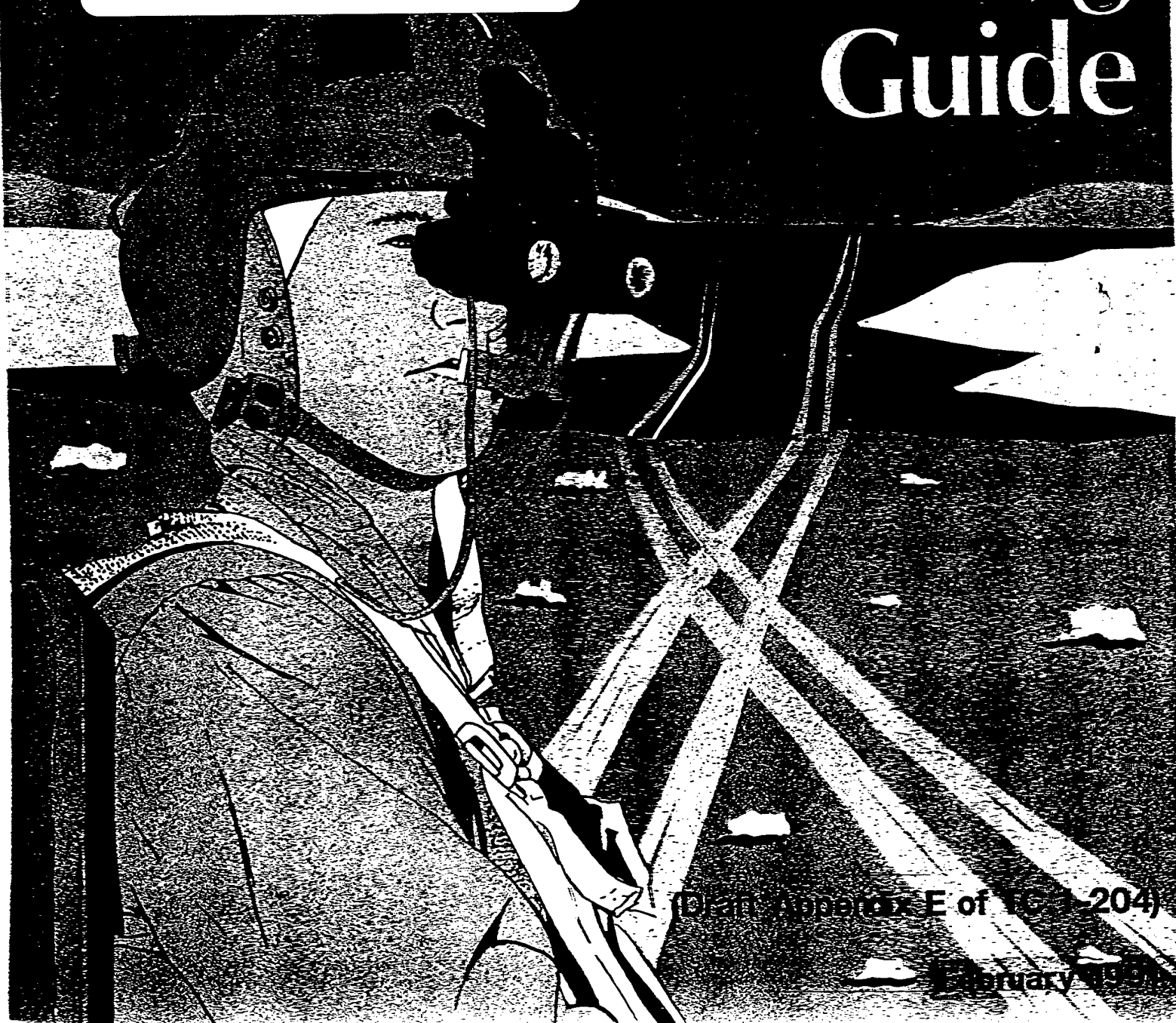


# Aviation NVG Desert Training and Operations Planning Guide

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(Draft Appendix E of IC 1-204)

February 1991

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## FOREWORD

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Operations Desert Shield and Desert Storm have presented Army aviation with some challenges to the safe operation of our aircraft under night vision goggle conditions. The combination of visual illusions, featureless terrain, and extreme temperatures creates unforgiving situations for *untrained* night vision goggle crews. Experience has proven that commanders who focus on desert-specific night vision goggle training, battle rostering crews, and crew coordination will be able to reduce the risks associated with desert flying. Operations Desert Shield and Desert Storm have required that certain long-standing night flight procedures and techniques be re-examined, the most significant of these being Aircrew Training Manual airspeed limitations. This draft appendix E to TC 1-204 includes new planning guidance appropriate for the environment in Southwest Asia.

Suggest you use this guidance for operational planning and the crawl-walk-run progression of unit night vision goggle training programs in Southwest Asia. This guide is intended to improve your combat effectiveness through smarter, safer flight training and operations.

RUDOLPH OSTOVICH III  
Major General, Commander  
U.S. Army Aviation Center and Fort Rucker

20000929 034

# Aviation NVG Desert Training and Operations Planning Guide

(Draft Appendix E of TC 1-204)

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## TABLE OF CONTENTS

---

I. INTRODUCTION	1
II. ILLUMINATION	
A. Illumination Considerations	3
- Moon Position	3
- Sunrise and Sunset	3
- Cultural Light Contamination	3
- Other Considerations	3
B. Illumination Data Sources	4
- Sources	4
- Description of TDA and LUNACAL	4
- CHART 1 - Kuwait City, Feb 91	5
- CHART 2 - Kuwait City, Mar 91	6
- CHART 3 - Kuwait City, Apr 91	7
- CHART 4 - Kuwait City, May 91	8
- CHART 5 - Kuwait City, Jun 91	9
III. NVG TERRAIN FLIGHT	
A. Scrub Desert Terrain	11
- Characteristics	11
- NOE Flight	11
- Contour Flight	11
- Low Level Flight	11
B. Dry Lake Bed Desert Terrain	11
- Characteristics	11
- NOE Flight	12
- Contour Flight	12
- Low Level Flight	12
C. Sand Dune Desert Terrain	12
- Characteristics	12
- Special Notes on Sand Dune Areas	12
- NOE Flight	13
- Contour Flight	13
- Low Level Flight	13
D. Terrain Transition	13
- Terrain Transition Identification	13
- Problems Encountered	14
IV. VISUAL ILLUSIONS	
A. False Horizon or Lack of Horizon	15
- Description	15
- How to Combat	15
B. Height Perception Illusion	15
- Description	15
- How to Combat	15
C. Ground Light Misinterpretation	15
- Description	15
- How to Combat	15
D. Fixation	15
- Description	15
- How to Combat	15

E. Crater Illusion . . . . .	16
- Description . . . . .	16
- How to Combat . . . . .	16
F. Lack of Motion Perception (Motion Parallax) . . . . .	16
- Description . . . . .	16
- How to Combat . . . . .	16
 V. NVG MISSION PLANNING . . . . .	 17
A. Airspeed Limitations . . . . .	17
- NOE & Contour Altitudes Below 80 feet . . . . .	17
- Contour & Low Level Altitudes Above 80 feet . . . . .	17
B. Phases of Flight . . . . .	17
- Takeoff . . . . .	17
- En Route . . . . .	17
- Landing . . . . .	17
C. Approach to Visibility Altitude . . . . .	18
D. Hover OGE . . . . .	18
 VI. NVG MISSION AIRSPEED AND ALTITUDE PLANNING FIGURES . . . . .	 19
A. Important Precautions . . . . .	19
B. Use of Figures . . . . .	19
FIGURE 1. Scrub Desert Terrain . . . . .	20
FIGURE 2. Dry Lake Bed Desert Terrain . . . . .	21
FIGURE 3. Sand Dune Desert Terrain . . . . .	22
 VII. EQUIPMENT . . . . .	 23
A. Navigation . . . . .	23
B. Band-Pass Filter (Pink Light) . . . . .	23
C. Position Lights . . . . .	23
D. Radar Altimeter . . . . .	23
E. Night Vision Goggles . . . . .	24
F. Terrain Perception Enhancement Kit (TPEK): Aiming Lights . . . . .	24
- Cautions . . . . .	24
- Description . . . . .	24
- Adjustment . . . . .	24
- Operating Principles . . . . .	24
 VIII. CREW COORDINATION AND SCANNING . . . . .	 25
A. Crew Coordination . . . . .	25
- Definition . . . . .	25
- Planning . . . . .	25
- Responsibilities . . . . .	25
- Procedures . . . . .	25
- General Considerations . . . . .	26
B. Scanning . . . . .	26
- Responsibilities . . . . .	26
- Procedures . . . . .	28
- Adjusting Seat Position for Optimum Field of View . . . . .	28
- Obstacle Detection . . . . .	28
- Band-Pass Filter . . . . .	28
 IX. RISK MANAGEMENT . . . . .	 29
A. Definition . . . . .	29
B. Risk Management Rules . . . . .	29
C. Risk Management Process . . . . .	29
- Risk Identification . . . . .	29
- Risk Assessment (Evaluation/Quantification) . . . . .	30
- Risk Decisions and Development of Controls . . . . .	30
- Implementation of Controls . . . . .	30
- Supervision . . . . .	30
D. NVG Specific METT-T Considerations . . . . .	30
 X. REFERENCES . . . . .	 33

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## SECTION I

---

# INTRODUCTION

**T**he airborne sand, featureless terrain, and sand dunes prevalent in Southwest Asia present aviators with a hazardous environment for night vision goggle operations. To provide planning guidance specifically oriented toward this environment, a research project sponsored by the Director of Army Safety and directed by the U.S. Army Safety Center was conducted in Southwest Asia during the period 1-30 December 1990. The primary purpose of the project was to determine maximum airspeeds, optimum altitudes, and auxiliary aircraft lighting for safer NVG operations under the full spectrum of illumination levels for terrains

characteristically encountered.

