

LOADING INSTRUCTIONS

COMMODORE 64

For the C128, choose C-64 mode as advised by the manufacturer. Please ensure that joystick is connected to port 2.

- 1 Insert cassette into a cassette recorder
- 2 Hold down the SHIFT and RUN/STOP key
- 3 Press PLAY on the cassette recorder
- 4 The program will load and run

ATARI

This program requires Atari 600XL/800XL/130XE machine with a minimum of 64K memory. Please ensure that joystick is connected to port 2.

- 1 Turn off the computer and all peripherals except the cassette recorder
- 2 Remove cartridges. Hold down START and OPTION keys. Switch on power.
- 3 Atari will beep. Press play on cassette recorder and RETURN key
- 4 Program will load and run

3D real-world display:

Features include landing pads, buildings, trees, transmission pylons, mountains, enemy tanks, field guns and helicopters. Ground texture is visible when flying below 500 feet to enhance the sensation of speed. It is possible, with practice, to fly between trees and mountain peaks.

MENU OPTIONS

MISSION 1 – FLYING TRAINING – used for helicopter familiarisation & developing ground attack skills. Enemy ground forces will not return fire.

MISSION 2 – COMBAT – a short mission to destroy invading ground forces and return to base.

MISSION 3 – COMBAT – Surrounded totally by enemy territory, your task is to liberate the entire map from enemy occupation. Each hostile sector becomes allied when enemy forces destroyed.

MISSION 4 – COMBAT – A strategic battle for occupation of the entire map. Your task is to support allied ground forces in their battle along the front line.

DAY OR NIGHT – Daytime: blue or overcast sky, green ground

Night-time: no horizon, computer-enhanced infra-red imaging. (Pilots' Night Vision System.)

CLEAR OR CLOUDY – option for overcast sky with selectable cloudbase for instrument flying.

CLOUDBASE – selectable from 50 ft to 5000 ft.

CROSSWINDS & TURBULENCE – for the experienced pilot! Variable crosswind & turbulence effects.

PILOT RATING – TRAINEE
SQUADRON
INSTRUCTOR
ACE

The pilot rating is equivalent to difficulty level and varies potency of enemy. With each increase in pilot rating, the enemy's accuracy doubles!

SOUND – ON or OFF.

INSTRUMENT PANEL LAYOUT

Bar scales, from left:

Collective lever position indicator – COL

Engine Torque – TORQ 0 to 130%
(power demanded from engines)

Turbine & Rotor RPM – 0 to 120%

Throttle position indicator – T

Fuel

WEAPONS:

AMMO – 1200 rounds 30mm ammunition, 750 rounds/min, 38 unguided rockets (19 each side), 8 Hellfire missiles – laser guided, auto-tracking

Failure status lights: engines, weapons, nav. computer, TADS

INSTRUMENTS: (left to right)

TADS

Target Acquisition & Designation System – (small instrument above fuel indicator). Used to identify and track tanks, field guns and helicopters. Red = hostile, green = friendly. Includes range readout in feet when target is less than 10,000 feet away.

VDU – Visual Display Unit

Speed, in knots (yellow = forwards, cyan = backwards)

Altitude, feet

VSI – Vertical Speed, ft/sec (arrow UP = climb, arrow DOWN = descent)

TIME – Time to reach target, in hours and minutes (hashed if greater than 4 hrs, zero if less than 1 minute)

Ground position – autoranging navigation computer

Within 0.1 mls: resolution in feet

Within 4.9 mls: resolution in 0.1 mls

Over 5 mls: resolution 1 mile.

ARTIFICIAL HORIZON

Roll symbol & roll angle readout

Pitch indicator – nose up/down attitude

Sideslip indicator – sideways "drift"

DOPPLER NAVIGATION/COMPASS – (rightmost instrument)

Readout of Heading, Bearing & Track.

Heading: direction in which the helicopter is pointing.

Track: flight path direction.

Bearing: heading required to point at objective.

Note: a helicopter can be pointing in one direction (Heading) but moving in a different direction (Track) e.g. sideways! Match the heading to the target bearing to intercept target. The flashing cross indicates relative bearing of target.

Four modes:

B: Beacon navigation (8 beacons)

H: Landing Pad guidance (4 pads per sector)

T: Ground target tracking (8 targets per sector)

Lightning symbol: enemy helicopter interception

Flashing symbol warns of approaching enemy helicopter.

CONTROLS

THROTTLE – key W to open throttle
key S to close throttle

Controls engine/turbine rpm. Normally set to fully open unless practising engine-off landings. Assisted in flight by computerised autothrottle control.

