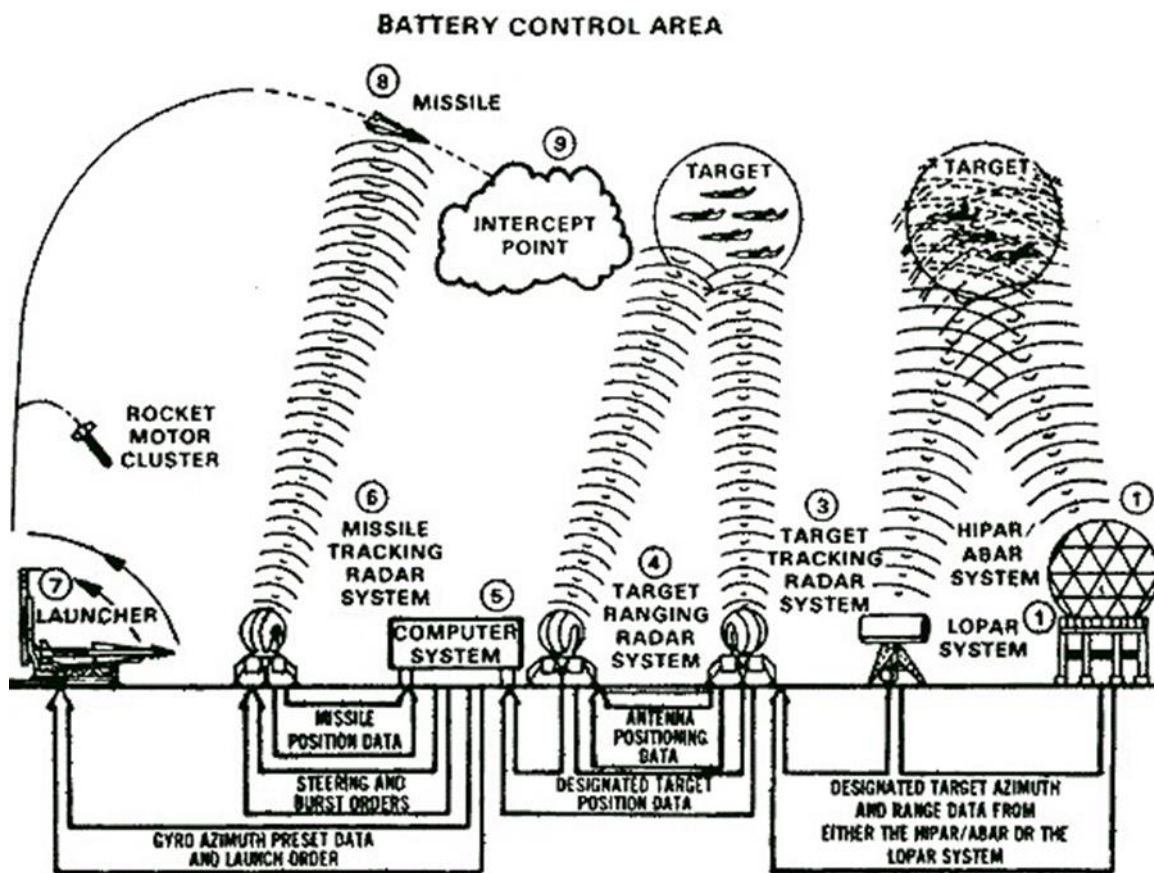


Figure 4.1 (C). Surface-to-air mission capabilities against manned aircraft and air supported missile (U).

SA and SA-LA system performance (TM 9-1400-250-10/2)

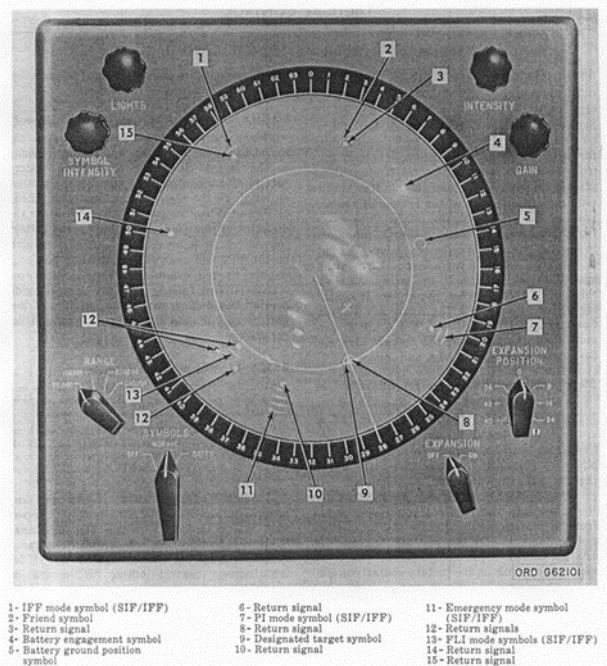
Surface-to-Air (SA) mission (conventional). To engage a target and to fire a missile, the NIKE system first had to be brought into operational status by performing the crew drill. This status was called Battle Stations. At Battle Stations, all fire control and launch

positions were manned, the radars were checked for proper functioning and switched to radiating, the missiles and the launchers were checked, the booster ignition cable connected to the launcher and at least two launcher beams erected in the near vertical firing position (the second launcher was the immediate backup in case there would be a problem with the primary launcher/missile). The Section Chief's crew safety keys were placed in the Section Panel and turned. For exercises, the status was called Blazing Skies and the conditions were the same as for Battle Stations, except that the booster ignition cable was connected to the training firing simulator. The BCO commanded the mission (here 'Surface-to-Air, BHE'). The MTR was locked on the missile selected by the LCO, which condition was indicated to the BCO in the BCT by three green lights ('missile designated', 'ready', 'tracked') on the Battery Control Indicator Panel in front of him.



SA mission (TM 9-1400-250-10/2)

A potential target was detected by the HIPAR or LOPAR, depending on which radar was selected. The target echo was projected onto the PPI so that the BCO had a first indication of azimuth and range of the target, and by the movement of the target echo an indication of its course and speed. Based on this information, the BCO made a first assessment whether this target complied with the applicable engagement criteria. In case of multiple targets, he had to prioritize on the basis of the general and the higher echelon's specific tactical instructions. If the BCO decided to take the target into consideration for engagement, he commanded the acquisition operator to interrogate the target by means of the IFF ('challenge').



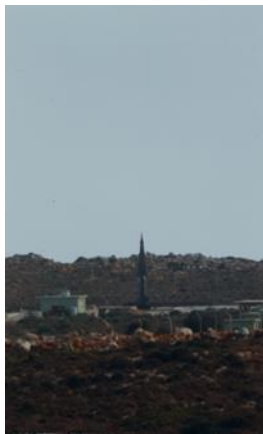
Plan Position Indicator PPI (TM 9-1400-250-10/2)

If a positive response from the target was not present, the BCO assigned the target the status of 'foe' and ordered the target to be put under the cross hairs of the PI, so that a possible multiple target echo could be determined. The BCO then instructed the acquisition operator to assign the target to the TTR operator ('designate') by means of an electronic assignment. The TTR operator could, on his B-scope, see a cut-out of the PPI around the designated target. By accepting the order, the TTR automatically slewed to the right azimuth and searched for the global range ('acquire'). The TTR elevation operator was then instructed to search in elevation until the radar echo became visible ('search'). As soon as this was the case, the target echo was visible on the A-scopes of the TTR-elevation, azimuth and range operators. The Tracking Supervisor checked whether the target tracked by the TTR corresponded to the target information on the B-scope and commanded the TTR-crew to switch to auto-lock. The TTR now automatically followed the target in azimuth, elevation and range. The BCO was informed of the progress in this process by the illumination of the green lights for 'foe', 'designated', 'confirmed' and 'tracked' respectively. If necessary (e.g. in case of serious electronic interference on the range channel of the TTR), the target could also be tracked in range by the TRR.

The position data of the TTR (when required supplemented by the range information provided by the TRR) were automatically transferred to the computer. The computer firstly calculated the altitude of the target above the earth's surface. Secondly, from this point on, the computer permanently calculated the position in space where the target would be intercepted when the missile was to be launched at that moment; the Predicted Kill Point/PKP. This calculation was based on a generic, average missile performance (e.g. speed at burn-out of the rocket engine). The computer now permanently displayed both the target position, course and PKP on the horizontal plotting board, and the altitude of the PKP against the calculated missile flight time on the vertical plotting board. Thirdly, the computer permanently calculated the azimuth of the selected launcher to the PKP (azimuth or gyro; AG) and passed this constantly to the azimuth gyro in the selected missile. Finally,

the computer presented the calculated data (target altitude and speed, missile flight time (time-to-intercept) and the azimuth of the PKP) to the BCO. When all of these data were steady, the PKP was within an acceptable range (engagement envelope) and the time-to-intercept was less than 200 seconds, after four seconds the computer would show a green light indicating that the system was ready to fire.

The BCO evaluated once more whether the tracked target could still be engaged according to the current tactical orders, no target with a higher priority was present and there were no other objections to the upcoming engagement. The BCO then did the count-down for the engagement: 'about to engage, 5, 4, 3, 2, 1, fire'. On 'fire' he flipped the firing switch under the red protective cover. The green light indicating 'fire' would illuminate.



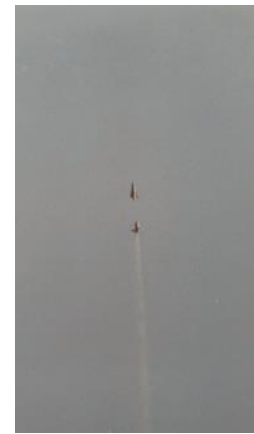
Fire: gyro azimuth stabilization



+ 2.25sec: booster ignition



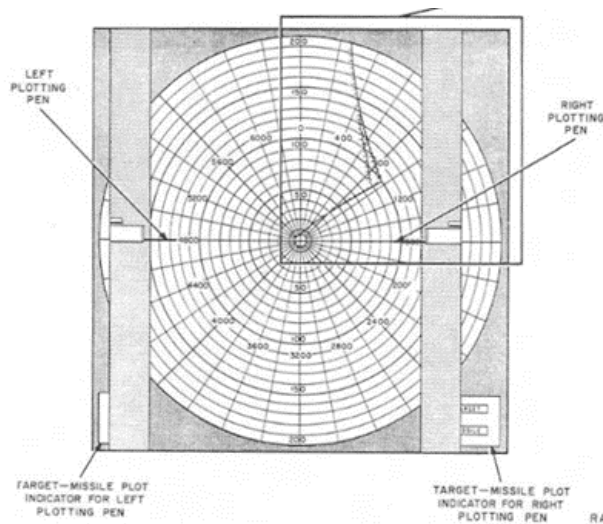
Booster burn time 3.4sec



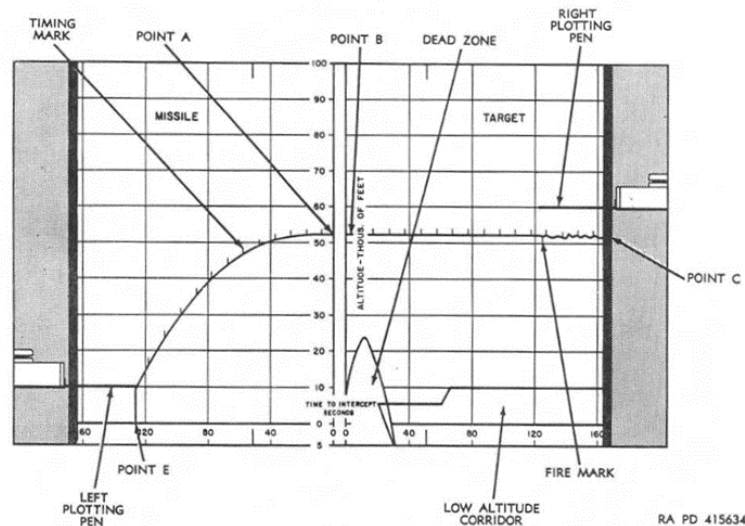
+ 3.4sec: booster burn out, booster separation and roll

(pictures: author)

The BCO's fire command firstly initiated the firing program in the computer. At the same time, the fire command went via the interarea connecting cable to the LCT, via the LCC to the selected section and via the Section Panel to the selected launcher and via the umbilical cable to its missile. Within the missile's gyroscope, the fire command led a freeze of the last AG information from the computer. The missile started to build up hydraulic pressure and the internal power supply was activated. This process took about two seconds. Two and a quarter seconds after receiving the fire command, the booster was ignited via the booster ignition cable. Under the thrust of the booster, the missile moved with great force over the launching handling rail. The umbilical cable and the cooling hose were pulled from the missile, the missile away switch on the launching handling rail was activated. Due to the acceleration, the SADs were armed, closing the warhead detonation circuit and the rocket engine ignition circuit. The horizontal plotting board in the BCT now showed the target's and missile's horizontal trajectory, on the vertical plotting board the vertical flight paths of the missile and that of the target were presented.