Evaluation flights were conducted by two highly experienced instructor pilots from Fort Rucker along with two such pilots assigned to Operation Desert Shield aviation units. Two UH-1H aircraft with radar altimeters were used and pilots were equipped with AN/AVS-6 goggles. A series of flights were conducted over three different types of terrain prevalent in Southwest Asia (scrub, dry lake bed, and sand dunes) with various altitude, airspeed, and lighting configurations. Video and audio tapes, interviews of in-theater pilots, and quantitative data were used to develop the information contained in this planning guide.

---

## SECTION II

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# ILLUMINATION

**I**llumination level is one of the most important factors in NVG mission planning. Section II-A below contains illumination considerations for desert regions that, while applicable in all areas of the world, may be more important to planners of NVG missions in Southwest Asia. Section II-B provides sources of illumination data for use in NVG mission planning.

## A. ILLUMINATION CONSIDERATIONS

---

### MOON POSITION

- Use forecast moon position in NVG planning process to ensure crews do not fly directly into a rising or setting moon.
- Moon angle:
  - Moon at low angles (less than 30 degrees) may distort the shape of terrain features, making them hard to correlate with a map.
  - Moon at high angles (70 to 90 degrees) and high illumination levels (above 80%) can cause washout of terrain detail with a corresponding decrease of visual cues.
- Optimum moon conditions for NVG operations in the desert may be 40- to 80-percent illumination and a 40- to 80-degree angle above the horizon.
- Obstacle detection is best when moon is behind the aircraft.
- Shadows.
  - If necessary, shadows provided by terrain features can be used to hide the aircraft.
  - Shadows can be used as visual cues for spatial orientation.
  - In terrain with high vertical relief, when the moon is located behind the aircraft, terrain features stand out more and shadows extend away from the aircraft.

- When moon is located to either side of aircraft, obstacle detection can become difficult because lateral shadows can obscure obstacles.

### SUNRISE AND SUNSET

- Position of the sun should be considered when operations are planned near sunset and sunrise because over-the-horizon sunlight can degrade NVG effectiveness.
- Avoid flying due west immediately after sunset or due east just before sunrise to avoid bright over-the-horizon sunlight.
- Over-the-horizon sunlight may be too bright at—
  - Sunset until the sun drops beyond 12 degrees below the horizon (end of evening nautical twilight).
  - Sunrise as the sun rises from 12 degrees below the horizon.

### CULTURAL LIGHT CONTAMINATION

- Cultural light contamination (effect of lighting from cities, fires, flares, etc.) is difficult to predict.
- Cultural light increases total ambient illumination level.
- Point light sources may reduce ability to detect/identify terrain features lying between them and the NVG user.

### OTHER CONSIDERATIONS

- When forecast ambient light level is very low or very high, assign a *higher risk* factor for the mission during planning.
- When light level is very high, the reflectance of sand can reduce detectability of obstacles in the foreground.
- Fog, smoke, haze, sand, and dust will diffuse light and reduce the effectiveness of available illumination.

## **B. ILLUMINATION DATA SOURCES**

---

**SOURCES.** Illumination data can be obtained from—

- U.S. Air Force Weather Service
- Computer programs such as Tactical Decision Aid (TDA) and Light Level Planning Calendar (LUNACAL)

### **DESCRIPTION OF TDA AND LUNACAL**

#### ■ TDA

- Used by some U.S. Air Force weather forecasters.
- Primarily an electro-optical forecasting tool used to determine infrared target detection and identification ranges based on local weather, terrain, and target activity.

• Can provide NVG mission planners with moon zenith, set times, percent illumination, angle, and position in the sky relative to True North.

• May be obtained from local U.S. Air Force weather forecaster.

#### ■ LUNACAL

• Provides predictions of sun and moon positions for any point on the earth designated by latitude and longitude.

• May be obtained from local U.S. Air Force weather forecaster.

• Examples of LUNACAL output for the months of February through June 1991 are included in Charts 1 through 5 for Kuwait City (latitude 29 degrees 22 minutes North, longitude 48 degrees 00 minutes East, GMT +3).

\*\*\*\*\* Light level planning calendar, Clear sky condition \*\*\*\*\*  
 Latitude N 29 degrees 22 minutes Longitude E 48 degrees 0 minutes

1 February 1991 to 28 February 1991

For PM on	Moons R/S	Sun set	Mag	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	For AM on	Moons R/S	Sun rise
1 Feb	R1955	1726	91%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2 Feb	S0822	637
2 Feb	R2456	1726	84%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3 Feb	S0853	636
3 Feb	R2155	1727	76%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4 Feb	S0925	636
4 Feb	R2253	1728	66%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5 Feb	S0958	635
5 Feb	R2358	1729	57%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6 Feb	S1034	635
6 Feb	none	1730	47%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7 Feb	R0047	634
7 Feb	none	1731	34%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8 Feb	R0142	633
8 Feb	none	1731	29%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9 Feb	R0236	632
9 Feb	S1246	1732	21%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10 Feb	R0326	632
10 Feb	S1338	1733	14%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11 Feb	R0412	631
11 Feb	S1434	1734	8%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12 Feb	R0453	630
12 Feb	S1531	1735	3%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13 Feb	R0531	629
13 Feb	S1629	1735	1%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14 Feb	R0605	628
14 Feb	S1727	1736	0%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15 Feb	R0637	628
15 Feb	S1825	1737	1%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16 Feb	R0708	627
16 Feb	S1923	1738	5%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17 Feb	R0739	626
17 Feb	S2022	1738	11%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18 Feb	R0811	625
18 Feb	S2123	1739	18%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19 Feb	R0845	624
19 Feb	S2226	1740	27%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20 Feb	R0925	623
20 Feb	S2332	1741	38%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21 Feb	R1010	622
21 Feb	none	1741	49%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22 Feb	S0038	621
22 Feb	none	1742	61%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23 Feb	S0144	620
23 Feb	R1263	1743	71%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24 Feb	S0244	619
24 Feb	R1309	1743	81%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25 Feb	S0338	618
25 Feb	R1417	1744	89%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26 Feb	S0426	617
26 Feb	R1526	1745	95%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	27 Feb	S0507	616
27 Feb	R1632	1746	99%	.....XXXXXXXXXX	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28 Feb	S0544	615

- (....) indicates Sun above horizon
- (XXXX) indicates Moon below horizon
- (0000) indicates Moonlight level less than .003 lux and moon not 23% illuminated or not 30 deg above horizon or neither
- ( ) indicates Moonlight level greater than or equal to .003 lux but moon not 23% illuminated or not 30 deg above horizon
- (---) indicates the Moon is at least 23 percent illuminated and at least 30 degrees above the horizon

\*\*\*\*\* Data provided by U.S. Army Aeromedical Research Laboratory \*\*\*\*\*

\*\*\*\*\* Light level planning calendar, Clear sky condition \*\*\*\*\*  
 Latitude N 25 degrees 22 minutes Longitude E 45 degrees 3 minutes