COLLECTIVE LEVER – key Q increases lift
key A decreases lift

This is basically a vertical lift control used for take-off to the hover, and forward thrust control in straight & level flight.

CYCLIC CONTROL

joystick forward tilts nose down

joystick back tilts nose up

and destroy enemy targets in both map mode and in cloud, but the weapon sights will not be displayed.

During combat, enemy fire is indicated by flak. The screen will flash if your helicopter is hit. Damage to helicopter systems is indicated on the failure status panel and structural damage is shown by the Doppler helicopter symbol flashing. A third structural hit is fatal! The chances of being hit by the enemy are decreased by swerving during the attack. You have a total of 3 helicopters per mission. Study the mission report for crash evaluation and performance report.

If an enemy helicopter is approaching, a warning symbol will be flashed on the Doppler instrument if you are not in air-to-air combat mode. You are advised to select air-to-air combat mode and destroy the enemy helicopter before he gets too close!

Scoring Scheme

Weapon Used	Target		
	Field gun	Tank	Helicopter
Gun	20	—	100
Rockets	10	20	50
Missiles	5	10	25
Points Scored			

It is not possible to destroy a tank with the chain gun. Destruction of allied forces will result in total loss of score. Although it is much easier to hit a target with a missile, fewer points will be scored. The enemy will begin to fire back at a range between 4000 and 5000 feet, making it much more dangerous to use guns (range 2000 ft!) but the points scored will be higher.

MAP

Use key M to select map or to return to normal display. Your helicopter is shown by the flashing symbol with a tail. Enemy helicopters are shown without a tailplane. Beacons 0 to 7 are used for navigation purposes.

By selecting MAP mode when sitting on any allied pad, the helicopter may be moved to another allied sector by using joystick. This feature eliminates the need for lengthy straight and level flight to visit each sector.

When training (Mission 1), all sectors are allied and any landing pad may be used for refuelling, rearming or repairs. All sectors contain enemy tanks and field guns for target practice.

In combat missions, territory is distinguished by blue (Allied) sectors and red (Hostile) sectors. A flashing blue sector indicates the presence of enemy forces in allied territory. Likewise, a flashing red sector indicates the presence of allied forces in hostile territory. You will be captured by the enemy if you touchdown in hostile territory.

The destruction of all enemy forces in a hostile sector will result in the sector becoming allied. Likewise, if all allied forces in a sector are destroyed, the sector becomes hostile.

The map is designed to “wrap around” at the edges i.e. when flying off the map, the helicopter will reappear at the opposite edge.

COMPLETION OF MISSION

A mission is completed when all enemy ground forces have been destroyed and you have returned safely to a landing pad. After touchdown, close the throttle to bring the turbine and rotor rpm to zero. A complimentary mission report will follow.

PILOT'S NOTES

The controls in a real helicopter are “proportional”, i.e. their effect is proportional to the displacement from centre. It is not possible to implement this feature with a joystick since it contains simple on/off microswitches. By making the effect of each control proportional to how long the joystick is held, a simple approximation to “real” controls has been achieved, i.e. momentary operation of the joystick for fine control, and hold to build up a rapid rate. This does however mean that the joystick must be operated repeatedly for manoeuvres such as a steady turn or to hold a steady pitch angle.

Helicopters are naturally unstable and difficult to fly without autostabilisation. The Apache is fitted with Digital Automatic Stabilisation Equipment (DASE) making it far easier to fly than most modern helicopters.

Take-off procedure:

- 1 Ensure that collective indicator at minimum.
- 2 Select full throttle – key W – hold pressed until throttle indicator at maximum.
- 3 Wait for turbine rpm & rotor rpm to reach 100%.
- 4 Increase collective pitch by pressing key Q until lift-off occurs. VSI indicates vertical speed in ft/sec.
- 5 Reduce collective (key A) to achieve hover i.e. VSI = 0. The helicopter is now hovering above the helipad.
- 6 Turning on the spot is accomplished by applying left or right rudder (key X or key Z).

Transition to forward flight from hover

- 1 Increase collective (key Q) to between 80% to 100% Torque. Reduce collective (key A) if overtorque warning sounds.

- 2 Tilt nose of helicopter downwards joystick forward to between 15 and 30 degrees.

- 3 Speed will be seen to increase. Autostabilisers will slowly raise the nose of the helicopter to a level attitude.

- 4 Reduce collective (key A) to adjust for VSI = 0 ft/sec i.e. not climbing or descending.