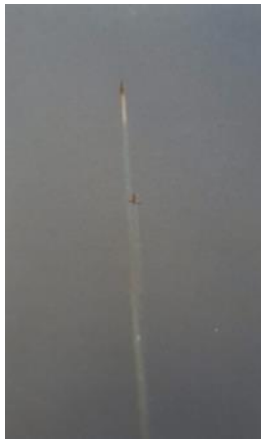


Horizontal plot of an engagement (TM 9-1400-250-10/2)



Vertical plot of an engagement (TM 9-1400-250-10/2)

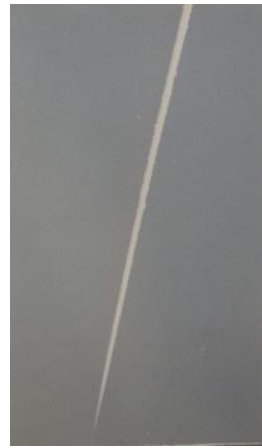
Because the MTR was locked on the missile and the missile moved upwards, the MTR rotated in the vertical plane. This was, after 1.2 seconds, the computer's indication for 'missile away', which was shown in the BCT by a green light ('launch'). Because the missile's elevons were still locked by the booster's elevon locks, the missile was still not able to maneuver until booster separation. With booster burn-out 3.4 seconds after ignition, the booster's higher aerodynamic drag forced the booster to separate from the missile. While pulling away, the booster pulled a pin from the missile (the propulsion arming lanyard), causing the thermal batteries to activate and the rocket engine to ignite after 0.7 seconds. In addition, the missile's elevons were released and the missile became maneuverable. The first maneuvering command was generated by the missile itself and involved a turn in the longitudinal direction (roll) so that the missile's 'belly' (the side that rested on the launching handling rail prior to launch) turned to the azimuth of the PKP (as recorded just before launch in the missile's gyroscope). Approximately two seconds were allocated for completion of this maneuver.



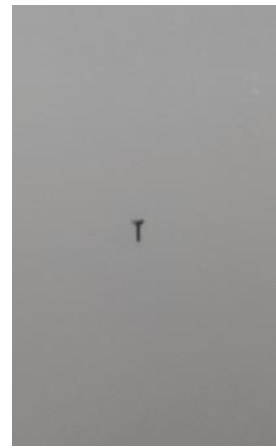
Missile engine ignition



7G initial dive to PKP



On trajectory to PKP and acceleration to Mach 3.65



Booster falls back

(pictures: author)

Five seconds after launch, the missile received the computer's first steering command via the MTR. This involved an initial dive command that caused the missile to dive from the near vertical position during launch to a more horizontal flight path in the direction of the PKP. This command generated a fixed angular acceleration of 7G, the duration was determined by the distance and altitude of the PKP. The steering command aimed the missile to a position slightly above the PKP, this to compensate for the normal 1G gravitational fall during the flight (the so-called 'super elevation'). Furthermore, until 10 seconds prior to the calculated intercept time, the missile received a continuous nose-up command of +0.5G to extend the flight range to the maximum (the so-called 'glide bias'). Finally, the computer directed the missile to a point above the PKP to compensate for the loss of the glide bias during the last 10 seconds of the engagement: the 'ballistic falling factor'. Once the missile reached the flight path to the PKP the missile was 'on trajectory', this was about 12 seconds after launch. 29 seconds after ignition, the rocket engine reached burn out, the missile was now at its maximum speed and the missile glided to the PKP. At this moment the computer made a recalculation of the engagement, now based on the missile's actual altitude and speed. On the plotting boards, this was visible by a repositioning of the missile tracks.

Meanwhile on the LA, the fired launcher erecting beam was returned to the horizontal position, a new launcher beam was erected to a near-vertical position and prepared for the next mission. When all three launchers in a section had been emptied, the launching crew could move all three empty launching handling rails aside and reload three new missiles on the launchers and prepare them for firing. The LCO selected the next Section and launcher for the next engagement. The RCT-crew was still busy tracking the target and the missile. The BCO monitored the engagement but in the meantime was looking for a next target and would prepare for its engagement.

Meanwhile, the computer continuously calculated the position of the PKP based on the target's position, speed and course and the missile's flight data. The aim of the computer was to bring missile and target together as close as possible. Any change in the calculated position of the PKP, for example because of the target maneuvering, led to a new steering

command to the missile. During the first flight phase, the steering commands were dosed in such a way that they cause a minimal loss of energy to the missile due to violent maneuvering. The computer tried to guide the missile in such a way that it would reach the last flight phase with maximum speed and energy, so that the missile could still react optimally to evasive maneuvers of the target. As of 24 seconds before the calculated intercept time, the steering commands led to more aggressive steering movements. From 10 seconds before the calculated intercept time, the computer ordered maximum control commands to compensate for any change in the PKP in order to minimize the miss distance.

Ten seconds before the calculated intercept, the 0.5G glide bias flight profile was removed: the missile now followed a 1G parabolic trajectory to the PKP under the influence of normal gravity. The BCO did the countdown: 'ten seconds to burst, 5, 4, 3, 2, 1, burst'. At 0.5 seconds before the calculated PKP was reached, the computer sent the burst enabling command to the missile, after which the missile no longer received steering commands. At 0.12 seconds before intercept, the missile received the burst command. At 10 milliseconds before reaching the PKP, the warhead detonated. Under ideal conditions, the detonation would take place about 10 meters away from the target for optimal effect. The actual distance was determined by this intended miss distance plus the margin of error caused by the alignment of TTR/TRR and MTR, and other system inaccuracies. The target would be destroyed by a combination of air blast and shrapnel from the warhead. The target's destruction could be detected on the TTR and TRR by the loss of the target echo. The Tracking Supervisor reported this to the BCO with the statement 'effective' (or 'ineffective' if the target echo on the TTR/TRR persisted). At burst, the MTR had lost track of the missile. The MTR automatically locked on the new launcher selected by the LCO.

The computer's data recorder had recorded the entire engagement and could provide an analysis of the engagement, among which the miss distance at burst. The NIKE system was now ready for another engagement.

Surface-to-Air (SA) mission (nuclear). The nuclear SA mission was largely identical to the conventional mission described above. However, first of all, a valid nuclear release message was required from both the NATO and the US national commanding authorities. This release message indicated how many nuclear weapons were released and during which timeframe. The NATO tactical order gave further restrictions for the employment of nuclear warheads, for example in terms of time frame (which could deviate from the release time limits in the release message), geographical restrictions, altitude limits for target and detonation, minimum target speed, target's heading etc.

After a validated nuclear release, the US personnel had to remove the PAL plug and the SS-shorting plug from the warhead, after which the SA arming plug could be installed. Furthermore, the self-aligning static probe's red protective cap had to be removed. The rest of the preparation of missile and launcher did not deviate from that of a conventional mission, but obviously took place under the strict supervision of US personnel. In peacetime, these procedures were performed on a nuclear training missile (known as the 'Black Molly'), not on 'live' nuclear missiles.

When one or more nuclear missiles were ready for employment and the BCO had selected a target that fulfilled the conditions for a nuclear engagement, he ordered the mission:

'Surface-to-Air, BXS'. If, according to the NATO commander's instructions, a nuclear detonation had to take place above a certain altitude, the Minimum Burst Altitude (MBA) dial had to be set to the specified value. This adjustable altitude was set by the computer operator between 0 and 30,000ft and prevented a detonation at too low an altitude which could cause radioactive fall-out. The standard minimum altitude prescribed by NATO was known as the Minimum Normal Burst Altitude (MNBA). If the NATO commander intended to take the risk and accept detonations at low altitudes, the BCO placed the MBA switch in the override position.

The BCO had the choice between a normal or an offset detonation. In the latter case, the detonation occurred slightly in front and above the normal intercept point, as a result of which air pressure and the fireball could disable a large, somewhat dispersed flying formation of aircraft in one detonation. MBA override and offset burst were no longer in operational use operation since the late 70's.

Surface-to-Air Low Altitude (SA-LA) mission. Although the NIKE system was intended for engagement of targets at medium and high altitude, the BCO could also select the Low Altitude Engagement option. The engagement was identical to the normal SA mission, except that after booster separation the computer delayed the ignition of the rocket motor for eight seconds. This enabled the missile to take a more aggressive (up to 10G) dive at a lower speed after booster separation. Initially, the missile was aimed at a displaced aiming point above the actual PKP. Just before reaching this displaced aiming point, the missile received a dive command and dived from above to the PKP. If the PKP was located within a zone with a radius of 10,000 yards (9 km) and an altitude of 21,000 ft (6400 m) around the MTR at launch, the target could not be intercepted. This was the NIKE system's dead zone. In operations, Low Altitude Engagements did not occur as targets at that altitude were taken care of by the HAWK systems.

Surface-to-Air Anti-Missile (SA-AM) mission. Between 1967 and 1978, one Dutch NIKE unit (118 Sq in Vörden) was re-equipped to intercept enemy Tactical Ballistic Missiles (TBMs). In this configuration, the NIKE system was able to intercept TBMs with a maximum speed of 2380 knots (4400 km/h). The threat consisted of the Soviet FROG-7 and SS-1 SCUD TBMs with a maximum range of 70 and 300 km respectively. The system used differed from the standard NIKE system. First of all, a HIPAR was needed to be able to detect the small and fast TBMs at a sufficient distances.

Furthermore, the BCT was equipped with two PPIs: one for short range and one for long range. The SA-AM mission could be performed both conventionally or with nuclear warheads. The NIKE system could only engage TBMs that were targeted within a certain area around the NIKE system (the footprint). The footprint was a fixed area in relation to the IFC. Because the NIKE system was static, the footprint could not be moved to defend important objects outside the current footprint.

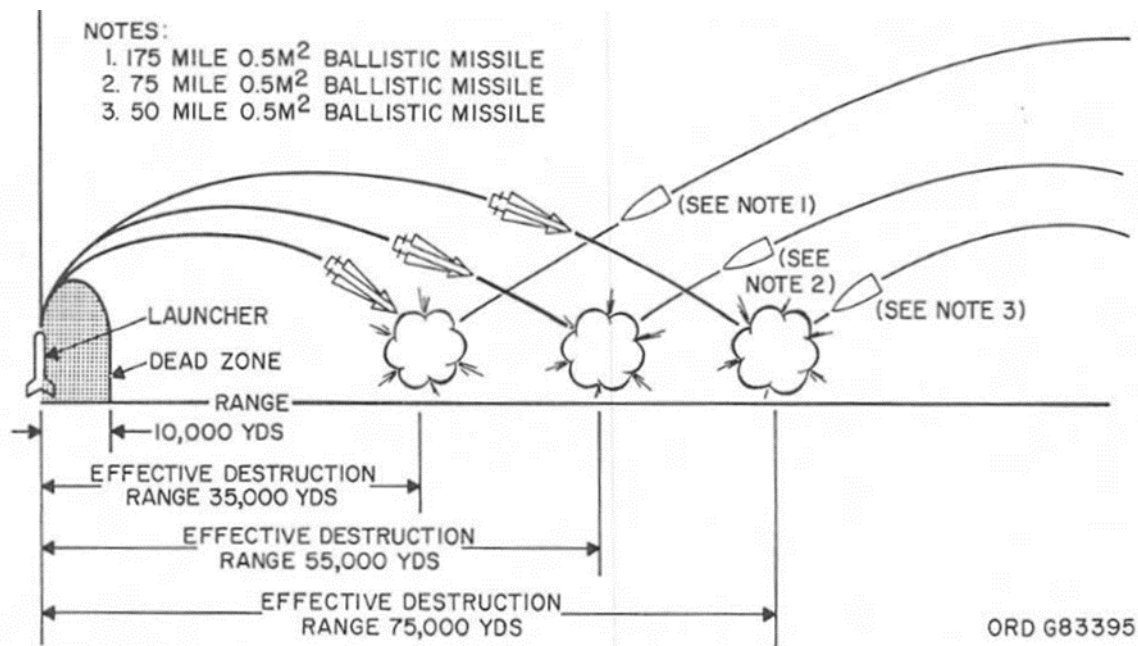
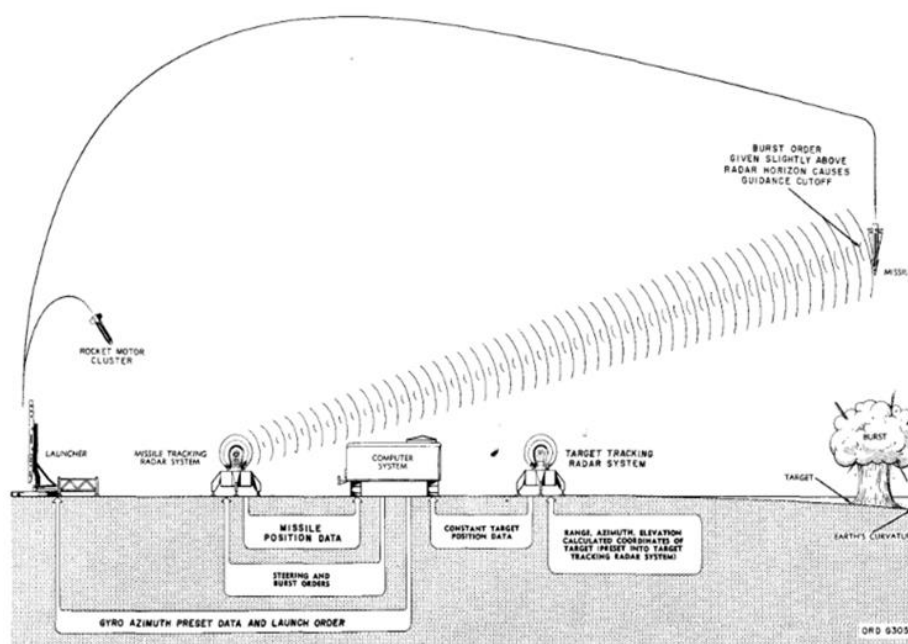