1 March 1951 to 31 March 1951

For	Moon	Sun	AM	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	For	Moon	Sun
PM on	R/S	set	2400	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	AM on	R/S	rise
1 Mar	R1838	1747	98%	.....	XXXXX00															2 Mar	S0650	613
2 Mar	R1938	1748	95%	.....	XXXXXXXXXX00															3 Mar	S0722	612
3 Mar	R2038	1748	89%	.....	XXXXXXXXXXXXXXXX000															4 Mar	S0755	611
4 Mar	R2136	1749	82%	.....	XXXXXXXXXXXXXXXXXXXX0000															5 Mar	S0831	610
5 Mar	R2234	1750	74%	.....	XXXXXXXXXXXXXXXXXXXXXXXX00000															6 Mar	S0909	609
6 Mar	R2331	1750	65%	.....	XXXXXXXXXXXXXXXXXXXXXXXXXXXX000000															7 Mar	S0952	608
7 Mar	none	1751	55%	.....	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX00000000															8 Mar	S1026	607
8 Mar	none	1752	46%	.....	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX000000000															9 Mar	S1118	606
9 Mar	none	1752	37%	.....	XX00000000000															10 Mar	S1205	604
10 Mar	S1223	1753	28%	.....	XX000000000000000															11 Mar	S1248	603
11 Mar	S1319	1753	20%	.....	XX000000000000000000															12 Mar	S1327	602
12 Mar	S1417	1754	12%	.....	XX0000000000000000000															13 Mar	S1403	601
13 Mar	S1514	1755	7%	.....	XX0000000000000000000															14 Mar	S1436	560
14 Mar	S1613	1755	2%	.....	XX0000000000000000000															15 Mar	S1508	559
15 Mar	S1711	1756	0%	.....	XX0000000000000000000															16 Mar	S1539	557
16 Mar	S1811	1756	1%	.....	OGXX0000000000000000000															17 Mar	S1611	556
17 Mar	S1913	1757	3%	.....	OG0000000XX0000000000000000000															18 Mar	S1646	555
18 Mar	S2017	1758	8%	.....	OG0000000000000XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX0000000000000000000															19 Mar	S1724	554
19 Mar	S2123	1758	15%	.....	OG00000000000000000000000XXXXXXXXXXXXXXXXXXXX0000000000000000000															20 Mar	S1808	553
20 Mar	S2230	1759	24%	.....	OG00000000000000000000000000000XXXXXXXXXXXX0000000000000000000															21 Mar	S1859	552
21 Mar	S2336	1759	34%	.....	OG000															22 Mar	S1956	550
22 Mar	none	1800	46%	.....	OG000															23 Mar	S2038	549
23 Mar	none	1801	57%	.....	OG000															24 Mar	S2134	548
24 Mar	R1207	1801	68%	.....	OG000															25 Mar	S2222	547
25 Mar	R1314	1802	78%	.....	OG000															26 Mar	S2304	546
26 Mar	R1419	1802	87%	.....	OG000															27 Mar	S2341	545
27 Mar	R1523	1803	93%	.....	OG000															28 Mar	S2415	543
28 Mar	R1624	1804	98%	.....	OG000															29 Mar	S2448	542
29 Mar	R1724	1804	100%	.....	OG000															30 Mar	S2520	541
30 Mar	R1823	1805	99%	.....	XIX															31 Mar	S2552	540
Date	R/S	Sun	AM	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	Date	R/S	Sun
		set	2400	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800			rise

(....) indicates Sun above horizon  
 (XXXX) indicates Moon below horizon  
 (0000) indicates Moonlight level less than .063 lux and moon not 23% illuminated or not 30 deg above horizon or neither  
 ( ) indicates Moonlight level greater than or equal to .063 lux but moon not 23% illuminated or not 30 deg above horizon  
 (----) indicates the Moon is at least 23 percent illuminated and at least 30 degrees above the horizon

\*\*\*\*\* Data provided by U.S. Army Aeromedical Research Laboratory \*\*\*\*\*





\*\*\*\*\* Light level planning calendar, Clear sky condition \*\*\*\*\*  
 Latitude 1 29 degrees 22 minutes Longitude 2 48 degrees 0 minutes

1 June 1991 to 30 June 1991

Per	Moon	Sun	Time	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	Per	Moon	Sun	
PH	on	R/S	set	2400	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	AM	on	R/S	rise
1 Jun	R2154	1843	84%																	2 Jun	S0845	449	
2 Jun	R2229	1843	76%																	3 Jun	S0934	449	
3 Jun	R2301	1844	67%																	4 Jun	S1033	449	
4 Jun	R2331	1844	58%																	5 Jun	S1128	448	
5 Jun	none	1845	48%																	6 Jun	R0021	448	
6 Jun	S1224	1845	38%																	7 Jun	R0032	448	
7 Jun	S1323	1846	27%																	8 Jun	R0106	448	
8 Jun	S1425	1846	18%																	9 Jun	R0143	448	
9 Jun	S1532	1846	10%																	10 Jun	R0227	448	
10 Jun	S1641	1847	4%																	11 Jun	R0318	448	
11 Jun	S1751	1847	1%																	12 Jun	R0417	448	
12 Jun	S1859	1848	0%																	13 Jun	R0524	448	
13 Jun	S2000	1848	3%																	14 Jun	R0635	448	
14 Jun	S2053	1848	8%																	15 Jun	R0747	448	
15 Jun	S2139	1849	16%																	16 Jun	R0854	448	
16 Jun	S2218	1849	26%																	17 Jun	R1012	448	
17 Jun	S2253	1849	36%																	18 Jun	R1144	448	
18 Jun	S2325	1850	47%																	19 Jun	none	449	
19 Jun	S2357	1850	57%																	20 Jun	none	449	
20 Jun	none	1850	67%																	21 Jun	S0829	449	
21 Jun	R1359	1850	76%																	22 Jun	S0915	449	
22 Jun	R1456	1851	84%																	23 Jun	S0948	449	
23 Jun	R1552	1851	91%																	24 Jun	S0927	450	
24 Jun	R1648	1851	95%																	25 Jun	S0855	450	
25 Jun	R1741	1851	99%																	26 Jun	S0835	450	
26 Jun	R1830	1851	100%																	27 Jun	S0444	450	
27 Jun	R1915	1851	99%																	28 Jun	S0543	451	
28 Jun	R1955	1851	97%																	29 Jun	S0634	451	
29 Jun	R2031	1851	93%																	30 Jun	S0733	451	
Date	R/S	Sun	%Illum	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	Date	R/S	Sun	
Moon	set	2400	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	Moon	rise			

(....) indicates Sun above horizon  
 (....) indicates Moon below horizon  
 (0000) indicates Moonlight Level less than .003 lux and moon not 23% illuminated or not 30 deg above horizon or neither  
 ( ) indicates Moonlight Level greater than or equal to .003 lux but moon not 23% illuminated or not 30 deg above horizon  
 (---) indicates the Moon is at least 23 percent illuminated and at least 30 degrees above the horizon

\*\*\*\*\* Data provided by U.S. Army Aeronomedical Research Laboratory \*\*\*\*\*

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## SECTION III

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# NVG TERRAIN FLIGHT

**T**he type of terrain along the flight path should be considered when planning an NVG mission in the desert. This section describes characteristics of the three most prevalent types of terrain in Southwest Asian deserts (scrub, dry lake beds, and sand dunes) and key terrain flight considerations for each.

## A. SCRUB DESERT TERRAIN

---

### CHARACTERISTICS

- Light-colored sand with low, uneven surface.
- Single dune may occur in isolation within scrub.
- Sparse to medium vegetation consisting of small trees, bushes, and low-growing plants.
- Areas of loose sand should be expected (especially in bivouac areas and where vehicular traffic has broken the surface).
- Bedouin camps are more frequent in scrub areas than other types of terrain.
- Major visual cues provided by vegetation, vehicle tracks, and camel tracks.

### NOE FLIGHT

- Sparsely vegetated areas provide poor visual cues.
- Altitude estimation in sparse scrub difficult without radar altimeter.
- Rolling terrain difficult to detect.
- Transition from moderately to sparsely vegetated areas causes loss of visual cues and contrast.
- Crew coordination and scanning important (uninterrupted scan of flight path essential).
- Medium density vegetation provides good contrast.
- Left (red) position light aids terrain feature detection at low altitudes (see Section VII-C: Position Lights).

### CONTOUR FLIGHT

- Most unforgiving profile.
- Altitude determination and acquisition of visual cues difficult in sparsely vegetated areas.
- Tend to inadvertently descend to acquire visual cues.
- Frequent altitude callout required.
- Crew coordination and scanning critical (uninterrupted scan of flight path essential).
- ATM maximum airspeeds for contour flight above 80 feet AHO can be exceeded provided adequate illumination levels exist and associated risks have been considered (see Section V-A: Airspeed Limitations and Section VI: NVG Mission Airspeed and Altitude Planning Figures).

### LOW-LEVEL FLIGHT

- Similar to VFR on top/instrument flight due to loss of horizon (caused by sand, dust, haze, or fog).
- Loss of ground visual cues and contrast.
- Crew coordination and scanning important.
- Step down to land (40-50 kts to 80 ft AGL) (see Section V-C: Approach to Visibility Altitude).
- Obstacle clearance assured if map and route reconnaissance conducted.
- ATM maximum airspeeds for low level (AHO) can be exceeded provided adequate illumination levels exist and associated risks have been considered (see Section V-A: Airspeed Limitations and Section VI: NVG Mission Airspeed and Altitude Planning Figures).

## B. DRY LAKE BED DESERT TERRAIN

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### CHARACTERISTICS

- Dark-colored sand with a hard crust, very flat.
- Single dune may occur in isolation within dry lake bed.
- Little if any vegetation.

- Normally, no loose sand except where vehicle traffic has broken surface.

- Major visual cues provided by vehicle tracks and surface cracks.

- Rise in terrain may be very rapid when transitioning to dune area.

- Loss of visual reference more likely at higher altitudes due to lack of terrain features.