The helicopter will now be cruising at a steady forward speed. The Apache is a very agile helicopter. From a stable hover, it can reach 100 kts in approx. 6 seconds by pulling 100% torque and tilting the nose downwards to approx. 30 deg.

Straight & Level Flight

Forward speed is related primarily to the torque setting & hence the collective lever setting, assuming the helicopter is not autorotating (explained later). Typical speed/torque settings are as follows:

Torque	Speed
44%	60 kts
60%	119 kts
75%	147 kts
100%	159 kts

These values will vary slightly with altitude and changes in helicopter weight resulting from fuel consumption and weapon release. The Apache is fitted with a computer-controlled stabilator which enables the helicopter to cruise at any speed with the fuselage level.

Turning Flight

Providing that the forward speed is greater than 60 kts, turning is achieved by simply banking left or right. Some vertical lift will be lost when banking and the helicopter will begin to descend. This may be counteracted by increasing the collective setting. The helicopter will tend to slow down in a

turn unless the pilot dives to sacrifice height to maintain speed.

At speeds under 60 kts, the helicopter will tend to "drift" into the turn, shown by the sideslip ball at the bottom of the artificial horizon. Turns may be assisted by applying the rudder, but this will reduce forward speed.

Fluctuations in rotor rpm occur during a turn because of g force effects. The autothrottle will adjust the turbine rpm accordingly to keep the rotor rpm at approximately 100%.

Slowing down & returning to the hover

1 Gently raise the nose of the helicopter by pulling back on the joystick. The aircraft will begin to slow down and also climb. Maintain the nose-up attitude by repeatedly pulling back on joystick (gently!).

2 Reduce the rate of climb by reducing collective (key A) to keep VSI to approximately zero. As the forward speed drops below 60 kts, increase collective (key Q) to counteract sink rate. Allow nose of helicopter to return to level flight as speed approaches zero.

3 Adjust collective as required to achieve a VSI of zero. The helicopter should now be in a stable hover.

4 The helicopter will also slow down when turning, providing that it is not in a dive. Banking repeatedly left and right is another common method of slowing down.

5 Providing that the forward speed is less than 60 knots, the pilot may apply rudder to increase sideslip (sideways drift). The helicopter will slow down dramatically as a result of the large drag forces generated.

Landing

The helicopter may be landed from the hover (vertical descent) or at forward speeds of less than 60 kts.

(a) From hover: Lower the collective lever to maintain a steady rate of descent. Maximum VSI at touchdown = 12 ft/s. Ground cushion effect will be experienced below 30 ft, resulting in reduction of the descent rate.

(b) Rolling touchdown: With a forward speed of less than 60 kts, gently lower the collective lever to begin descent. Max VSI at touchdown = 12 ft/s. After touchdown, the helicopter will slow down and eventually stop. Steer on the ground by using rudder control.

Taxiing on ground

The helicopter may be taxied on the ground, up to a maximum speed of 60 kts, providing that the engine/rotor rpm are at 100%. Assuming that the helicopter is stationary, raise the collective lever to produce about 20% torque. Pushing forward on the main joystick will accelerate the aircraft, and likewise pulling back will decelerate and eventually stop. Steer by using the rudder.

Refuelling/Rearming/Repairs

By landing or taxiing onto a helipad (not an enemy one!) the aircraft may refuel, reload with weapons, and be repaired. Once on the pad, close the throttle to bring turbine & rotor rpm to zero. The helicopter will be serviced and prepared for the next take-off immediately.

Backward & Sideways Flight

Starting from the hover, the helicopter may be flown backwards by raising the collective lever and

raising the nose to approximately 10 deg. The speed readout will turn cyan to denote backward flight. Keep the nose of the helicopter pitched up to sustain speed. Likewise, the helicopter may be flown sideways by rolling left or right and raising the collective lever. The speed readout does not show sideways speed and the pilot must watch the sideslip indicator on the artificial horizon in order to monitor sideways drift.

Torque Turn

This manoeuvre allows the pilot to perform a 180 deg turn with a dramatic climb & simultaneous turn.

With a forward speed of 100 kts or more, pull the nose of the aircraft up to approx 70 deg pitch. Hold this nose-up attitude until the speed drops to approx 60 kts. Release joystick & apply rudder until heading has changed by approx 160 deg. Release rudder, adjust roll to zero if necessary and accelerate with nose down attitude. During this manoeuvre, the helicopter will roll, pitch & yaw simultaneously, pulling down on a reciprocal heading.