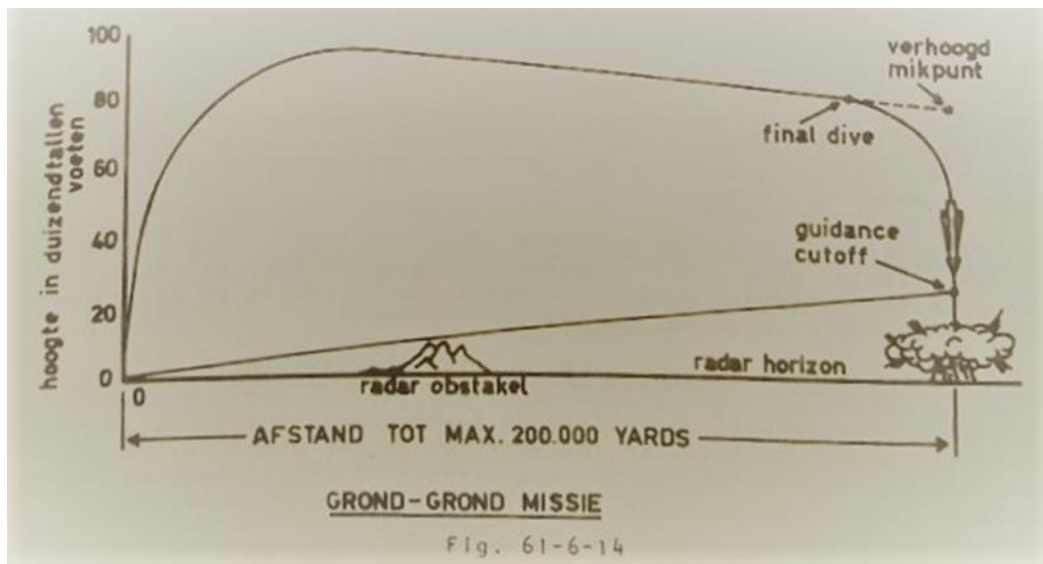
Figure 4.2 (C). Surface-to-air mission capabilities against ballistic missiles (U).

SA-AM system performance (TM 9-1400-250-10/2)

Surface-to-Surface (SS) mission. The Surface-to-Surface (SS) mission was a secondary task for the NIKE system. Although the NIKE system could hit a ground target very accurately, the system had to be released from the primary task of air defense for half an hour (30 minutes of preparation including maximum missile flight time). The SS mission was performed with nuclear warheads exclusively against ground targets at a maximum distance of 200,000 yards (183 km): the maximum range of the MTR and TTR. Even from 12GGW's two most easterly NIKE squadrons of (118 Sq in Vöörden and 120 Sq in Borgholzhausen), the territory of the GDR could not be hit, except for some small western outcrops of East German territory.



SS mission (TM 9-1400-250-10/2)



SS mission (OL152/3)

A SS mission commenced with an encrypted order from a higher NATO commander about one and a half hours before the desired time of detonation, sent to two batteries (not necessarily from the same Group/Battalion). The decoded message indicated whether it was a warning or an execution order and which unit was primary and which one secondary (back-up) for the mission. The message also contained the target coordinates (in 13 digits UTM i.e. an accuracy of 10 meters), the first and last moment of permissible detonation (time-on-target/TOT and not-later-than time/NLT respectively) and the desired detonation altitude. This data had to be converted into parameters suitable for the NIKE system. In the early years, this had to be calculated manually using goniometric tables (sin, cos, tan and log), later on a programmable calculator became available. Unfortunately, this was found to be disturbed by the HIPAR's electromagnetic radiation, so that the calculation still had to be carried out by hand. After the NIKE system's last modification (about 1984), it was possible to enter the target data directly into the computer which then converted the data into the necessary system parameters, which relieved the BCO from the complicated calculations. To carry out the SS mission the TTR and the TRR did not have to radiate as the target position was at a fixed position.

First of all, the BCO had to calculate the azimuth and range to the target by comparing the target coordinates and the coordinates of the TTR. The distance between them determined the missile's flight time; at maximum range this was 325 seconds. However, during the missile's flight time the earth rotated slightly from West to East. Therefore, at the end of flight, the target would no longer be in the same position as at launch. This had to be compensated by a lead angle and corrected range that had to be calculated. The flight time to the target also determined the first and last allowed firing time (TOT minus flight time or NLT minus flight time). Both units designated in the SS mission order performed the calculations, but only the unit designated as primary actually prepared the system for the mission.

There were three options for the detonation altitude:

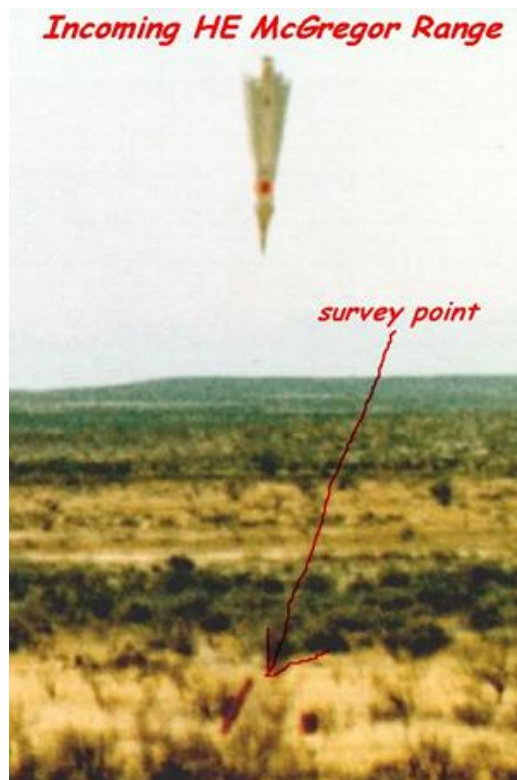
- Airburst/Ground Preclusion (an air explosion at an altitude which in principle would not cause any fall-out, if the air explosion did not take place the warhead would not detonate on impact).
- Airburst/Ground Back-up (air detonation desired, but in the event of an air explosion failure, a ground detonation was allowed, so the risk of fall-out was accepted).
- Ground Burst (an explicit order for a ground detonation, which would cause fall-out).

In the first two options, the barometric value had to be calculated, using the target altitude, ordered detonation altitude and a meteorological correction factor (the 'D-value'). This value; the barometric pressure for detonation at the desired altitude, was passed to the LCO who passed it on to the Section Chief. The calculated azimuth, range and elevation values were manually set on the TTR console and locked. On the MTR, the guidance cut-off value was set to an elevation that was five mils above the radar horizon in that azimuth.

After receiving the execution order, the unit that was designated as primary, at TOD minus 30 minutes started system preparation for the SS mission. For the LA, this required a nuclear release both from the NATO and US national authorities. The PAL plug had to be removed from the warhead by US personnel and they had to ensure that the SS shorting plug was still in place, after which the SS-arming plug was installed. In case of a desired air burst, the barometric value for the detonation altitude was entered on the launcher's LCI by the Section Chief.

When both IFC and LA were ready to execute the SS mission, the crew had to wait until the calculated firing time. After firing the missile, booster separation and the initial roll to the direction of the azimuth to the target, the missile made a 7G dive to a flight path that brought the missile right above the target at an altitude of 60,000 ft (18 km). Thus the MTR could still follow and guide the missile at maximum distances. Just before arriving at this displaced aiming point, the computer sent the missile the final dive command. This resulted in the missile diving and plunging straight down towards the target. To achieve optimum precision, the missile performed a 180-degree roll around the longitudinal axis. Just before the MTR reached the guidance cut-off elevation, the missile received the burst command via the MTR. The burst command armed the warhead but did not immediately lead to a detonation. The burst command disabled the warhead's failsafe circuit and shut off the guidance section's receiver channels. Until the moment of guidance cut off, the missile was a guided weapon, after that it would be an unguided, free-falling projectile subject to crosswinds etc.

For an air burst, the warhead detonated when the air pressure measured by the self-aligning static tube corresponded with the barometric value commanded to the missile during launch. In case of a ground burst, the weapon detonated on impact with the ground. The CEP (Circular Error Probable: the radius of a circle in which statistically 50% of the missiles would impact) in a SS mission at maximum range was in the order of ten meters. After completing the SS mission, the normal air defense mission could almost immediately be re-assumed.



*Test of a (conventional) SS mission in the USA
(picture: NIKE Historical Society)*



Two missiles ready-to-fire at NAMFI

(picture: author's archive)

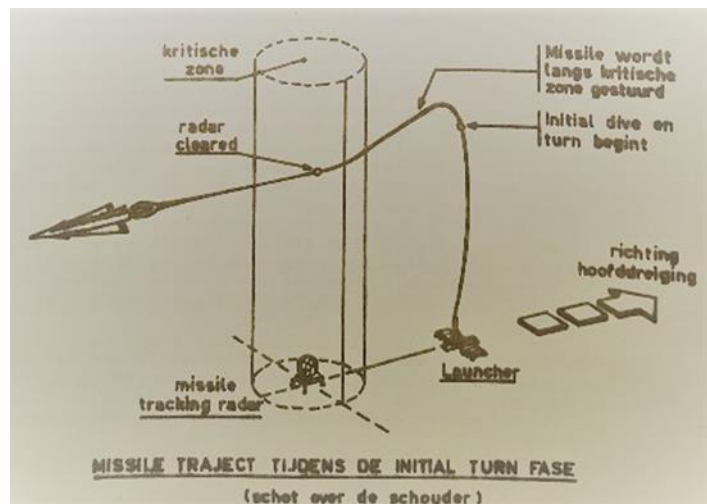
Complications. During an engagement, many complications could occur.

Misfire/hangfire. Occasionally, for some reason the firing command did not reach the booster's igniters. The missile remained on the launcher, although a number of systems in the missile were already activated by the firing command. In theory, there was a chance that the booster would still spontaneously ignite later on. If the situation allowed, the established procedure was to deselect and deactivate the relevant launcher and missile and wait for a minimum of 30 minutes. During this time, the electrical systems in the missile should have discharged. After the waiting time, or if due to the (war) circumstances no waiting period could be allowed, the Section Chief had to go to the missile to disconnect the booster ignition cable from the launcher, with a slight chance that the booster would ignite precisely at this time, for example due to stray voltage. When the booster ignition cable and the SADs were removed, the missile was safe again. The missile was then discarded as unreliable and checked-out at a later date by the Assembly's mechanics.

Booster failure. During the ignition of the booster all four booster rockets had to ignite simultaneously. If one or more booster rockets did not ignite, or gave an irregular thrust, for example due to a crack in the solid fuel, an asymmetric propulsion of the booster/missile combination would occur. The missile/booster combination would not lift-off vertically but in an erratic manner and would probably impact somewhere close to the LA. From the BCT, RCT, LCT or Launching Section this situation could not be observed as there was no visual contact with the missile, neither could anything be done about it except give a command burst order. In such cases, the Range Safety Officer would become very nervous during live firings on Crete.