- Few navigational landmarks.

### NOE FLIGHT

- When less than 20 feet AGL, take care to avoid fences, large oil pipes, etc.

- Be aware of tendency to unintentionally increase airspeed over flat terrain.

- Crew coordination and scanning important (uninterrupted scan of flight path essential).

- Good texture (dark, crusty surface and vehicle tracks).

- Contrast between lake bed and dune areas is high.

- Left (red) position light aids terrain feature detection at low altitudes (see Section VII-C: Position Lights).

- Maximum ATM NOE airspeed is attainable (knowledge of highest obstacle and location of terrain transition required).

### CONTOUR FLIGHT

- Most unforgiving profile.

- Crew coordination and scanning critical (uninterrupted scan of flight path essential).

- Altitude estimation without radar altimeter difficult.

- Frequent altitude callout is required.

- Transition to other terrain hazardous if not anticipated.

- Be aware of tendency to unintentionally descend to better acquire visual cues.

- Vehicle tracks and ground texture provide visual cues but are harder to detect at contour level than at NOE.

- ATM maximum airspeeds for contour flight above 80 feet AHO can be exceeded provided adequate illumination levels exist and associated risks have been considered (see Section V-A:

Airspeed Limitations and Section VI: NVG Mission Airspeed and Altitude Planning Figures).

### LOW-LEVEL FLIGHT

- Similar to VFR on top/instrument flight due to loss of horizon (caused by sand, dust, haze, or fog) and false horizon (caused by light-colored sand surrounding lake bed blending in with night sky).

- Loss of ground visual cues and contrast.

- Obstacle clearance assured if map and route reconnaissance conducted.

- Crew coordination and scanning important.

- Step down to land (40-50 kts to 80 ft AGL) (see Section V-C: Approach to Visibility Altitude).

- ATM maximum airspeeds for low level (AHO) can be exceeded provided adequate illumination levels exist and associated risks have been considered (see Section V-A: Airspeed Limitations and Section VI: NVG Mission Airspeed and Altitude Planning Figures).

## C. SAND DUNE DESERT TERRAIN

### CHARACTERISTICS

- Light- to medium-colored sand.

- Windward side: gradual convex slope.

- Leeward side: sharp concave wall.

- Single dune may occur in isolation within either scrub or dry lake bed.

- Vegetation is sparse to nonexistent.

- Many large areas contain no terrain features.

- Camel/vehicle tracks and wind ripples in the sand may be found in low ground between dunes and provide good visual cues.

### SPECIAL NOTES ON SAND DUNE AREAS

- *Stay out* (avoid if possible).

- If avoidance is not possible—

- *Do not* fly straight line over dunes in NOE or contour flight modes. Maneuver around rather than over dunes.

- As you enter the dunes, plan an approach to an area in dunes with definition and contrast as in a confined area operation. After the approach, establish visual contact with the ground before

proceeding on the planned route.

- Loose sand can be expected everywhere in dunes.

## NOE FLIGHT

- If required to operate in the dunes—

- Maneuver around rather than over dunes.

Straight-line NOE flight extremely hazardous.

- **WARNING:** Anticipate frequent occurrence of deadends in pathways through dune areas.

- As you enter the dunes, plan an approach to an area in dunes with definition and contrast as in a confined area operation. After the approach, establish visual contact with the ground before proceeding on the planned route.

- Airspeeds:

- Airspeeds lower than ATM NOE maximums required during periods of low illumination (see Section VI: NVG Mission Airspeed and Altitude Planning Figures).

- Recommend airspeed above ETL to stay clear of rotor-induced blowing sand.

- Crew coordination and scanning important (uninterrupted scan of flight path essential).

- Visual cues at NOE:

- Camel and vehicle tracks.
  - Wind ripples in the sand.
  - Slope of surrounding dunes.
  - Some brush.

- Contrast between dry lake bed and dunes.

- Left (red) position light aids terrain feature detection at low altitudes (see Section VII-C: Position Lights).

## CONTOUR FLIGHT

- Most unforgiving profile. **NOT RECOMMENDED** but if necessary—

- Contour below 80 feet AHO—Maneuver around rather than over dunes.

- Contour above 80 feet AHO—Traverse at 100 feet AHO and travel shortest distance through area.

- **WARNING:** Knowledge of highest obstacle (sand dune) required but remember dune height may change due to blowing sand.

- Altitude determination very difficult due to loss of most ground visual cues.

- May require reference to basic flight instruments.

- Radar altimeter a must. (Pilots have been observed to misjudge altitude by plus or minus 70 feet without use of radar altimeter.)

- Frequent altitude callout required.

- Crew coordination and scanning critical (uninterrupted scan of flight path essential).

## LOW-LEVEL FLIGHT

- Similar to VFR on top/instrument flight due to loss of horizon (caused by sand, dust, haze, or fog).

- Loss of ground visual cues and contrast.

- Frequent altitude callout required due to difficulties in determining altitude.

- Obstacle clearance assured if map and route reconnaissance conducted.

- If required to land, extreme caution must be exercised (see Section V-C: Approach to Visibility Altitude).

- Crew coordination and scanning important.

- ATM maximum airspeeds for low level (AHO) can be exceeded provided adequate illumination levels exist and associated risks have been considered (see Section V-A: Airspeed Limitations and Section VI: NVG Mission Airspeed and Altitude Planning Figures).

## D. TERRAIN TRANSITION

### TERRAIN TRANSITION IDENTIFICATION

- Route reconnaissance should be performed, if possible, and hazard maps developed that identify transition areas.

- *Transition characteristics.*

- Terrain transitions can be identified by watching for changes in contrast, texture, and other visual cues.

- Change to light-colored sand without vegetation indicates you may be entering a sand dune area.

- Change to dark, crusty surface without vegetation indicates you may be entering dry lake bed area.

- Change to sparse vegetation indicates

you may be entering or leaving scrub area.

■ *Identification during various flight modes.*

• **Contour above 80 feet AHO and low level flight:** Best mode of flight for early identification of transition areas and obstacle avoidance.

• **Contour flight below 80 feet AHO:** Transition may be abrupt and obstacle avoidance is not assured when transitioning to scrub-free sand or dunes. **Most unforgiving profile.**

• **NOE:** Transition will be obvious but may be abrupt. Obstacle avoidance is not assured. Slow airspeed and low altitude provide best visual cues and reaction time.

**PROBLEMS ENCOUNTERED**

■ At NOE and contour flight altitudes, visual cues may start to become obscure. When this occurs, the pilot must decide to either—

• Go lower and slower. This provides for acquisition of visual cues and increases reaction time; however, obstacle avoidance is not assured.

OR

• **Climb.** This will increase probability of obstacle avoidance. However, visual contact with the ground will be degraded or lost. If contact is lost, the unit's plan for re-establishment of ground reference should be executed.

■ The amount of illumination, contrast, and obscuration, as well as position of the moon, can affect the distance at which you can see (and react to) terrain transition.

■ Transition from high to low contrast (dark to light sand, scrub to non-scrub) is most difficult due to loss of visual cues:

• Dry lake bed (dark) transitioning to flat sand or dunes (light).

• Scrub transitioning to flat sand or dunes.

■ **Transition to dune area.** As you enter the dunes, plan an approach to an area in dunes with definition and contrast as in a confined area operation. After the approach, establish visual contact with the ground before proceeding on the planned route.

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## SECTION IV

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# VISUAL ILLUSIONS

**I**t is critical that pilots be familiar with visual illusions that may affect safe NVG flight. Each visual illusion listed in Chapter 1 of TC 1-204 can occur in the desert environment. Discussed below are the illusions most frequently encountered in Southwest Asia and ways to overcome them.

## A. FALSE HORIZON OR LACK OF HORIZON

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**DESCRIPTION.** Correct identification of real horizon may be hindered by—

- False horizon created by light-colored area surrounding dark area blending with night sky (e.g., sand dunes bordering dry lake bed).
- Sand, dust, haze, or fog obscuring the horizon.

### HOW TO COMBAT

- Cross-check attitude indicator and increase scan for identification of reliable visual cues.
- Direct assistance from crewmembers to correctly identify horizon.

## B. HEIGHT PERCEPTION ILLUSION

---

**DESCRIPTION.** Sensation of being higher or lower than you actually are due to poor contrast and lack of visual references. This may result in a tendency to inadvertently descend to acquire visual cues.

### HOW TO COMBAT

- Cross-check radar or barometric altimeter.
- Direct assistance from crewmembers for altitude determination.
- Decelerate, then descend slowly to obtain

visual cues.

- Look for any shadows cast by near objects.
- Drop chemical stick for ground reference.

## C. GROUND LIGHT MISINTERPRETATION

---

**DESCRIPTION.** Confusing ground lights with stars or other aircraft. When ground lights are confused with stars, aviators unknowingly position the aircraft in unusual attitudes to keep ground lights (believed to be stars) above the aircraft. When ground lights are confused with other aircraft, aviators adjust attitude incorrectly based on relative position of misinterpreted ground light.