Aerobatics

The Apache may be flown safely within the following limits:

Pitch $\pm$ 90 deg

Roll $\pm$ 110 deg

Control response may become unpredictable outside these limits i.e. loops & rolls are NOT recommended!

Autorotation

Autorotation is equivalent to the helicopter "gliding" through the air and is used when the pilot wishes to descend rapidly or after engine failure.

During autorotation, the rotor blades are being driven by airflow through the rotor disc as the helicopter descends. This reduces the power required from the engines and the engine RPM is automatically reduced to maintain 100% rotor speed and the "split" between turbine rpm & rotor rpm can be seen on the bar scales. Autorotation is best performed at approximately 60 kts. and above 500 ft. Entry into autorotation is made by gently lowering the collective lever:

(a) Engines active

As the descent rate builds up, the automatic throttle control will be seen to reduce the turbine rpm. Any fluctuations in rotor rpm will be compensated automatically by the autothrottle. As the altitude falls to below 200 feet, the pilot should begin to pull the collective lever up to reduce the rate of descent, accompanied by raising the nose of the helicopter if he wishes to slow down. With practice, the pilot will co-ordinate increasing the collective and adjusting the pitch angle in order to slow down to the hover just a few feet above the ground.

(b) Engine-off landings

In the event of failure of both engines or if the pilot deliberately closes the throttle in flight, engine rpm will reduce to zero. The pilot must respond quickly by lowering the collective lever before the rotor blades slow down too much. Rotor rpm is controlled during the descent by careful adjustment of the collective lever. Keeping the helicopter level and the speed between 50 & 60 kts, raise the collective lever just before touchdown to bring the rate of descent to below 12 ft/sec.

Warnings – limits worth noting!

1. The maximum permissible speed of Apache is

197 kts, in a dive. If the speed should rise above this, the speed readout will flash red and the pilot will get an audible warning. If he continues to increase his speed, the helicopter will shed a rotor blade at 210 kts, resulting in catastrophic loss of control!

2. If the pilot demands too much power from the engines (overtorque), the torque readout will be in the red, the engine temperature will rise into the red, and an audible warning will occur. If this warning is ignored, the engines will overheat and eventually fail. It is possible to hover and fly on one engine but flying time is limited if both engines have failed!

HELICOPTER AERODYNAMICS

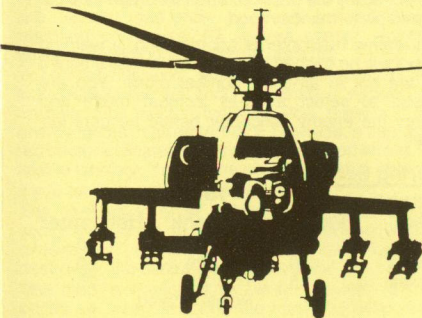
The following description is intended only as an introduction to the subject. We recommend the following book for further reading:

"The Helicopter – history, piloting & how it flies" by John Fay, Published by David & Charles

The rotor blades of a helicopter force air downwards as they pass through the air. This results in an upward lifting force. The pilot may increase this lift by "collectively" increasing the "angle of attack" of all the rotor blades and the helicopter will rise. In order to move forwards, the rotor blades are tilted forwards, thereby using part of the lift to accelerate the helicopter.

The amount of lift generated by the rotor blades increases with helicopter speed. This is called translational lift and results in the pilot requiring less collective as his speed increases. However, as the helicopter continues to accelerate, this extra lift is offset by the build up of large drag forces which in turn must be overcome with higher collective settings. This variation in "operating

efficiency" can be visualised as a curve, with its peak at approximately 60 kts. A helicopter requires much more power for a vertical climb than it does for the same rate of climb with forward speed. Its hovering ceiling is much lower than its ceiling with forward speed. Both of these effects are due to translational lift.



TECHNICAL DATA

Performance:

Maximum speed 197 kts
Maximum cruise speed 162 kts
Maximum vertical rate of climb: 1450 ft per min.
Service ceiling 20,000 ft.
Endurance: 1 hr 50 min to 2 hr 30 min, according to weapon load and mission profile.

Engines: Two General Electric T700-GE-701 turboshaft engines
Each rated at 1695 shp

Weight: Empty: 11,015 lb (4996 kg)
Primary mission gross weight: 14,694 lb (6665 kg)
Maximum take-off weight: 17,650 lb (8006 kg)

Armament:

One Hughes M230A1 chain gun 30 mm automatic cannon with up to 1200 rounds, rate of fire 750 rnds/min. Four underwing strongpoints to carry up to 16 Rockwell AGM-114A Hellfire laser-seeking anti-armour missiles or up to 76 2.75 inch rockets

Dimensions:

Rotor diameter 48 ft, tail rotor diameter 9 ft 2 in
Overall length 58 ft 3 in
Overall height 15 ft 3 in

Crew:

Co-pilot/gunner and pilot in tandem

History:

First flight (YAH 64) 30th September 1975
Entered service with US Army in 1984.