Emergency procedures. When the interarea connecting cable was broken, automatic data exchange between LA and IFC could not take place. This affected information on the selected launcher/missile, the gyro azimuth for the missile and the firing command. If this condition was recognized, the BCO would order 'Emergency Procedures, LCT in action'. The LCO reported which launcher/missile was selected to the MTR operator verbally (via field wire or radio link). The computer operator verbally passed the gyro azimuth to the Section Panel operator, who inserted it on the Section Panel. Upon the BCO's countdown for launch, the LCCO flipped a firing switch on the LCC which initiated the launch of the missile. It was also possible that the LCT was out-of-action, or the cable between LCT and a Section was interrupted. In that case the BCO ordered 'Emergency Procedures, LCT out of action'. Because now there was no LCO available, the BCO had to decide which launcher to fire. The Section Panel Operator of the selected Section fired the missile from the Section Panel, after having first set the gyro azimuth. Further procedures were the same as described above. These emergency procedures were frequently practiced.

Over the shoulder. In Dutch NIKE units, the LA was located more or less East of the IFC, i.e. in the expected threat direction. If a target should be engaged West of the IFC, the missile would have to fly approximately straight over the MTR; an over-the-shoulder engagement. The MTR's maximum rotation (700 mils/39° per second) did not allow the MTR to keep tracking the missile in this case. The missile was therefore automatically 'redirected' by the computer around the MTR so that the MTR could continue to track the missile.



Over the shoulder (OL152/3)

Missile Loss. If for some reason the MTR lost track of the missile for three seconds or longer, or could not transmit a signal to the missile in flight, this would cause a self-destruct of the missile; the failsafe burst. The failsafe would cause the MTR to lock on the next selected launcher, so the BCO could 're-engage'. For this reason, there would always be two launchers in the firing position.



*Fail-safe burst immediately after booster separation
(picture: author)*

Track loss. If the TTR lost the target and could not establish a lock again within a few seconds, the engagement had to be aborted by the BCO. For this, he used the Command Burst switch, which sent a detonation signal to the missile via computer and MTR. A Command Burst always caused a conventional detonation, even with a nuclear missile.

Gyro Limit. In the horizontal plane, the missile could only move a maximum of 70° left and right of the azimuth of the AG which was set at launch, otherwise the missile lost its orientation. If this happened, the BCO was alerted by the 'Gyro Limit' light illuminating and then had to detonate the missile by throwing the Command Burst switch. A Gyro Limit situation could be caused by a violently maneuvering target at close range and/or high speed that would cause the PKP to move in all directions.

Moonshot. Sometimes it happened that booster separation did not result in the ignition of the rocket engine, or that the missile did not respond to steering commands. The missile then remained in a near vertical flight path and had to be destroyed by the BCO using the Command Burst switch. Because the detonation took place directly over the LA, there was a risk of damage due to falling metal parts and solid fuel.

False identification. If, after launch, the BCO came to the conclusion that the target was friendly after all, or the higher echelon determined so, the BCO had to use the Friend Switch which resulted in the missile's self-destruct.

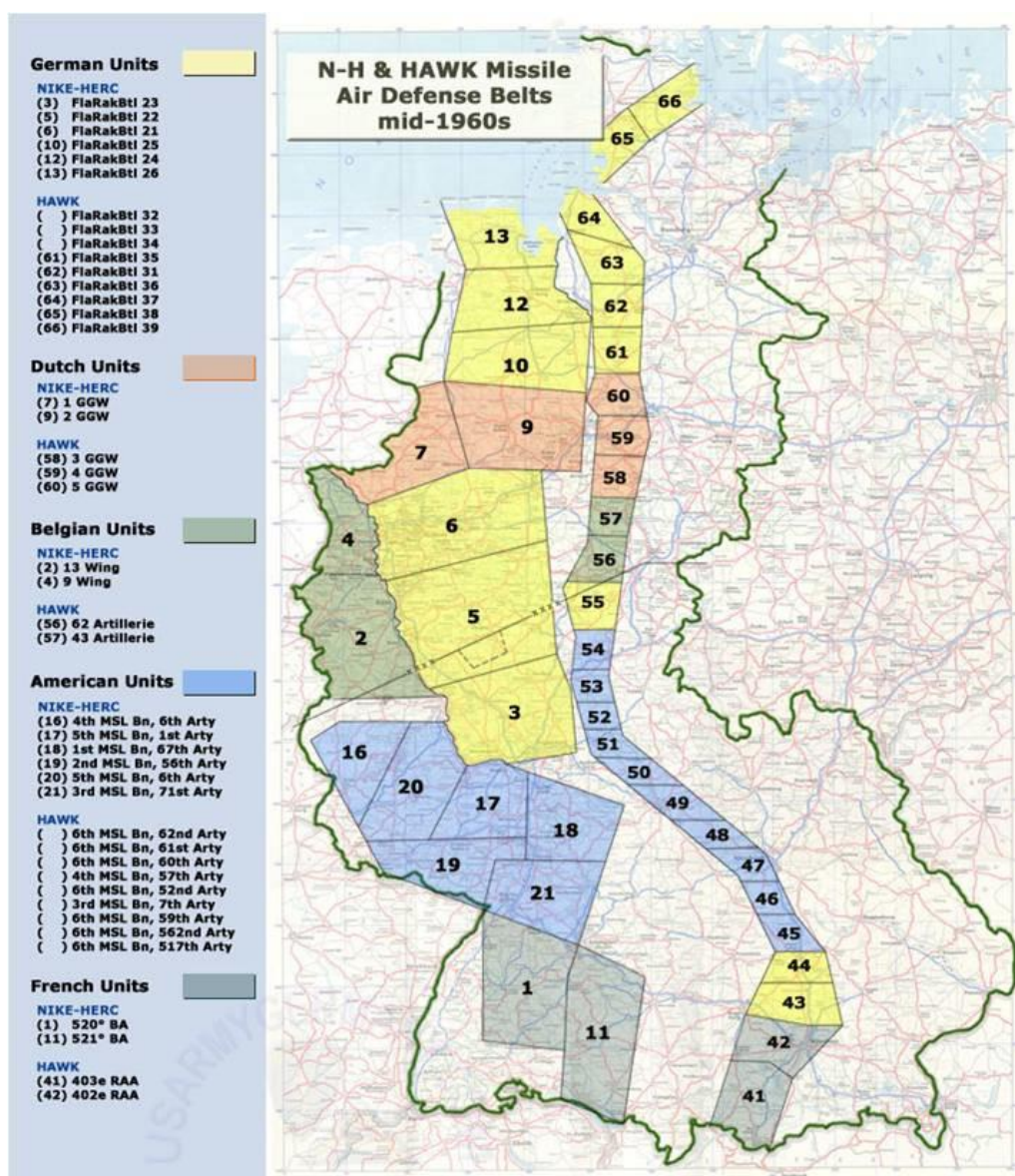


(picture: author's archive)

DOCTRINE, COMMAND & CONTROL AND TACTICAL OPERATIONS

Doctrine. Ground-based air defense doctrinally comes under one of the four roles of Air Power, namely Control of the Air. This means establishing (temporary, local or absolute) air superiority, so that one's own territory as well as own armed forces are not exposed to enemy air actions, and own offensive air actions in own and enemy airspace cannot be prevented by an opponent. Ground-based air defense, within Control of the Air, falls in the subcategory of Defensive Counter Air: the actions take place in own airspace defending against attacking air forces.

Ground-based air defense takes due regard of four principles and six guidelines. These principles and guidelines play a dominant role at the higher levels in preparing a defense against an opponent (defense design). NATO had opted for a double belt of guided missile units (NIKE and HAWK) along the border with the Warsaw Pact, in addition to an area more to the West where fighters were responsible for air defense. Short-range systems (SHORAD) were charged with local air defense.



The HAWK and NIKE missile belts in West Germany (HCGLVD)

The four principles are: **mass, mix, mobility and integration**. NATO adhered to these principles through the large number of deployed weapon systems (including NIKE, HAWK and SHORAD), a mix of weapon systems with complementary capabilities (in altitude, range, rate of fire, radar frequency range, ability to deal with electronic interference, etc.), the tactical mobility (not in the case of NIKE) and the integration and employment of the various weapon systems under central NATO command but with decentralized execution of operations ('centralized command, decentralized execution').

The six guidelines are: **mutual support, overlapping fires, balanced fires, weighed coverage, early engagement and defense in depth**. By positioning the systems in such a way that they covered each other's dead zones (mutual support) and so that the engagement zones overlapped (overlapping fires), an uninterrupted defense could be created, even if one system was (temporarily) not operational. Balanced fires guaranteed a defense in all directions. Because NIKE and HAWK had a 360° coverage, an opponent on the homeward flight could be intercepted again. Weighted coverage gave priority to air defense directed against an opponent from the east. Due to NIKE's long range, an opponent could be engaged while still far away (early engagement). The positioning in depth of multiple and diverse weapon systems in one's own airspace (defense in depth) made sure that an opponent had to survive several air defense systems before he could reach his target in the hinterland of the NATO area.

Command & Control. As described above, the mantra for air defense command was centralized command, decentralized operations. This was executed as follows. During the Cold War, (most) of NATO's member states had placed their air defenses under the direct authority of NATO. Thus, 12GGW was a NATO Assigned Force under Operational Command (OPCOM) of the Commander, Second Allied Tactical Air Force (COM2ATAF). Consequently, the Netherlands no longer had direct operational control over 12GGW. Only the logistical and administrative support was a Dutch responsibility, exercised by the Tactical Air Force Command. Readiness and operational duties were determined by a NATO commander. For 12GGW, the NATO command line (chain of command) ran from top to bottom as follows:

- Supreme Allied Commander Europe (SACEUR), executed from the Supreme Headquarters Allied Powers Europe (SHAPE) in Bergen/Mons, Belgium.
- Commander Allied Forces Central Europe (COMAFCENT) in Brunssum, the Netherlands.
- Commander Allied Air Forces Central Europe (COMAIRCENT) in Ramstein, Germany.
- Commander Second Allied Tactical Air Force (COM2ATAF) in Rheindahlen, Germany.
- Commander Air Defense Operations Center (COMADOC) in Maastricht, the Netherlands.
- Commander Sector Operations Center 2 (COMSOC2) in Uedem, Germany.
- Commander Control and Reporting Center (CRC) Uedem in Uedem (call sign 'CRABTREE'). From within the CRC, a SAM Allocator coordinated the actions of the air defense missile units in the CRC's sector.
- Commander 12GGW in Hesepe, Germany (with its Group Operation Center/GOC in Vörden).

In peacetime, the NATO command over 12GGW was delegated to COMSOC2 by SACEUR. In times of crisis and war, command could both be taken back by a higher NATO commander than COMSOC2, or delegated further to a lower level. If in wartime all connections with higher echelons were lost, the BCO assumed the authority to identify and engage hostile targets. At least in theory, the BCO always had the final say on engagements; the NATO manuals were very clear on this: 'The BCO has the final responsibility to ensure that no-friendly aircraft are mistakenly engaged'

Alert States. The preparedness and employment of NATO's air defense was first and foremost a result of the Alert State as declared by NATO. The higher the declared Alert State, the higher the preparedness of the air defenses. Furthermore, the declaration of certain Alert States automatically led to the entry into force of important measures for air defense, e.g. the activation of the NATO identification procedures. In addition to Alert States, NATO could announce partial measures e.g. authorizing the use by air defense units of ECCM (Electronic Counter Counter Measures: measures to minimize the effectiveness of enemy electronic interference).

In addition to the formal Alert States that had to be declared at the political level by the North Atlantic Council (NAC), a system of alert measures that could be activated by NATO military commanders in the event of a (possible) surprise attack was available.

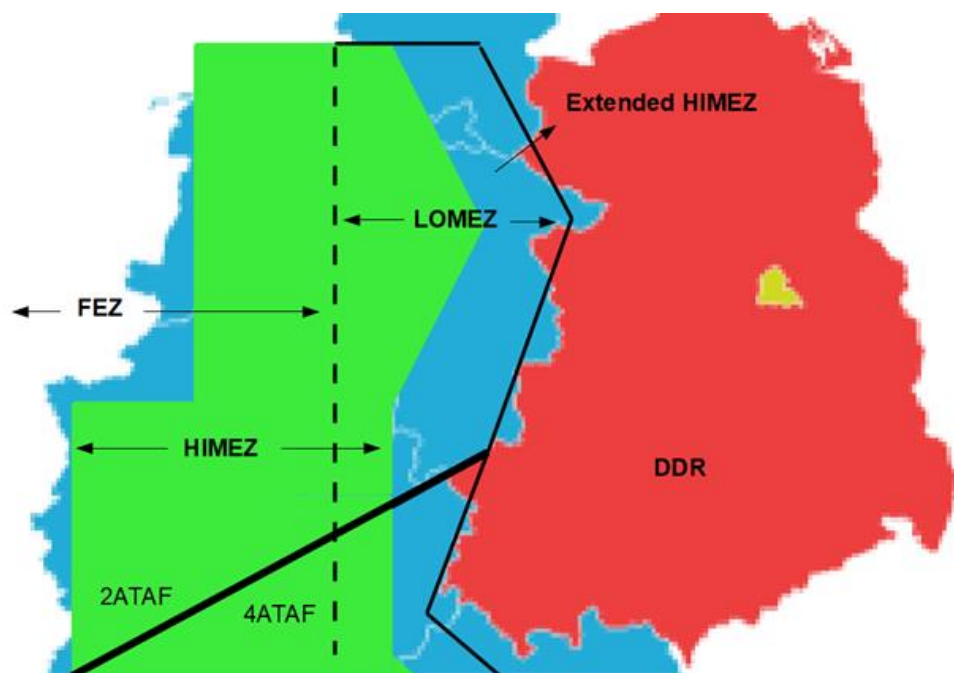
STO. The NATO commander possessed of a number of options to direct the employment of the air defense. He ordered the employment by issuing a SAM Tactical Order (STO)⁵. The STO was issued at midnight, updates were unlimited in number, depending on changes in the tactical situation etc. If the communications with the higher echelon were lost, the highest level with which contact still existed issued a new STO.