### HOW TO COMBAT

- Check attitude indicator.
- Direct crewmember assistance to confirm source of light and aircraft attitude.
- Increase scan for more reliable cues on aircraft attitude and source of light.

## D. FIXATION

---

**DESCRIPTION.** Fixing attention on high interest targets/objects and ignoring orientation cues. This results in missing cues critical to safe flight such as aircraft-ground closure rate.

### HOW TO COMBAT

- Be aware of the tendency to stare at high interest targets.
- Do not stare at any location/point for more than 2 or 3 seconds.
- Increase frequency of scan.
- Direct crew assistance.

## **E. CRATER ILLUSION (not discussed in TC 1-204)**

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**DESCRIPTION.** Viewing the periphery of the IR band-pass filter (pink light) or IR searchlight gives the illusion that flat terrain slopes upward. Viewing another aircraft landing using the pink light or IR searchlight can give the illusion that the observed aircraft is descending into a crater when the terrain is actually flat.

### **HOW TO COMBAT**

- Knowledge and awareness of the illusion.
- Conduct thorough map and route reconnaissance to identify terrain features/contour.
- Conduct high and low recon prior to landing.
- Sweep searchlight laterally for terrain cues.
- Scan past pink light limits.

## **F. LACK OF MOTION PERCEPTION (MOTION PARALLAX)**

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**DESCRIPTION.** At low level flight mode altitudes, the lack of discernible terrain features may result in perception of near zero groundspeed.

### **HOW TO COMBAT**

- Refer to airspeed indicator. (NOTE: Airspeed indicators are typically unreliable below 20 kts IAS.)
- Direct crewmember assistance for airspeed callout.

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## SECTION V

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# NVG MISSION PLANNING

**P**lanning for NVG missions includes all daytime planning considerations but must be more detailed. Extra planning time must be provided whenever possible. The following are planning considerations specific to South-west Asia.

## A. AIRSPEED LIMITATIONS

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**NOE & CONTOUR ALTITUDES BELOW 80 FEET AHO.** Airspeed limitations for NVG missions specified by each individual aircraft ATM shall not be exceeded.

### CONTOUR & LOW LEVEL ALTITUDES ABOVE 80 FEET AHO

■ Mission demands may dictate a faster airspeed than currently listed in the ATM.

■ Exceeding ATM airspeeds above 80 feet AHO is authorized *provided* commanders consider the associated risks. Faster airspeed is mission, enemy, terrain, troops, and time (METT-T) dependent. Use of higher airspeeds will increase overall mission risk.

■ **CAUTION:** Higher airspeeds may cause the aviator to exceed his capability to detect and avoid obstacles.

■ Visual contact with terrain is preferred for orientation, but may be degraded or lost at altitudes above 80 feet AHO.

## B. PHASES OF FLIGHT

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### TAKEOFF

■ Assume that conditions for brownout exist and may be amplified by other aircraft operating in close proximity.

■ Minimize obscuration by accelerating above ETL as quickly as practicable, or using altitude

over airspeed technique.

■ Increased crew coordination and scanning is required (see Section VIII: Crew Coordination & Scanning).

### EN ROUTE

■ A thorough route reconnaissance (map, intelligence, scout, etc.) is essential to reduce risk within the flight corridor/route.

■ In addition to basic METT-T and NVG specific METT-T considerations (see Section IX-D), the following are significant factors in determining mission airspeeds:

- Illumination levels.
- Obstacles.
- Number and type of aircraft.
- Aircraft exterior lighting.

■ NVG mission airspeed and altitude planning figures in Section VI—

• Should be used by the commander to aid in determining altitudes AHO and maximum airspeeds over different types of terrain.

• Should be used in risk assessment, training, and operational planning.

• Do not represent all types of terrain that may be encountered.

• Should not be construed as regulatory in nature.

• Should not be used until familiar with the precautions and directions for use discussed in Sections VI-A & B.

■ Transitioning from the faster en route airspeeds to lower airspeeds in contour, NOE, and landing configurations requires detailed planning (see sections on "Landing" and "Approach to Visibility Altitude" below).

### LANDING

■ Landing zones.

• An area should be identified that has minimal loose dirt/sand, if possible.

• A crosswind landing that allows for increased visibility may benefit a formation.

• If more than one sortie into the same LZ/PZ is expected, the first flight of aircraft into the area could set up an inverted "Y", using clear bottles of water with chemical sticks inside.

• CH-47s may require close-in "Y" and far-out "T" to maintain hover position in the LZ/PZ.

• If available, Pathfinders should be used to direct aircraft.

■ Approach to landing zones.

• Prior to conducting mission, it is important to determine the distance from the LZ/PZ that an aircraft or formation should start decelerating. (KEY is to gradually slow down.)

□ When traveling as single aircraft or in a small formation, deceleration should begin approximately 3 to 5 kilometers from the LZ/PZ.

□ Larger formations should begin deceleration approximately 5 to 8 kilometers from the LZ/PZ.

□ **RULE OF THUMB**—Decrease airspeed 20 knots per kilometer.

• Descents should be gradual:

□ Avoid rapid changes in altitude.

□ Rapid changes in airspeed may degrade pilots' viewing perspective outside aircraft or induce spatial disorientation.

• Best landing procedure is shallow approach angle and touchdown with slight forward movement. If disorientation occurs at any time during the approach, apply power and execute a go-around. If go-around is not feasible, attempt to maneuver the aircraft forward and down to limit the possibility of touchdown with sideward or rearward movement.

• During the approach it is essential that crew chiefs/observers call out location of the dust cloud

and the ground in relation to the aircraft.

■ Rate of descent, altitude, and drift should be constantly monitored.

## **C. APPROACH TO VISIBILITY ALTITUDE**

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■ When descending from altitudes above 100 feet AHO, the pilot should slowly step down to an altitude where visual ground reference can be acquired and maintained, then execute an approach from that altitude.

■ Altitude of approximately 80 feet has been determined to be sufficient for gaining ground reference in most situations. This altitude will vary with terrain type, illumination, and obscuration.

■ Recommend that an approach airspeed less than cruise (perhaps as slow as 40-50 kts) be maintained until reaching the visibility altitude.

■ Monitor rate of descent using VSI.

## **D. HOVER OGE**

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■ One of the most demanding maneuvers in the desert, especially with limited illumination and visual cues.

■ Pilot on the flight controls must maintain visual reference with the ground throughout this maneuver.

■ Radar altimeter is critical, and continuous callouts by pilot not on the flight controls is required (see Section VIII: Crew Coordination & Scanning).

■ Some types of aircraft (e.g., CH-47, UH-60) may experience brownout conditions as high as 60 feet AGL during OGE maneuvers.

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## SECTION VI

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# NVG MISSION AIRSPEED AND ALTITUDE PLANNING FIGURES

**T**he figures below provide altitude and airspeed *recommendations* (clear nights) developed for three prevalent types of terrain in Southwest Asia under various levels of moon illumination. These figures do not represent all types of terrain that may be encountered and *should not be construed as regulatory in nature*.

## A. IMPORTANT PRECAUTIONS

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The following are points to keep in mind when using the figures below to plan NVG missions.

### NO SAFETY MARGIN IS INCLUDED IN FIGURES.

- Knowledge of highest obstacle is required.
- Airspeeds presented in figures are **RECOMMENDED MAXIMUMS**. Airspeeds must be chosen with consideration of crew experience and mission demands.
- Maximum airspeed data are based on test flights in UH-1 aircraft using highly experienced instructor pilots.
- Response time of aircraft will vary with gross weight and density altitude.

## B. USE OF FIGURES

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■ Figures are provided for three terrain types (scrub, dry lake bed, and sand dunes). Each figure shows maximum recommended airspeeds for four altitudes representing NOE, contour, and low-level flight according to the amount of moon illumination present.

• The horizontal axis is percent of the moon illuminated (assumes moon angle 60 degrees or more above horizon).