SUMMARY OF CONTROLS

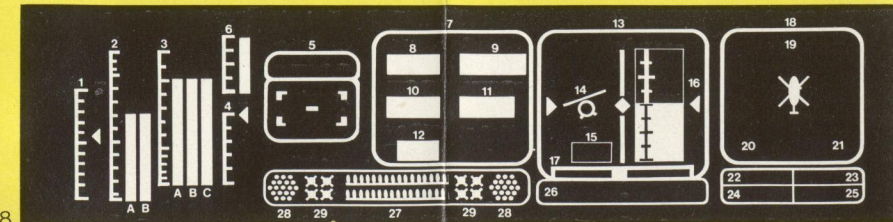
roll left joystick left
pitch UP joystick back
pitch DOWN joystick forward
roll RIGHT joystick right
Z LEFT rudder
X RIGHT rudder
C change mode of Doppler
N Next objective
P Select weapon system

FIRE button joystick fire button
Q increase collective
A decrease collective
W open THROTTLE
S close THROTTLE
M MAP
H Pause
J Continue
CONTROL and RETURN together to Abort mission & return to menu.

INSTRUMENT PANEL NOTATION

1 Collective lever
2 Torque % (a) Engine 1 (b) Engine 2
3 RPM % (a) Engine 1 (b) Rotor blades (c) Engine 2
4 Throttle indicator
5 TADS - Target Acquisition & Designation System
6 Fuel level
7 Pilot's Visual Display Unit
8 Speed, in knots (yellow = forwards, cyan = backwards)
9 Altitude, in feet
10 Time to objective, hours & mins
11 Vertical speed indicator, VSI, feet per sec
12 Distance from objective, in feet or miles
13 Artificial Horizon

14 Roll symbol
15 Roll angle
16 Pitch angle
17 Sideslip (drift) indicator
18 Doppler
19 Navigation/Compass Heading
20 Bearing
21 Track
22 Engines
23 Weapons
24 Nav computer
25 TADS
26 Score
27 30mm chain gun ammo supply
28 Rockets
29 Hellfire Missiles
) Failure Status Panel



Acknowledgements

Digital Integration would like to thank McDonnell Douglas Helicopters for their technical assistance during the design of TOMAHAWK. We would also like to thank the many pilots who kindly assisted in the testing and evaluation of this product.

All information stated herein is accurate to the best of our knowledge. Although considerable effort has been given to achieving a realistic simulation, approximations have been made due to the limitations of the computer and certain technical data not being available to the public.

© 1986 DIGITAL INTEGRATION LTD

TOMAHAWK is a trademark of Digital Integration Ltd.

TOMAHAWK is protected by national and international copyright laws. Its distribution, sale or use are intended for the original purchaser only, on the specified computer. It may not be transmitted, copied, lent, hired or sold on any optional buyback basis without the written permission of DIGITAL INTEGRATION LTD.

DIGITAL
INTEGRATION 
DIGITAL INTEGRATION LTD.,
WATCHMOOR TRADE CENTRE,
WATCHMOOR ROAD, CAMBERLEY,
SURREY, GU15 3AJ. (0276) 684959

ONLY THE BRAVEST FLY.... TOMAHAWK®

TOMAHAWK is a real-time flight simulation based upon the U.S. Army AH-64A APACHE Advanced Attack Helicopter – the meanest, deadliest combat helicopter ever to rule the skies! Its specialised job is to hunt tanks and destroy anything that gets in its way. The Apache was built specifically to fight and survive, night and day, in the thick of the battlefield.

Flying a real helicopter is a demanding task requiring training and practice – particularly ground attack. TOMAHAWK gives you this challenge. Climb into your cockpit and prepare for take-off.....

Features of TOMAHAWK:

- Spectacular 3D real world display
- Fully aerobic (within limitations of real helicopter)
- Ground attack & air-to-air interception
- Over 7000 ground features
- Day/night vision systems
- Cloudy conditions, crosswinds & turbulence
- Doppler navigation & target tracking system
- Laser guided missiles, plus rockets & 30mm chain gun
- Selection of training and combat missions
- Impressive sound effects
- Pilot ratings – Trainee to Ace
- Twin joystick option