The STO stated among other things:

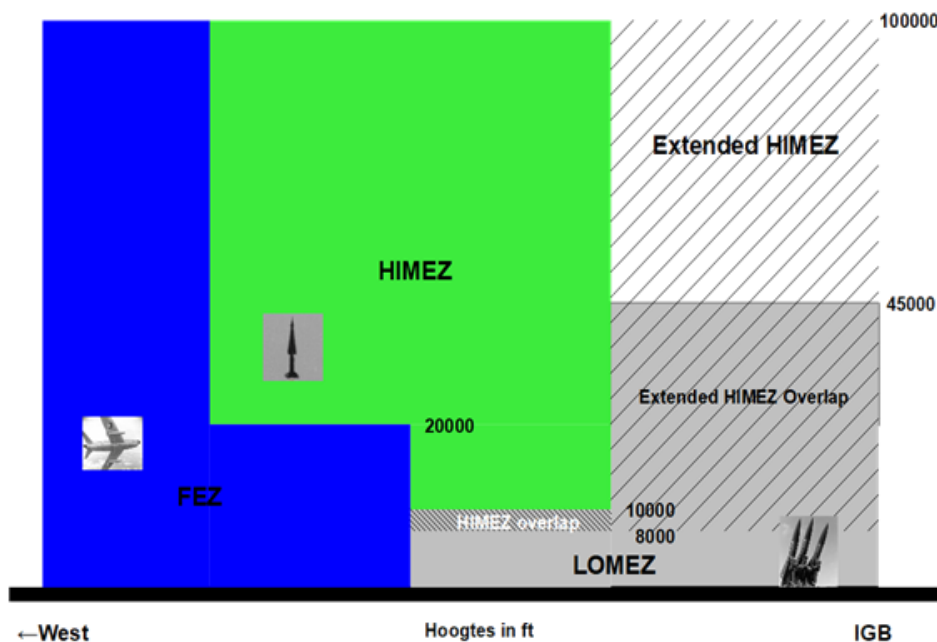
- The **Identification and Engagement Authority** (IA/EA): the NATO commander who was authorized to identify targets as 'hostile' and to order their engagement. During crises, the level would be as high as possible to prevent further escalation of the conflict to the maximum extent. When hostilities had broken out and the air war assumed such an intensity that the overview at higher level was lost, IA/EA could be delegated, even to the level of BCO. When engagements were only allowed on order of the higher commander, this was named Centralized Operations. When the higher commander only monitored the air war and intervened only by exception, this was called Decentralized Operations. When a NIKE squadron executed operations without communications to a higher commander, this was named Autonomous Operations.
- The **Readiness State** (preparedness) of the air defense (expressed in minutes or hours, or Battle Stations: immediate readiness for engagements).

⁵ Later SAM/SHORAD Tactical Order: SAM = Surface-to-Air Missile, including NIKE; SHORAD = Short Range Air Defense, including gun systems.

- The **Weapon Control Order (WCO)**: with Weapons Hold, only engagements at the higher echelon's order were allowed. With Weapons Tight, any targets identified as hostile could be engaged. Engagement of a target in self-defense was always allowed.
- The **Weapon Engagement Zone (WEZ)**. NATO airspace was divided into a number of zones. From east to west these were:
 - The **Low Missile Engagement Zone (LOMEZ)**. Air defense systems such as the HAWK operated here with the aim of engaging low-flying targets. The LOMEZ ran from ground level to an altitude of 45,000 ft, except where the LOMEZ was overlapped by the HIMEZ; here the upper limit was 10,000 ft.
 - The **High Missile Engagement Zone (HIMEZ)**. This was the part of the airspace in which the NIKE systems operated. The altitude bracket ran from 20,000 ft to 100,000 ft, except where the LOMEZ was overlapped; here the lower limit was 8000 ft. The HIMEZ could be extended further eastwards, especially for the deployment of nuclear warheads. This was the Extended HIMEZ.
 - The **Fighter Engagement Zone (FEZ)**. In this part of the NATO airspace, fighter aircraft were responsible for intercepting enemy aircraft. The FEZ was West of and partly below the HIMEZ.
 - **Short Range Air Defense Zones (SHORADEZ)**; here, short-range weapon systems were responsible for air defense (e.g. defending an air base or part of a land maneuver unit). A SHORADEZ could be embedded in both the FEZ, HIMEZ or LOMEZ.



Schematic overview of FEZ, HIMEZ and LOMEZ in N-Germany (author)



Vertical cross-section of FEZ, HIMEZ and LOMEZ (author)

The authority issuing the STO determined whether and which Engagement Zones were activated and decided on any modifications in height, horizontal dimensions etc.

- The **Warhead Control Order** (WHCO) for NIKE. The default WHCO was 'Case III': only the use of conventional warheads was allowed. During the war's escalation, Case I and/or Case II could be declared. Under Case I, the employment of nuclear warheads above the Minimum (Normal) Burst Altitude (MBA) was allowed, under Case II nuclear detonations below MBA were allowed. Under Case II the MBA switch had to be placed in the 'override' position. Case II was no longer in use since the late '70s. Normally, under Case I additional restrictions were declared in the STO. A WHCO in the STO could read like: 'Case I in JH and KH East (geographical restriction in GEOREF boxes), between 12:00 and 12:30Z (time limitation), above FL300 (altitude limitation: above Flight Level 300 = 30000 ft/± 9100 m), westbound aircraft only (heading restriction), target speed above 500kts (speed restriction: 500 knots = over 900 km/h), multiple targets only (only engagements on formations of two or more aircraft allowed), Case III in remainder'.
- The **Air Raid Warning** (ARW). The NATO commander indicated which air threat was applicable: ARW White meant no air threat, ARW Yellow meant air attacks possible, ARW Red meant air attacks in progress'.

The BCO noted the STO on a display in front of him and would plot Case I and/or II areas on the horizontal plotting board. Flight Levels vary in altitude above sea level with the current air pressure in the atmosphere; for the actual altitude, they had to be corrected using 'D-values'. This was the only meteorological information needed for the NIKE weapon system and this was provided by the SOC/CRC.

ROE (Rules of Engagement). In peacetime and until the announcement of certain Alert

States, the Tri-MNC's ROEs (the Rules of Engagement of the three Major NATO Commanders [i.e. SACEUR, SACLANC and CINCCAN]) were in force. These ROEs meant that targets could only be engaged in self-defense or on the specific order of the NATO commander who held the Engagement Authority. Self-defense was defined as an aircraft actually attacking the squadron or demonstrating clear intentions to do so. Because aircraft could not be engaged by NIKE at such short distances and low altitude, self-defense for NIKE was only a hypothetical option. After Cancellation of Tri-MNC's ROEs, targets could be engaged in accordance with the stipulations in the STO.

Airspace Control. Aircraft with an offensive task (support of ground troops, attacks in the hinterland of the opponent), reconnaissance aircraft and helicopters had to fly through the HIMEZ and LOMEZ to carry out their duties. Of course it was very important that these aircraft and helicopters were not fired upon by NATO's own air defense. In order to prevent these blue-on-blue engagements, procedures were established known as Airspace Control (ASC). The ASC measures came into effect automatically with the announcement of certain NATO Alert States.

Most important measure was the use of IFF. All NATO aircraft were deemed to be equipped with IFF. When a potential target was interrogated by, for example, a NIKE unit and the target was a NATO aircraft, then the aircraft gave a positive response which was visible on the PPI, provided NIKE unit and aircraft had installed the same code. Because the IFF mode 1 and 3 codes changed every half hour, great care was required from both parties to set the correct code. IFF Mode 4 was a crypto-mode that remained in force for 24 hours, but not all NATO air forces were equipped with IFF mode 4.

As a back-up, in case e.g. the aircraft's IFF was defective, there was a procedural way of identification. This consisted of a system of airways. As long as an aircraft flew within an established airway, on the basis of this 'track behavior' it had to be regarded as a friendly aircraft, even if no positive IFF response could be obtained. Every eight hours a new airway system was announced through an Airspace Coordination Order (ACO). The ACO was drawn on a plexiglass plate that was attached in front of the horizontal plotting board. LED lights on the plot pins enabled correlation of the position of the tracked target with the ACO.

Target assignment and selection. The NIKE system was equipped with an Automatic Data Link (ADL). During Centralized and Decentralized Operations, using ADL the higher echelon (e.g. the CRC) could assign a target electronically to a NIKE unit. The BCO was alerted to the target allocation by a buzzer, at the same time a combination of illuminated lights indicated what the assignment was (search, track, engage, cease fire, hold fire) and a symbol on the PPI indicated the target position. The ADL assignment could be augmented by voice with, for example, the target altitude or the NATO track number. Once the TTR locked on the assigned target, the ADL passed the target position electronically to the higher echelons. The fire command and the mission result were also reported to the higher echelon through ADL. Voice traffic was only possible with the GOC; it was not possible to talk to the CRC directly from the BCT. The voice traffic between BCT and GOC took place via the hotloop: a conference circuit in which the GOC and the BCTs of the four squadrons were connected.

During Decentralized and Autonomous Operations the BCO selected the targets. Usually,

more than one target were simultaneously eligible for engagement, so there were rules for prioritizing targets. First of all, a fixed part of the HIMEZ was assigned to 12GGW, outside of which other NIKE units were responsible for the air defense. There was an overlap area between 12GGW's area and those of the neighbors, but engagements here could only take place under the supervision of the CRC. Within 12GGW's area of responsibility, the four squadrons had their own sector: their Primary Target Area/PTA. These sectors overlapped, but the GOC coordinated the engagements by hotloop and ADL so to prevent two squadrons engaging the same target. If the connection between GOC and a squadron was interrupted, the squadron only engaged targets within its own PTA. The priority was then on the target, within the PTA, flying from East to West, which would first pass the imaginary North-South line through the squadron. Targets that caused serious electronic interference to HIPAR or LOPAR had the highest priority because those were likely masking approaching formations of enemy aircraft.

Fire Control Orders (FCO). For minute-to-minute control of a NIKE unit, and in the event of failure of the ADL, voice FCOs between squadron and GOC were used. Used FCOs were:

- **Search:** a GOC order to track a target. For example: "A (callsign for 118 Sq), search MH234 (NATO track number), KH2030 (position in GEOREF coordinates), Northwest (heading), angels 15 (altitude in 1000 ft), speed 500 (speed in knots)".
- **Engage:** GOC order to engage a target ("A, engage MH234").
- **Cease Fire:** GOC order to continue to track a target but not (further) to engage it. If a missile had been fired on this target already, the engagement could be completed but no re-engagement in case of a miss was permitted. ("A, cease fire MH234").
- **Hold Fire:** GOC order to immediately interrupt an engagement (by a Command Destruct on a missile in flight) and to break the lock on the target. ("A, hold fire MH234").

The BCO reported back to the GOC with:

- **Lock-on report :** "A locked on MH234, Northwest, KH1025, angels 15, speed 500".
- **Engage report:** "A engaged MH234".
- **Mission Result report :** "A effective MH234".

SAMSTATREP. The higher echelon had to keep an overview of the status of all units. To this end, the NIKE units sent a SAM Status Report (SAMSTATREP) via the GOC to the SOC once a day and after each change in (equipment) status. The SAMSTATREP reported the status of the squadron, any defective equipment, the expected time the squadron would again assume its assigned status and the number of remaining missiles.

KILLSUM. Periodically, the squadron had to report all successful engagements to the GOC by means of a Kill Summary (KILLSUM). The report mentioned the time and location of the engagements. It was the computer operator's task to fill in the KILLSUM. The GOC compiled the squadron KILLSUMs and submitted them to the CRC, so that the NATO commanders were informed about the enemy losses.

Jamming report. When electronic or mechanical interference was encountered, this had to

be reported to the higher echelon. In this 'Jamming Report', the direction of the jamming or the position of the jamming aircraft, the frequency band on which the jamming was experienced, the nature of the jamming ('music' was electronic jamming, 'stream' was mechanical jamming i.e. chaff, and the severity of the jamming (with 'grade three' being the heaviest form in which operations were hardly possible).