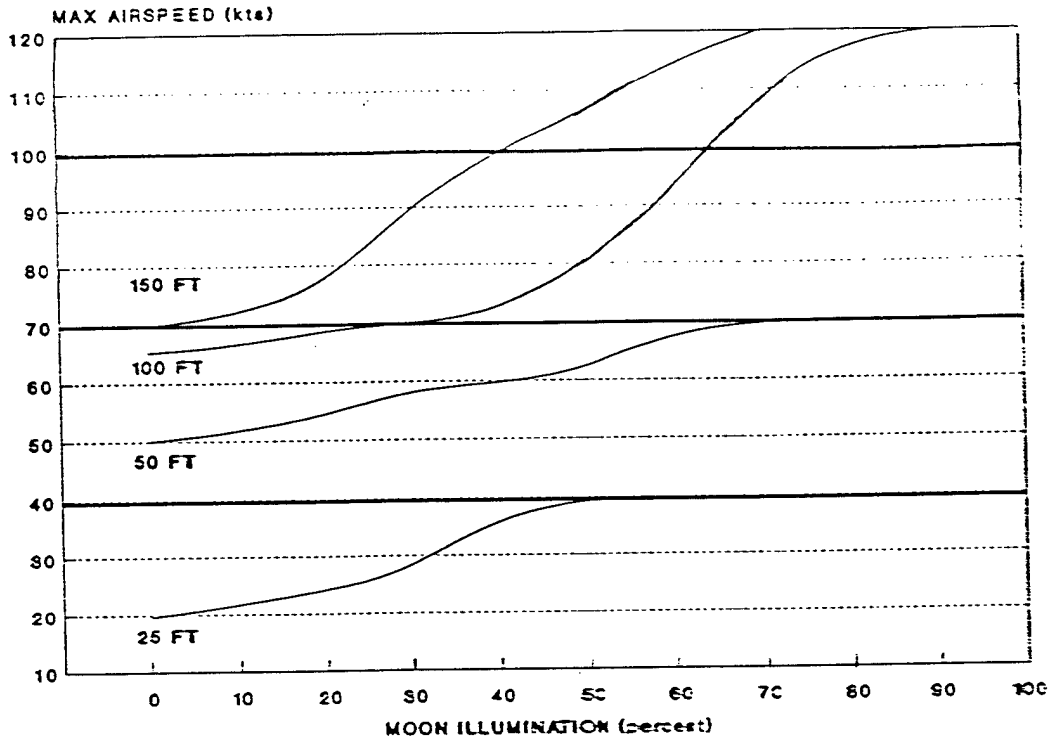
• The vertical axis is maximum airspeed for safe flight over the indicated terrain type. (*No safety margin included.*)

• ATM airspeed limits for NOE, contour, and low-level flight modes (40, 70, and 100 kts) are indicated by dark horizontal lines.

• Curved lines representing maximum airspeeds are plotted for each of four altitudes that correspond roughly to the three modes of terrain flight (NOE at 25 feet or less, contour at 50 and 100 feet, and low level at 150 feet).

• Important points about each mode of flight for each terrain are included below the figure (also see Section III: NVG Terrain Flight).

## TERRAIN: SCRUB



EXAMPLE: AT 20% ILLUM - PLANNED NOE FLIGHT (25) - MAX SAFE AS = 25 KTS

- FUNCTIONS REPRESENT MAXIMUM RECOMMENDED AIRSPEED WITH NO SAFETY MARGIN
- DATA DERIVED FROM UH-1H (WITH RADAR ALTIMETER) AT MOON ANGLES ABOVE 60 DEGREES WITH REPORTED VISIBILITY IN EXCESS OF 7 MILES
- DATA MAY NOT BE REPRESENTATIVE OF ALL TYPES OF SCRUB TERRAIN
- ALL ALTITUDES ARE AHO

### NOE:

- VEGETATION PROVIDES RELIABLE CUES
- ROLLING TERRAIN DIFFICULT TO PERCEIVE
- ALTITUDE ESTIMATION IN SPARSE SCRUB DIFFICULT

### CONTOUR:

- MOST UNFORGIVING FLIGHT PROFILE
- TENDENCY TO INADVERTENTLY DESCEND TO ACQUIRE VISUAL CUES
- FREQUENT ALTITUDE CALL-OUT IS REQUIRED
- CREW COORDINATION AND SCANNING CRITICAL
- TRANSITION TO OTHER TERRAIN HAZARDOUS IF NOT ANTICIPATED (SEE SECTION III-D)

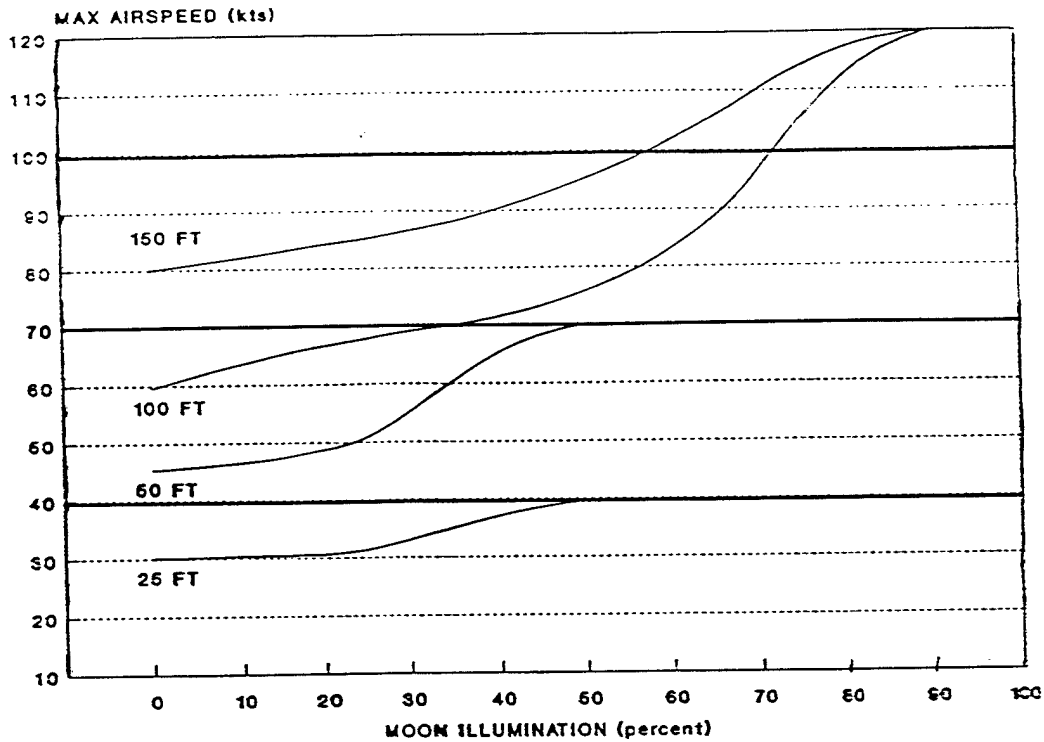
### LOW LEVEL:

- MOST GROUND VISUAL CUES LOST
- MAY REQUIRE REFERENCE TO BASIC FLIGHT INSTRUMENTS
- DESCENT TO VISIBILITY ALT REQUIRED FOR APPROACH/LANDING (SEE SECTION V-C)

### OTHER PLANNING CONSIDERATIONS:

- MOON POSITION (SEE SECTION II-A)
- USE OF A/C LIGHTING (SEE SECTION VII-B & C)
- VISUAL ILLUSIONS (SEE SECTION IV)
- VISUAL CUES FOR TERRAIN TRANSITION (SEE SECTION III-D)

TERRAIN: DRY LAKE BED



EXAMPLE: AT 40% ILLUM—CONTOUR FLIGHT 50' AHO—MAX SAFE A/S = 66 KTS

- FUNCTIONS REPRESENT MAXIMUM RECOMMENDED AIRSPEED WITH NO SAFETY MARGIN
- DATA DERIVED FROM UH-1H (WITH RADAR ALTIMETER) AT MOON ANGLES ABOVE 60 DEGREES WITH REPORTED VISIBILITY IN EXCESS OF 7 MILES
- DATA MAY NOT BE REPRESENTATIVE OF ALL TYPES OF DRY LAKE BED
- ALL ALTITUDES ARE AHO

NOE:

- TENDENCY TO INCREASE AIRSPEED OVER FLAT TERRAIN
- VEHICLE TRACKS AND CRACKS IN LAKE BED PROVIDE RELIABLE CUES
- FEW NAVIGATIONAL LANDMARKS
- CONTRAST BETWEEN LAKE BED AND DUNE AREAS IS HIGH

CONTOUR:

- FREQUENT ALTITUDE CALL-OUT IS REQUIRED
- CREW COORDINATION AND SCANNING CRITICAL
- TENDENCY TO INADVERTENTLY DESCEND TO ACQUIRE VISUAL CUES
- TRANSITION TO OTHER TERRAIN HAZARDOUS IF NOT ANTICIPATED (SEE SECTION III-D)