LCT

(picture: Ramiro Ballola)



BCO Control Console: upper left the ADL push buttons and lights, center top various dials, lower left firing switch, command burst switch, MBA-override switch and friend switch, lower center and right-hand side Computer Operator's Panel

(picture: Ramiro Ballola)

EXERCISES AND EVALUATIONS

The threat during the Cold War and its high readiness requirements demanded a high degree of training and availability of the equipment. That is why there was an extensive repertoire of exercises and evaluations to train and evaluate personnel. The number of exercises and their character was prescribed in the Annual Exercise Program (JOP).

Crew drill. The most frequent form of exercise was the crew drill. This was initiated by the BCO at least once per duty when the squadron was in the highest peacetime readiness (for NIKE this was 30 minutes). The aim was to achieve a ready-to-fire status within the time limit of the readiness status, whilst carefully carrying out all prescribed procedures. The crew drill started with the BCO's announcement of 'Blazing Skies', switching the Battery Status Indicator to 'blue status' and the sounding of the siren. In the IFC and LA, the crew rushed to their action stations and reported themselves present. As soon as all were present, the BCO announced the mission: 'BCO to all stations, Blazing Skies, Case III, Surface-to-Air, BHE'. All crew members performed their part of the crew drill. The IFC equipment was adjusted, if necessary with the help of the '226' mechanics. In the LA, launchers and missiles were prepared for use, except for the connection of the booster ignition cable.

Meanwhile, the BCO held a time check and a line check with the GOC and inquired about the presence of 'Zombies' (civilian airplanes within the NATO airspace belonging to one of the Warsaw-Pact countries, which were suspected of electronic espionage and therefore should not be tracked by our radars). As soon as all posts reported 'ready for action', the BCO ordered 'prepare to engage, red status'. When the MTR had a lock on the selected missile, the crew drill was complete. The exercise continued with some further practices e.g. Emergency Procedures, or the system was switched to 'yellow status' for system checks. When everything was satisfactory, the equipment was returned to 'white status' and the ordered peacetime readiness.



Crew drill under the Section Chief's supervision

(picture: NIMH)

State of Alert test and Operational Readiness Evaluation. The GOC or a higher echelon could order State of Readiness tests which were intended to establish whether a squadron was able to comply with its ordered peacetime readiness. A State of Alert test could be evaluated, but if so only crucial errors were taken into account. NATO-wide, the unannounced alerting exercise 'Active Edge' was held at least once a year, not only for air defense units.

An interesting exercise was the simulated interception of an SR-71 'Blackbird'. The US Air Force regularly stationed such an aircraft in the UK and periodically conducted a reconnaissance flight along the Inner German Border (IGB, the 'Iron Curtain'). 'CRABTREE' (the CRC) could alert the 'hot' squadron in anticipation of the flight. The SR-71 took off, was refueled over the North Sea and then continued its mission along the IGB from North to South and when over Southern Germany returned to the home base. With a timely target allocation, a lock on the SR-71 approximately above Hamburg was achievable. The computer displayed a target speed of 1600 knots (almost 3000 km/h) at an altitude of 80,000 ft (almost 25 km)! The PKP would be in the vicinity of Kassel, i.e. the computer indicated a lead angle for the missile of around 90 degrees. At such speed, no violent maneuvering of the target was possible, so the SR-71 was easy to track by the TTR.

An Operational Readiness Evaluation (ORE) was ordered by the Commander 12GGW and conducted by his ORE team. It consisted of a crew drill followed by system checks, all rigorously evaluated for compliance with established drills and regulations. An ORE resulted in a combined rating: OPS or NONOPS concerning the technical condition of the system and achieving a Ready-to-Fire status within the time constraints of the ordered readiness; Excellent, Satisfactory, Marginal or Unsatisfactory concerning crew performance (i.e. compliance with procedures). Periodically, an SS-ORE would be held: this started with the receipt of an encoded SS order approximately one and a half hours before the intended execution of the mission. This ORE assessed the decoding of the mission order and the correctness of the calculations, as well as the (simulated) preparation (together with US personnel) of a nuclear missile for a SS mission.

T1 training. Each fire control crew had to be subjected to training with the T1 regularly: engaging targets under conditions of severe electronic interference (jamming). A T1 training period was concluded with a number of evaluated scenarios in which the score Excellent, Satisfactory, Marginal or Unsatisfactory could be achieved.

Electronic interference is basically either in the form of 'brute force jamming' or 'deception jamming'. In the first form, the opponent tries to drown out the target's radar reflection by masking it with 'noise' or other pulse shapes and thereby becoming 'invisible'. Because the target now emits a strong signal to the radar, it betrays its position in azimuth and elevation (where the signal is strongest). Through certain anti-jamming circuits, the target's azimuth can be visualized on the PPI in azimuth (jam strobe) and the BCO will instruct the TTR to search for the target in this azimuth ('jam strobe procedures'). The target's range can be obtained by the (fast) changing of the TTR's frequency or by using the TRR with its specialized anti-jamming capabilities, enabling the target to be tracked.

With 'deception jamming', the opponent attempts to mislead the BCO by creating false target echoes on the PPI and/or by forcing a 'break-lock' with the TTR or TRR, for example

by using a 'range gate stealer'. Detecting and countering deception jamming requires a lot of training, and by using the anti-jamming circuits, an experienced crew was able to counter this jamming. Because elevation and/or range operators often were conscripts with a limited operational 'shelf life', there was a continuous need for training.

Mechanical jamming using 'chaff' (metallized strips or wires, fired or dropped by the aircraft, reflecting radar energy) was intended to mask the target or force a 'break lock' by creating a target with a larger RCS than the real target. However, chaff is (almost) stationary in the air and is therefore easy to detect as a deception.

Nuclear inspections. Every year, the US authorities examined the facilities, protection, assembly and operations associated with nuclear warheads. Not only US personnel was evaluated, Dutch assembly personnel, launching crew and security personnel were subjected to these inspections as well. An unsatisfactory result would have led to decertification of the unit as being nuclear capable, which would certainly be frowned upon at the RNLAH Headquarters and ministerial level.

Group alert and TACEVAL Phase 1. A Group alert was issued for the whole unit i.e. 12GGW as a whole. It intended to practice the transition from peacetime to crisis and war conditions. For the operational duty crew, the priority was to achieve a ready-to-fire status as quickly as possible. In addition, it was necessary to call back staff on leave, to tighten the security measures, to camouflage the equipment, to set up command posts, to distribute weapons and ammunition, etc. etc.

On SACEUR's orders, COMAIRCEN was responsible for the Tactical Evaluation (TACEVAL) program. This program intended to give SACEUR insight into the preparedness and quality of the (air defense) units that had been placed under his command. A TACEVAL consisted of two parts: a no-notice Phase 1 and a scheduled Phase 2. For a Phase 1, a team of NATO evaluators 'raided' all 12GGW locations simultaneously and evaluated whether the squadrons were ready for action within the time specified by their peacetime status. E.g., the 'hot squadron', with a peacetime readiness of 30 minutes, should report 'at Blazing Skies' within that timeframe with an operational system. The team also evaluated the measures that had to be taken as described in the Group Alert.

Tactical exercises. Every Friday morning the tactical exercise 'Scholarship' was held for the four 12GGW squadrons, led by the GOC. A full war was fought over a period of three hours. Often one of the squadrons was evaluated by the staff of 12GGW. On Tuesday afternoons the exercise 'Good Afternoon' was conducted with the hot squadron, and on Wednesday's and Thursday's the exercise 'Cover Girl' was held with all available squadrons. These were good opportunities to train and assess 'On-the-job' trainees.

During tactical exercises, especially in complex scenarios or while conducting nuclear engagements, the BCO surely could use some assistance. This was provided by the Commander, Operations Flight or the most experienced BCO, who took up position behind the BCO's back, looked over his shoulder and assisted in the identification and selection of targets - especially when Case I was in force. He also maintained contact with the GOC for the reception of STOs and the reporting of SAMSTATREPs, so that the BCO could keep his full attention to his primary duties. The LCO was supported in a similar way by the

Senior Launching Area CWO.

Group exercises and TACEVAL Phase 2. Group exercises followed a scenario of a crisis building up to and including full scale nuclear warfare, all in a period of a few days. The main focal points were Operations, Support (technical and logistical support) and Survival-to-Operate (STO: surviving and continuing to fight after enemy actions such as air strikes, attacks with chemical and nuclear weapons, ground attacks, treatment of the wounded, dealing with (unexploded) explosives, extinguishing fires, repairing damage, etc. Group exercises were usually evaluated by the Air Force Staff, supplemented with evaluators from other (foreign) NIKE units.

A standard scenario was based on a rapidly increasing tension between NATO and Warsaw Pact, resulting in the swift declaration of ever higher Alert States. Soon hostilities broke out and air defense was conducted in Centralized Operations under the tactical command of the SOC or CRC. Soon, the air situation would become too complex for Centralized Operations and Decentralized Operations were ordered. In the meantime, numerous simulated incidents took place on and around the squadron: espionage, subversion, demonstrations, ground attacks by special forces, air strikes, casualties, fire, damage to equipment and ultimately chemical or nuclear contamination. During the main part of the exercise, personnel was dressed in NBC⁶-protective clothing. After NBC attacks, the gas mask often had to be worn for a prolonged period of time (several consecutive hours).

During all these incidents, the intention was to continue to provide air defense for as long as possible. This meant shifting personnel in case of casualties, or conducting 'battle damage repair' to return a non-operational system back to a (limited) operational condition. E.g. if the data cable between RCT and TTR was damaged, the same cable between RCT and TRR could replace this damaged cable. Although the squadron was now more vulnerable to electronic warfare, it could still continue to provide air defense. At a higher level, the Group Staff was sometimes challenged to reconstruct an operational unit out of two or more non-operational squadrons.

Air strikes (often live and spectacular) were a realistic opportunity to interrupt the connections with higher echelons so that the squadron had to revert to Autonomous Operations. The evaluators would now pay even more attention to the correct identification procedures: the engagement of two or more 'own' aircraft irrevocably led to an unsatisfactory result for the squadron. A number of 150 interceptions per squadron during an exercise was not uncommon. This of course went far beyond the number of available missiles; the squadron would receive an 'unlimited reload' of missiles from the evaluators.

In every scenario the moment would come when NATO felt compelled to use nuclear weapons itself. The employment of nuclear warheads, either against air or ground targets, was of particular interest to the evaluators. Here too, there was absolutely no room for mistakes. A classic scenario was the interruption of communications with the higher echelon just after the receipt of a nuclear release and a STO that dictated Case I. It was now up to the BCO, a young lieutenant, to decide autonomously on the employment of nuclear weapons against air targets. The BCO, feigning a degree of nonchalance, would try to positively influence the squadron's score by successfully and flawlessly firing off all released nuclear

⁶ NBC = Nuclear, Biological and Chemical

missiles in front of the multiple evaluators. In the case of SS missions, the BCO's responsibility was more limited: without the higher echelon's explicit order ('execution order'), it could not be executed.

The scenario usually ended with full nuclear warfare and often literally with a big bang: a simulated attack would result in so many casualties and destroyed equipment that further operations were impossible. As a bolt out of the blue, a cease-fire between NATO and Warsaw-Pact was announced which ended the exercise.

In a TACEVAL Phase 2, the same scenario took place within a time frame of approx. 44 hours, but it was evaluated by the NATO TACEVAL team supplemented by specialists appointed by NATO from foreign (NIKE) units. For the fire control crews, end-of-exercise meant that an evaluated T1 run (missions under jamming conditions) still had to be performed. Two fire control crews from each squadron proceeded to the squadron where the T1 was located. Each crew was subjected to a scenario in which nine enemy targets had to be engaged under severe jamming conditions. The scenario was aggravated by the presence of friendly aircraft or jamming aircraft that remained out of range. Each crew could score a maximum of 1000 points, while 100 points were lost for each target not engaged. The scores of the two crews of one squadron were averaged and counted for the squadron result. The results of the Phase 2 were combined with those of the Phase 1 and presented as an integrated assessment. The final score gave a score (1 = Excellent, 4 = Unsatisfactory) for both Overall (facilities) and Performance (human performance), in the categories Alert Procedures & Readiness (mainly the result of Phase 1), Operations, Support and STO. Of course, there was a lot of competition between the squadrons for highest scores. 12GGW's results usually were 'above average'. The TACEVAL was one of the two annual operational highlights in a squadron.

ASP. The second annual highlight was the Annual Service Practice (ASP). For an ASP, part of the squadron traveled to the NATO Missile Firing Installation (NAMFI) on Crete. Here, a NIKE system and two missiles had to be assembled and prepared for a live-firing. During the preparation of the system, much attention was paid to strictly following the Technical Manuals (TM); every small deviation was penalized with the deduction of points. As a result, the ASP was more an exercise in accurately reading the TM instead of a tactical exercise. On the firing day, two fire control crews were subjected to a simple tactical scenario, but under severe jamming conditions, during which one crew (later both crews) fired a missile on a target simulated by the T1. For all concerned, there was great satisfaction when the system proved to be working 'as advertised', but especially for the Section Chief and the Unit Launching Area Safety Officer (ULASO) it was quite a relief when the missile did indeed lift off.

During the live-firing(s), all personnel and other interested parties needed to be under cover (i.e. under a concrete roof). Sometimes, a live-firing resulted in a fail-safe burst after booster separation right over the LA, after which metal fragments and lumps of toxic, solid fuel rained on the LA.

After the firing(s), the score (on a scale of 0-100%) was announced. For Dutch NIKE squadrons, a score below 95% was slightly disappointing. A good score contributed, but was certainly not a precondition, to an exuberant missile away party in Chania. A nice tradition

had the headgear of one of the visiting military dignitaries being ‘borrowed’ by the crew and put under the booster before the firing. The remains of his headgear, if recovered, was then presented to the victim during the missile away party. Navy officers with their white caps were popular targets, but some of them could not really appreciate this tradition.



*The author launches the penultimate Dutch NIKE, the very last missile is ready on the right.
(picture: author's archive)*

TRAINING AND MAINTENANCE

Education. Fire control and launching personnel received their initial training at the Air Force Electronics and Technical School (LETS) in Schaarsbergen near Arnhem, the Netherlands. Because the LETS had little or no fire control and launching equipment available, the training was mainly theoretical in nature. After graduating, the students were seconded to 12GGW for their practical training: the On-the-Job Training (OJT). Now the real tricks of the trade were taught by the OJT tutor. All exercises and activities had to be carefully recorded by the student in his OJT task book. The OJT tutor rated the activities and the student's progress. An OJT supervisor was responsible for quality control.

When the OJT tutor was of the opinion that the student's progress was sufficient to warrant his independent operations, a practical exam was taken. After a positive result, the student was posted to one of the squadrons and joined a crew. Posting also meant (except for conscripts) the eligibility for an allowance for being posted abroad, the granting of the NATO Status (which gave immunity to prosecution by the German judiciary but also access to the allies' duty-free shops), the right to family reunification, the right to duty-free purchase of alcohol, cigarettes, a car and durable goods (household goods etc.) and the granting of a monthly ration of coupons for duty-free fuel.

Maintenance. Maintenance of the NIKE system was a joint responsibility of crew and technicians. Technicians were not part of a specific crew (they worked according to their own duty roster), but whenever there was a crew on duty there always was also a '226' (radar mechanic) present. The launching technicians ('225's') were in principle only present during office hours.

The maintenance was based on the calendar and divided into daily, weekly, monthly, quarterly, annual and bi-annual maintenance. Maintenance was prescribed in the various Technical Manuals, the TMs. For example, during the weekly maintenance the complete alignment procedure (LOCOS) between MTR, TTR and TRR had to be carried out, to be completed with a Simultaneous Tracking test. The higher the level of the maintenance, the more it was the mechanics' responsibility and less that of the crew, and vice versa. In spite of this, almost all maintenance was performed in close cooperation between crew and mechanics. Specialized assistance was available at Group Headquarters or the Air Force Electronic Equipment Depot (DELM) level for annual and bi-annual maintenance.

Defective parts that could not be repaired quickly on site were replaced by new or refurbished parts (repair by replacement). Defective parts were returned to the Group Headquarters and repaired there, sent to the DELM in Rhenen (Netherlands) or to the NATO Maintenance and Supply Center in Capellen, Luxembourg.

The missiles had to be checked periodically as well. The assembly technicians would disassemble the missiles into main groups, check and replace parts where necessary, and mount missile and booster again on the launching handling rail. For safety reasons, the (dis)assembly of the warhead, rocket engine and booster took place in the Warhead Building, which was surrounded by an earthen berm. Nuclear warheads were (dis)assembled here as well, of course under the strict supervision of US personnel and rigorously checked for compliance with TM's and safety standards.



*Maintenance on the guidance section
(picture: NIMH)*



*Transport of a missile to or from
the Assembly (picture: NIMH)*

During crew drills, exercises etc., sometimes the equipment would fail. Corrective actions according to the TM might take too long. An experienced mechanic (or operator) often knew a trick not described in any TM to get the system up and running again. The most extreme form of this was a 'hammer adjustment': a well-dosed and placed bang against the equipment that usually achieved its desired effect.

Although the NIKE Hercules system possessed of advanced technology for its time, fortunately in practice it proved possible to keep the system up and running with simple tools and by the mechanics' thorough expertise. It was not uncommon for an equipment failure to be solved on the spot by old-fashioned soldering work or even by unorthodox repair methods using duct tape, paper clips or other improvised means. A NIKE mechanic was supposed to be able to do more than just 'change parts'!



*Checking a launcher. In the background the entrance
to the Section bunker (picture: NIMH)*

STATUS AND CREW LIFE

Status. Life on a NIKE squadron was largely determined by the readiness ordered by NATO: the status. The status was the maximum time available to present a ready-to-fire system after an alert. The NIKE system used four statuses :

- 30 minutes status (hot status). Until 1972 the hot status was five minutes and later was downgraded to 15 minutes, but NATO apparently had enough warning time so that a 30 minute readiness was deemed sufficient in later years.
- 3 hours. This was the backup for the squadron on hot status. The 3-hour squadron took over the status of the hot squadron every week when it carried out the weekly checks.
- 12 hours.
- 12 hours Restricted (12R). In this status, the squadron carried out the monthly maintenance and in principle was not ordered up to a higher status.

NATO required each NIKE group to have a hot status squadron available at all times. The group itself could determine the distribution of the statuses over the squadrons, but NATO had to be informed. When a squadron, and in particular the hot status squadron, could not meet its assigned status, everything was done to restore its status. This meant continuous corrective maintenance, even during the night or weekend until the equipment met requirements again. If the status still could not be restored within a reasonable amount of time, the GOC would order another squadron to take over the status of the non-ops squadron. The GOC itself was on a permanent hot status and, moreover, it was required to decrypt and pass on an incoming encrypted NATO alarm message in a matter of minutes.

Crew duty. Every squadron had three crews. There were no facilities for sleeping and showering on the squadrons. That is why the crews had a continuous schedule consisting of day, evening and night shifts. In combination with the four statuses, this resulted in a 12-week cycle crew duty roster.

In the 30-minute squadron, the day, evening and night shifts were on-site during the weekdays. The BCO had to remain at the IFC and could not visit the launching area part of his crew.

At the 3-hour squadron, the day and evening shifts were on-site. The night shift crew was confined at home or at the barracks, ready to take over the hot status within 3 hours when required.

At the 12-hour and 12R squadron, the day and evening shift were on-site. The evening shift was consigned for duty during the night hours when necessary. The night shift itself performed duties during daytime hours and was then available for courses, military refresher training, other necessary services or could take up leave. The 12R squadron's night shift was on 'crew leave' as compensation for the continuous services.

During the summer holidays a two-crew roster was used to give personnel the opportunity to go on holidays with their families. In each calendar year, a crew was scheduled for duty either during Easter, Christmas or New Year's Eve. These duties rotated amongst the crews

yearly.

Over the weekend (Fridays 13h30 to Mondays 17h00), the weekend schedule was in effect. The hot status was then divided over three squadrons: the previous week's night shift crew of the hot status squadron took care of the evening shifts, the night shift crew of the 3-hour squadron performed the night shift duties and the night shift crew of the 12-hour squadron performed the day shifts. The night service crew of the 12R squadron was confined at home or at the barracks. This meant that the hot status changed amongst the squadrons three times a day. The crew had to report for duty one hour before the scheduled status takeover to check the equipment. Only when the hot status was taken over by the next squadron, the former crew was released from duties.

Sometimes, the outgoing crew had to remain on duty longer than scheduled, waiting for the next squadron to report at hot status. If there were no prospects that the hot status could be taken over in the immediate future, the entire upcoming crew traveled by bus to the squadron that still maintained hot status. Because of the distances between the squadrons, this involved a journey of up to an hour and a half. Arriving at the other squadron, keys, crypto material, vault codes etc. had to be transferred before the outgoing crew finally - and slightly unhappily - could go home. Meanwhile, the non-operational squadron was working hard to get the equipment operational again. For that, extra personnel had to be recalled from home, as the complete crew including the mechanic had traveled to the other squadron. An interesting situation occurred when the conventional 223 Sq had to take over the hot status on a nuclear squadron.

The weekend's duties were followed by an extended free weekend (Thursdays 13h30 to Mondays 17h00), the weekend thereafter was a regular free weekend (Fridays 13h30 to Mondays 23h00).

When, between 1984 and 1987, 12GGW was composed of just two squadrons, a different weekend schedule was in force. The night shift crew of the hot status squadron continued its night shifts during the weekend (from 19h00 to 08h00) and the night shift crew of the other squadron took care of the day shifts between 07h00 to 20h00.

As the GOC did not have sufficient officers for a full-time roster, other qualified (staff) personnel was required to perform GOC duty. The BCOs of the four squadrons participated in this roster. A few times a year, the BCO then had to spend an evening/night shift at the GOC.

Additional duties. In addition to the assigned primary job, fire control and launching personnel had various additional duties.

- **General tasks.** All personnel were required for firefighting, casualty care, security duties etc. during exercises. The annual military training program ensured the required theoretical knowledge and practical skills for these tasks.
- **AF.** The duty crew at a nuclear squadron was appointed to act as Augmentation Force (AF) if necessary, even when it was consigned at home or at the barracks during night or weekend shifts. The normal guarding of the inner ring (with the

nuclear Alpha and Bravo Sections) was in the capable hands of the Air Force Security Forces (LB). If required, the LB platoon formed a Security Alert Team (SAT) and a Backup Alert Force (BAF) to deal with irregularities and sent them to the inner ring. Should the situation warrant so, the AF was alerted. The (US) requirement was that the AF was ready for action within 30 minutes after alerting, consisting of at least 30 soldiers, equipped with the necessary weapons, ammunition and other equipment. When the crew was on-site, this posed no problem. But if the crew was confined at home or at the barracks, this meant a race against the clock to meet the timeline. It also implicated that the duty crew, irrespective of the squadron's operational status, was on a 30-minute readiness and needed to be available immediately. Thus, no Saturday shopping with the wife: for some, one of the more positive aspects of an AF-consignment. An AF alert was conducted at least once a month.

- **40L70.** The launching personnel in their secondary job acted as gunners with the Short Range Air Defense (SHORAD) Bofors 40L70 guns during exercises and actual operations. Each NIKE squadron had two SHORAD sections for local air defense. Each section had a Flycatcher radar and fire control center, each linked to three 40L70 guns. The Flycatchers were manned by dedicated fire controllers, but there were no gunners. During their crew duties, the launching personnel had to practice with the guns (emplacing and aligning the guns, reloading, maintenance, etc.). An annual live-firing for SHORAD was conducted on the North Sea coast.



Launching personnel manning the Bofors 40L70 air defence gun (picture: NIMH)

- **Command post duties.** The fire control personnel were tasked for command post services. This meant duties in the Local Air Defense Command Post (LADCP): decoding messages, performing calculations for SS missions and drawing the ACO on a plexiglass plate. The coded messages concerning ACOs and SS missions were transmitted via a conference telephone connection from the GOC to the four squadrons. They consisted of up to 250 trigrams (a combination of three digits and/or

letters, each trigram corresponding to a letter, number or word in clear language). Particularly when the GOC staff wore their gas masks, the trigrams were not always clearly understood, which sometimes led to endless repetitions. A revolutionary development from 1984 onwards was the use of a telephone fax: the entire message could now be transmitted quickly and without errors. The LADCP provided the two Flycatchers with tactical information. Because LOPAR and HIPAR were rather blind to low-flying aircraft at short range, no 'early warning' could be provided to the Flycatchers. Other duties concerned NBC-plotting, calculations regarding nuclear and chemical attacks and contamination areas, dose registration, etc.) in the Squadron Command Post.