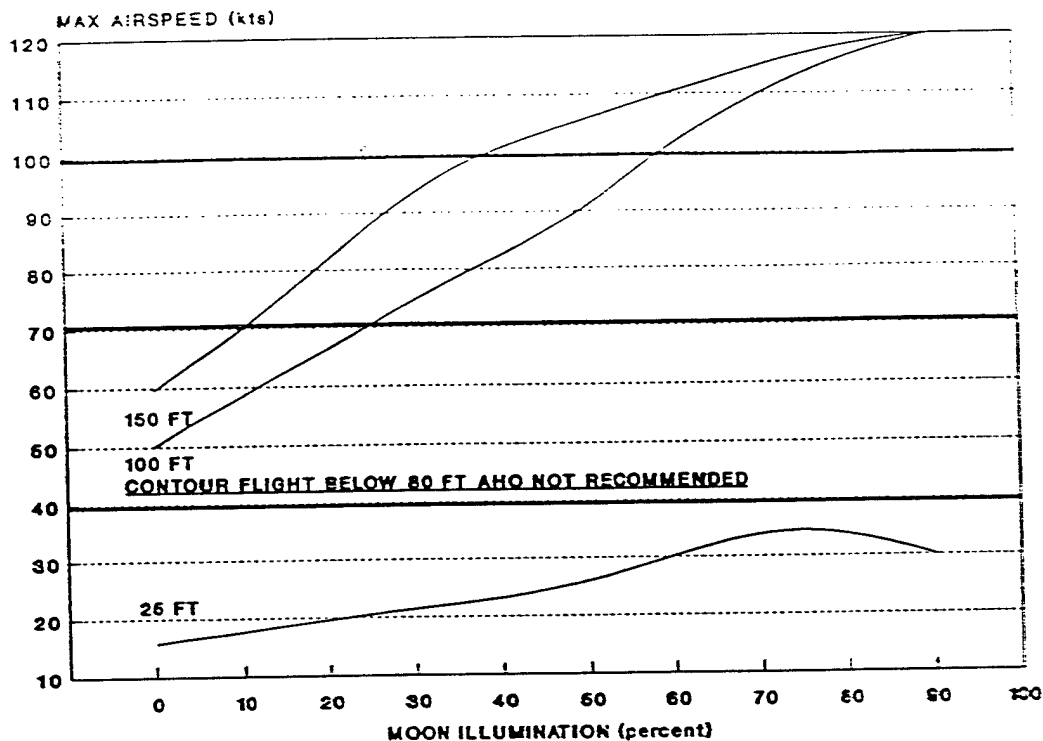
LOW LEVEL:

- MOST GROUND VISUAL CUES LOST
- MAY REQUIRE REFERENCE TO BASIC FLIGHT INSTRUMENTS
- DESCENT TO VISIBILITY ALT REQUIRED FOR APPROACH/LANDING (SEE SECTION V-C)
- FALSE HORIZONS OCCUR FREQUENTLY (LIGHT-COLORED SAND THAT SURROUNDS LAKE BED BLENDS IN WITH NIGHT SKY)

OTHER PLANNING CONSIDERATIONS:

- MOON POSITION (SEE SECTION II-A)
- USE OF A/C LIGHTING (SEE SECTION VII-B & C)
- VISUAL ILLUSIONS (SEE SECTION IV)
- VISUAL CUES FOR TERRAIN TRANSITION (SEE SECTION III-D)

## TERRAIN: SAND DUNES



EXAMPLE: AT 70% ILLUM-PLANNED LOW LEVEL FLT 100' AHO-A/S = 110 KTS

- FUNCTIONS REPRESENT MAXIMUM RECOMMENDED AIRSPEED WITH NO SAFETY MARGIN
- DATA DERIVED FROM UH-1H (WITH RADAR ALTIMETER) AT MOON ANGLES ABOVE 60 DEGREES WITH REPORTED VISIBILITY IN EXCESS OF 7 MILES
- DATA MAY NOT BE REPRESENTATIVE OF ALL TYPES OF DUNE TERRAIN
- ALL ALTITUDES ARE AHO

### VISUAL ILLUSIONS OCCUR FREQUENTLY AT ALL ALTITUDES

#### NOE:

- STRAIGHT-LINE NOE OVER DUNES EXTREMELY HAZARDOUS
- FOLLOW LOW GROUND BETWEEN DUNES: SPARSE SCRUB, VEHICLE AND CAMEL TRACKS PROVIDE GOOD CUES

### CONTOUR BELOW 80 FEET AHO NOT RECOMMENDED

#### CONTOUR ABOVE 80 FEET AHO AND LOW LEVEL:

- MAY REQUIRE REFERENCE TO BASIC FLIGHT INSTRUMENTS
- MOST GROUND VISUAL CUES LOST
- DESCENT TO VISIBILITY ALT NOT RECOMMENDED FOR APPROACH/LANDING.  
IF REQUIRED, USE EXTREME CAUTION (SEE SECTION V-C)
- PRIOR KNOWLEDGE OF HIGHEST OBSTACLE REQUIRED
- REQUIRES ALTITUDE CALL-OUT WITH INCREASED CREW COORDINATION AND SCANNING

#### OTHER PLANNING CONSIDERATIONS:

- MOON POSITION (SEE SECTION II-A)
- USE OF A/C LIGHTING (SEE SECTIONS VII-B & C)
- VISUAL ILLUSIONS (SEE SECTION IV)
- VISUAL CUES FOR TERRAIN TRANSITION (SEE SECTION III-D)

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## SECTION VII

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# EQUIPMENT

**T**he desert requires a thorough understanding of normal equipment as well as innovations developed specifically for this environment. It is important for crewmembers to know the capabilities and limitations of the following equipment.

## A. NAVIGATION

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- GPS is the most accurate navigation tool.
- LORAN and OMEGA are next best.
- Doppler is good if update points can be identified.
- Use non-directional beacons available in ATC units and post grid locations as well as latitude and longitude coordinates.
- Other considerations:
  - Aviation-related intelligence must be actively pursued (i.e., to document wires, towers, and terrain relief).
  - Whenever possible, conduct a route reconnaissance.
  - Close attention must be paid to the few contour lines and contour intervals shown on maps.
  - Time, distance, and heading must be used in addition to the above.

## B. BAND-PASS FILTER (PINK LIGHT)

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- Best altitude for use is approximately 80 feet AGL and below.
- Best bulb is 150w, 7,000cp, P/N 4571, NSN 6240-00-690-1094 (if rheostat light control not available).
- Most effective at near zero illumination levels.
- Can cause terrain washout at illumination percentages of 30% and above.
- Tends to limit pilots' scan to within area of

beam spread; a corresponding reduction in airspeed should be considered.

- Pilot may incorrectly infer terrain transition or change in ground slope based on artificial edge produced by beam.
- May cause brownout when used below ETL due to reflection from dust in rotorwash.
- Light- and heat-emitting active source that persists after light is extinguished, providing target for enemy sensors.
- In dusty terrain, avoid brownout by switching off during approach.
- Should be a key training tool (i.e., limitations and advantages need to be demonstrated). Use is dependent on terrain, illumination, and pilot's experience level in-theater.

## C. POSITION LIGHTS

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- May help maintain terrain reference during approaches with low to medium illumination levels and pink light off.
- Most illumination provided by red position light on left side of aircraft.
- Active source for enemy to detect; can be partially taped to reduce signature.
- IR position lights assist in maintaining aircraft separation during formation flights.

## D. RADAR ALTIMETER

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- **CAUTION:** Only gives altitude directly beneath aircraft; is not forward-looking (provides no direct measure of terrain ahead).
- Should be required for all flights below 150 feet AGL.
- The most critical flight instrument during contour flight, approaches, and OGE maneuvers. (Pilots have been observed to misjudge altitude by plus or minus 70 feet without use of radar altimeter.)

- Best way to determine altitude from 25 feet AGL up.

- Use (altitude callout) should be incorporated into crew coordination drills.

- Ensure radar altimeter complies with message, DTG 061200Z OCT 87, subject: Night Vision Goggle Operations. No red lighting in cockpit.

- If radar altimeter is red lit, contact maintenance officer to exchange.

## **E. NIGHT VISION GOGGLES**

- AN/AVS-6s should be used for all crewmembers when possible (instead of AN/PVS-5s).

- Care must be taken to keep lenses clean.

- Must strictly adhere to maintenance requirements.

## **F. TERRAIN PERCEPTION ENHANCEMENT KIT (TPEK): AIMING LIGHTS**

### **CAUTIONS**

- The TPEK was not designed as an obstacle avoidance system. At high airspeeds, pilot may have little if any response time to react to an obstacle illuminated by the aiming lights.

- The TPEK is only an aid to flying with ANVIS.

- If the enemy is using night vision equipment, they may be able to detect the IR light source used in the aiming lights.

- The TPEK provides additional visual cues only over upsloping terrain.

### **DESCRIPTION**

- The TPEK includes two infrared (IR) aiming lights mounted on brackets. The aiming light

emits an IR light that appears as a visible spot on the terrain or obstacle.

- The TPEK provides aviators with visual cues of approaching terrain features in the aircraft's flight path. The manufacturer reports obstacle illumination out to a distance of 150 meters.

(During NVG evaluation in the Southwest Asian desert, TPEK illuminated obstacles out to a distance of 400 meters.)

### **ADJUSTMENT**

- As of this publication, a pre-mission flight is required to adjust the aiming lights to the anticipated mission airspeed. Aiming lights **MUST BE RE-ADJUSTED** for airspeed changes. Basic adjustment guidance is found in the Installation/Operation/Maintenance Guide. More detailed instructions are being developed.

- **IF PROPERLY ADJUSTED**, when a TPEK-equipped aircraft approaches an object in the flight path, one or both aiming light spots become visible on the object. Two light spots indicate that the aircraft is on a collision course with the object.