- **Exercises.** In order to be able to perform all additional duties during exercises and actual deployment with the limited numbers of personnel available, a separate duty roster was set up for exercises. Usually, one crew was appointed for night and day shift and two crews for day and evening shift. Thus, the maximum personnel capacity was available during the daytime hours, when the highest exercise intensity was expected. During the nocturnal hours little activity was expected (and the evaluators had to sleep too) so that one crew would suffice. During exercises, crews either slept at home or in the barracks. Only very occasionally, a field bivouac was set up for personnel who were off-duty. One crew was employed in the primary job (fire control or launching), one crew was charged with the execution of the additional duties and the third crew, when available, was on stand-by for calamities and ad hoc activities. BCT and RCT personnel were rotated regularly as prolonged staring at a radar scope did not contribute to alertness.
- **Employment as an evaluator.** A limited number of experienced crew members, both officers and non-commissioned officers, were employed as evaluators in the evaluation of foreign NIKE units. 12GGW had a *Partnerschaft* (partnership) with the neighboring German 25th *FlugzeugabwehrRaketen* (FLARAK) Battalion. This *Partnerschaft*, besides providing an opportunity for the usual soccer tournaments and social activities, was even more useful for practical mutual support. For example, 25FLARAK and 12GGW supported each other's national evaluations and exercises by providing evaluators and sometimes even spare parts. Evaluating the German colleagues, the first time coached by an experienced colleague, was an instructive first step towards the status of a NATO evaluator. AIRCOM had a small core of full-time evaluators, but as at least 120 evaluators were needed for the evaluation of a NIKE group, it was necessary to have additional evaluators provided by the NIKE units. This system also guaranteed that a unit was evaluated by personnel with up-to-date knowledge and experience.

When evaluating the neighbors had led to some experience as an evaluator, the soldier concerned could be nominated as a prospective NATO evaluator. If AIRCOM's TACEVAL division agreed with the nomination, the soldier needed to participate twice in a NATO evaluation as an U/T (under training) evaluator. Here the specific do's and don'ts of a NATO evaluation were learned. Subsequently, if the soldier was declared 'qualified' by AIRCOM, he/she could be employed as a NATO evaluator. This meant evaluating once or twice a year a German, Belgian and sometimes even a Norwegian, Danish, Italian, Greek or Turkish NIKE unit for a

week (the US and French NIKE units stationed in Germany had already been dissolved at the end of the 1970s). It was always very instructive to see how other units had found solutions to similar problems with which one's own unit struggled. Copying 'best practices' led to a quality improvement in all NIKE units. It also provided all evaluators involved with the conviction that the NATO standards were uniformly applied and rated. The TACEVAL program, with its credible evaluation system, thus contributed to the standardization of tactics, techniques and procedures within the NATO NIKE community (and other air force units).

- DIENSTGEHEIM -

KONINKLIJKE LUCHTMACHT
12E GROEP GELEIDE WAPENS
120 Squadron

Ex. nr.: 16
Voor : BCOI

OPS-PLANNING
3101-010483

Borgholzhausen, 191282.

1. GENERAL: This programm must be executed without crosscheck.
2. UNDERLINED ITEMS: Are of special interest for US-Custodians and SGF.
3. WACHT SGF: Dient op onderstreepte tijden voldoende personeel beschikbaar te hebben bij het CGH.
4. HST: dient 20 min. vóór de dubbel onderstreepte tijden transport voor het custodian building te hebben.
5. SHORAD: Bij de diensten der respectievelijke Crews wordt aangegeven wanneer Ops.-Personeel voor training ter beschikking dient te staan voor het HASHORAD-120 Squadron. (zie SHORAD-rooster voor training en onderhoud).
6. TENUE APPÈLS: Wellicht ten overvloede: alle appels, behalve in de monthly-week, in het grijze werkpak!
7. EXERCISES: Since there is no exercise-schedule available at this moment, changes due to exercises will be passed on an appendix to this programm.
8. COMPENSATIE PASEN: in week 13 (2803-010483) is de compensatie voor de Paasdienst (Crew II) verwerkt.

DATE:	A-TIME:	PLACE:	CREW:	PLANNED:	
Mon 3101	0800-1600	IFC+LA	2	Dailies + JOP + X-training + 2 x SHORAD	c
	<u>0900-Cpl.</u>	<u>LA</u>	2	<u>Dailies</u>	c
	1600-2300	IFC+LA	3	JOP + X-training + T-I + 1 x SHORAD	c
	2245	IFC+LA	1	Appel MT	c
	2300-0800	IFC+LA	1/3	Crew 1: Systeemwacht + Cdt.Syst.w. Crew 3: On call	c
Tue 0102	0800-1600	IFC+LA	2	Dailies + JOP + X-training + T-I	c
	0800-1700	IFC+LA	1	IFC: on site. LA: tbv SHORAD	c
	<u>0900-Cpl.</u>	<u>LA</u>	2	<u>Dailies + Special Training</u>	c
	1600-2300	IFC+LA	3	JOP + X-training + T-I + 1 x SHORAD	c
	2300-0800	IFC+LA	1/3	Crew 1: Systeemwacht + Syst.w.Cdt. Crew 3: on call	c
Wed 0202	0800-1600	IFC+LA	2	Weekly	c
	0800-1700	IFC+LA	1	IFC: on site. LA: tbv SHORAD	c
	<u>0900-Cpl.</u>	<u>LA</u>	2	<u>Dailies</u>	c
	1600-2300	IFC+LA	3	JOP + X-training + T-I + 1 x SHORAD	c
	2300-0800	IFC+LA	1/3	Crew 1: Systeemwacht + Syst.w.Cdt. Crew 3: On call	c

- 1 -

- DIENSTGEHEIM -

120Sq's last Ops Planning for US and Dutch personnel. 'c' in the last column denotes 12-hours readiness status. (archive F.E. Rappange)

FINAL REMARKS

The three fundamental characteristics of Air Power are 'altitude', 'speed' and 'range'. Even being a ground-based air defense system, the NIKE Hercules system amply met these characteristics. Compared to contemporary ground-based air defense systems such as the PATRIOT, the NIKE Hercules still does not compare badly with them. The big missile, the nuclear capabilities, the continuous high readiness and the ever-impressive launch made the NIKE Hercules an icon of the Cold War.

On the other hand, the lack of tactical mobility and the low rate of fire made that the system gradually became outdated in a tactical sense. In addition, NIKE was designed against a threat that was no longer the most probable one in the 80's of the last century. Fortunately, it has never come to an armed confrontation between NATO and the Warsaw Pact, so we will never know what the actual operational value of the system would have been. It seems clear that the NATO concept of a double belt of ground-based air defense along the entire border with the Warsaw Pact, coupled with a high level of readiness, has contributed to deterrence. The nuclear capability of the NIKE Hercules, both in the SA and the SS role, presumably will have played a role here too. Although nuclear air defense might seem to be an overkill, perhaps it gave NATO a chance to issue a nuclear final warning with a low risk of collateral damage before the conflict really escalated into a nuclear war.

The NIKE Hercules system is nowhere in the world in use anymore and can only be seen in its full glory in museums. In the Netherlands, both the National Military Museum at the former Soesterberg Airbase⁷ and the Historical Collection of Ground-Based Air Defense in Vredepeel exhibit parts of the NIKE Hercules system, in particular launchers with missiles⁸.

For those who were involved with the NIKE system in any way, the memories remain. The phenomenon of 'status' dominated the life of all personnel, even the social part. For these Cold War veterans, this article hopes to have been a trip down memory lane. For the 'unfortunate ones' who have never been involved with this impressive weapon system, this article intended to provide an insight into the technology, tactics and everyday life on a NIKE squadron.

**'BCO to all stations: end of exercise, back to White Status,
thanks for your cooperation'⁹**

⁷ Incidentally, the erstwhile home base of the USAFE 32nd 'Wolfhounds' Tactical Fighter Squadron

⁸ For an Italian full NIKE system exhibition, see <http://www.basetuono.it/en/>

⁹ Traditional BCO's proclamation of 'end of exercise'



The very last Dutch NIKE firing... NAMFI, 30 sept. 1987 (picture © Ronald Dorenbos)

ABBREVIATIONS

2ATAF	Second Allied Tactical Air Force
AAFCE	Allied Air Forces Central Europe
ACO	Airspace Control Order
ADL	Automatic Data Link
ADOC	Air Defense Operations Center
AF	Augmentation Force
AFCENT	Allied Forces Central Europe
AG	Azimuth of Gyro
AIRCOM	Air Command
ARW	Air Raid Warning
ASC	Airspace Control
ASP	Annual Service Practice
BCO	Battery Control Officer
BCT	Battery Control Trailer (or -van)
BHE	NIKE Hercules, High Explosive Warhead
Bn	Battalion
Btry	Battery
BXS	NIKE Hercules, Small Nuclear Warhead
BXL	NIKE Hercules, Large Nuclear Warhead
CRC	Control & Reporting Center
EA	Engagement Authority
ECM	Electronic Counter Measures
ECCM	Electronic Counter Counter Measures
FCO	Fire Control Order
FEZ	Fighter Engagement Zone
GGW	(Netherlands) Missile Group
GOC	Group Operations Center
HIMEZ	High Missile Engagement Zone
HIPAR	High Power Acquisition Radar
IA	Identification Authority
IFC	Integrated Fire Control (area)
IFF	Identification Friend or Foe
LA	Launching Area
LADCP	Local Air Defense Command Post
LCA	Launching Control Area
LCCO	Launching Control Console Operator
LCI	Launcher Control Indicator
LCO	Launching Control Officer
LCT	Launching Control Trailer
LOCOS	Leveling, Optical, Collimation, Orientation & Synchronizing
LOMEZ	Low Missile Engagement Zone
LOPAR	Low Power Acquisition Radar
LOS	Line of Sight
MBA	Minimum Burst Altitude
MCDR	Multichannel Data Recorder
MEZ	Missile Engagement Zone

MNBA	Minimum Normal Burst Altitude
M & S	Maintenance and Supply
MTI	Moving Target Indicator
MTR	Missile Tracking Radar
NAMFI	NATO Missile Firing Installation
NBC	Nuclear, Biological, Chemical
NLT	Not Later Than Time
OPCOM	Operational Command
ORE	Operational Readiness Evaluation
OJT	On the Job Training
PAL	Permissive Action Link
PI	Precision Indicator
PIP	Predicted Intercept Point
PKP	Predicted Kill Point
PPI	Plan Position Indicator
PRF	Pulse Repetition Frequency
PTA	Primary Target Area
RCS	Radar Cross Section
RCT	Radar Control Trailer (or -van)
RNLAF	Royal Netherlands Air Force
ROE	Rules Of Engagement
RTSG	Radar Test Set Group
SA	Surface-to-Air
SACEUR	Supreme Allied Commander Europe
SAD	Safety and Arming Device
SA-LA	Surface-to-Air Low Altitude
SA-AM	Surface-to-Air Anti-Missile
SS	Surface-to-Surface
SAM	Surface-to-Air Missile
SAMSTATREP	SAM Status report
SHORAD	Short Range Air Defense
SOC	Sector Operations Center
STO	SAM Tactical Order/Survival to Operate
Sq	Squadron
TACEVAL	Tactical Evaluation
TBM	Tactical Ballistic Missile
TM	Technical Manual
TOT	Time On Target
TTR	Target Tracking Radar
TRR	Target Ranging Radar
ULASO	Unit Launching Area Safety Officer
WCO	Weapon Control Order
WHCO	Warhead Control Order

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The author joined the Royal Netherlands Air Force (RNLAF) as an officer-cadet in 1977 and started his NIKE career in August 1981. After the academics at the Air Force Electronics and Technical School (LETS) in Schaarsbergen (the Netherlands), in November 1981 he was seconded to 118 Squadron of the 12th Netherlands Missile Group (12GGW) for his On-the-Job-Training (OJT) for Battery Control Officer (BCO). In March 1982 he passed his exams and was subsequently posted as a BCO to 120 Sq in Borgholzhausen (West-Germany). At about the same time the political decision was announced that the NIKE-system would be phased out from operational service and 12GGW was to be de-established, starting with 120 Sq in April 1983. After the deactivation of 120 Sq he was posted back to 118 Sq in Vörden, where he remained a BCO until mid-1987. Until the deactivation of 12GGW and 118 Sq as the last Dutch NIKE unit on March 31st, 1988 he was Chief, Emergency Action Cell of 12GGW, the simplified version of the former Group Operations Center (GOC).

After his time with 12GGW, he was transferred to 3GGW and retrained to become a Fire Control Officer HAWK and PATRIOT. Upon completion of his training, he was posted as Operations Officer/Deputy Commander 327 Sq (PATRIOT). With this unit he deployed to Israel during the 1991 Gulf War to defend Jerusalem against Iraqi SCUDs. After this episode he became Commander 324 Sq (HAWK). In 1993 his operational air defense missile career ended but in his follow-up postings he was frequently involved in ground-based air defense, lastly as Section Chief, Air Operations and Ballistic Missile Defense at NATO's Supreme Headquarters Allied Powers Europe (SHAPE). He has now retired from the RNLAF as a Lieutenant-colonel and presently is a volunteer with the Historical Collection of Ground-Based Air Defense (HCGLVD).



Author (rolled-up sleeves) and his crew, 120Sq Borgholzhausen, 1983 (picture: author's archive)