### **OPERATING PRINCIPLES**

- When aimed at a solid object, IR energy is reflected back from the object and is seen as a spot of light through AN/AVS-6s.

- As the aircraft continues to approach an object, light intensity of the spots increases. The intensity of the spots may provide a relative cue to distance between the aircraft and the obstacle.

- The TPEK spots also provide cues that allow greater definition of terrain relief (i.e., tops of ridge lines) seen through the ANVIS imager. The pilot using this information surveys the terrain through the ANVIS and, using the TPEK spots as aids, changes aircraft course to avoid collision with objects.

## SECTION VIII

# CREW COORDINATION AND SCANNING

**E**ffective crew coordination and scanning are critical during desert NVG terrain flight. Basic crew coordination and scanning considerations and procedures are discussed in this section.

## A. CREW COORDINATION

**DEFINITION.** Crew coordination is the interaction between crewmembers (communication) and actions (sequence or timing) necessary for tasks to be performed efficiently, effectively, and safely.

**PLANNING.** Crewmembers should identify mission and flight requirements that will necessitate effective crew communication and proper sequence or timing of crew actions. They should decide what the crew coordination will be to accomplish these requirements and plan to discuss it during pre-mission brief.

■ **EXAMPLE:** Contact Task Force Bravo commander after crossing phase line BLACK.

### RESPONSIBILITIES

■ PIC assigns crew responsibilities during pre-mission brief.

■ Communications and sequence/timing of actions required to perform mission-related tasks efficiently and safely are discussed with all crewmembers and rehearsed (if necessary).

■ PIC amends responsibilities as necessary during mission.

■ **EXAMPLE:** PIC directs that when aircraft reaches PL Black, he will take the controls and the copilot will be responsible for changing the radio to TF Bravo command frequency and making an initial contact with TF Bravo commander.

## PROCEDURES

### ■ *Positive Communication:*

• Communication is positive when sender directs/announces/requests, receiver acknowledges, and sender confirms (based on receiver acknowledgment and/or correct action).

• Use positive communication procedure for critical crew coordination actions.

• Communications should employ standard terminology with specific qualification sufficient to ensure understanding.

• **EXAMPLE:** POC directs PNOC, "Turn on the IR light." PNOC acknowledges, "Roger, IR light on." PNOC's verbal acknowledgment and action of activating IR light serves as POC's confirmation.

### ■ *Direct Assistance:*

• POC directs assistance from non-flying crewmembers that is necessary for efficient, effective, and safe operation of aircraft.

• **EXAMPLE:** POC directs PNOC and CE to perform before-landing check.

### ■ *Announce Decision:*

• Each crewmember announces decisions made or actions planned that affect the performance of duties assigned to other crewmembers.

• **EXAMPLE:** POC (right side) states, "I'm beginning to lose visual reference at this altitude. I'm descending to maintain visual cues."

### ■ *Offer Assistance:*

• Each crewmember offers assistance or information that has been requested by the POC or that the crewmember recognizes is needed by the POC.

• **EXAMPLE:** Continued from the example above—PNOC (left side) clears his area of responsibility and announces "Roger, we're clear down left."

POC=  
Pilot on controls

PNOC=  
Pilot not on controls

PIC=  
Pilot in command

CE=  
Crew chief/observer

■ *Action Sequence / Timing:*

• Each crewmember ensures actions taken are properly sequenced and timed with actions of other crewmembers.

• **EXAMPLE:** POC requests left rear clearance from the CE and does not turn aircraft until clearance has been confirmed by CE.

**GENERAL CONSIDERATIONS**

■ Use of battle-rostered crews may enhance crew coordination.

■ Standardization of critical crew coordination actions will improve not only efficiency, effectiveness, and safety of mission but should also facilitate training and cross crew assignments.

■ Critical crew coordination procedures should be drilled for emergency situations (e.g., loss of ground reference such as brownout and IMC, visual illusions, engine failure).

■ Sound crew coordination procedures implemented in day operations should facilitate positive habit transfer to night/NVG operations.

■ It is the responsibility of every crewmember to

advise POC when ground reference is lost or aircraft appears to be in an unsafe condition.

• PNOC must alert POC any time unanticipated deviation from planned airspeed or altitude occurs.

• During approach it is essential that crew chiefs/observers track location of the dust cloud and alert POC if it appears that the aircraft may become engulfed.

■ If POC recognizes that he is experiencing a visual illusion, he should inform other crewmembers.

■ Efficient crew coordination is critical below 100 feet AGL.

■ Communication must be clear and concise. Use of standard terminology is recommended and encouraged.

**B. SCANNING**

**RESPONSIBILITIES**

■ Scanning responsibilities for each crewmember are presented in the following table.

**Crewmember Scanning Responsibilities**

Pilot Not On Controls (PNOC)	Pilot On Controls (POC)	Non-Rated Crewmember
<b>GENERAL</b>		
<ul style="list-style-type: none"> <li>• Provide continuous information on obstacles and terrain trends (e.g., transition, turns). Use clock method.</li> </ul>	<ul style="list-style-type: none"> <li>• Verbally acknowledge obstacles when visual contact is made.</li> </ul>	<ul style="list-style-type: none"> <li>• Provide information on terrain (e.g., obstacles, transition) and other aircraft. Use clock method.</li> </ul>
<ul style="list-style-type: none"> <li>• Announce when leaving sector of scanning responsibility (e.g., when studying map).</li> </ul>	<ul style="list-style-type: none"> <li>• Acknowledge and enlarge scanning sector when PNOC announces stopping outside scan.</li> <li>• If outside scanning is discontinued, transfer controls or coordinate with other crewmembers to ensure obstacle clearance is maintained.</li> </ul>	<ul style="list-style-type: none"> <li>• Acknowledge and enlarge scanning sector when either pilot or other crewmember announces he is stopping scan of his sector.</li> </ul>

Pilot Not On Controls  
(PNOC)

Pilot On Controls  
(POC)

Non-Rated  
Crewmember

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NOE

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- Scan for cues at all ranges (close, mid- and far-range).

- Provide navigation instructions and feedback regarding airspeed, altitude, descent rate, and system status.

- Primary attention *outside* aircraft (CRITICAL).

- Scan priority should be immediate flight path as airspeed increases.

- Conduct continuous scan that samples near to mid-range cues within intended course of flight for obstacle avoidance.

- Do not fixate.

- Keep attention *outside* (CRITICAL).

- Conduct continuous scan of assigned sector for obstacle avoidance.

- Provide feedback regarding altitude, attitude, and descent rate.

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CONTOUR

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- Scan for cues at mid- and far range.

- Provide navigation instructions and feedback regarding airspeed, altitude, descent rate, and system status.

- Frequent altitude callouts required.

- Primary attention *outside* aircraft, scanning immediate flight path (CRITICAL).

- Scan for near- and mid-range cues for obstacle avoidance.

- Do not fixate.

- Keep attention *outside* (CRITICAL).

- Conduct continuous scan of assigned sector for obstacle avoidance.

- Provide feedback regarding altitude, attitude, and descent rate.

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LOW LEVEL

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- Scan for cues at mid- and far-range.

- Provide navigation instructions and feedback regarding airspeed, altitude, descent rate, and system status.

- Systematically monitor light and dark areas of terrain to identify transitions in terrain type.

- Primary attention outside aircraft.

- Scan for cues at mid- and far-range.

- Systematically monitor light and dark areas of terrain to identify transitions in terrain type.

- Conduct continuous scan of assigned sector for obstacle avoidance.

- Provide feedback regarding altitude, attitude, and descent rate.

- Systematically monitor light and dark areas of terrain to identify transitions in terrain type.

■ Non-rated crewmembers are key participants in scanning, clearing, and monitoring aircraft attitude and descent rates.

■ Sectors of scanning responsibility must be assigned for each crewmember before flight. Aircraft type should be considered when assigning sectors of scanning.

■ **EXAMPLE:** In UH-60 pre-mission brief, PIC assigns sectors of scanning responsibility as follows:

a. Left-seat pilot assigned responsibility from center post to approximately 90 degrees left.

b. Right-seat pilot assigned responsibility from center post to approximately 90 degrees right.

c. Non-rated crewmember(s) assigned responsibility to scan left or right approximately 180 degrees.

d. When PNOC announces his intention to stop scanning his assigned sector (e.g., to study map), POC and non-rated crewmember(s) acknowledge and assume responsibility for his scanning sector.

## PROCEDURES

■ Do not allow scan of aircraft flight path to be interrupted.

■ Crewmembers must rotate head and eyes continuously. Scan should be slow enough to acquire visual cues and not so fast as to induce spatial disorientation. Occasionally, crewmembers may find it necessary to stop head movement momentarily to positively identify an object, but must not fixate.

■ POC should primarily scan outside aircraft and trust PNOC to provide information (i.e., systems status, altitude, airspeed).

■ When PNOC stops scanning (e.g., to study map), he must alert POC and crewmembers. POC and other crewmembers must then enlarge their scan patterns accordingly.

■ If pilot on controls discontinues scanning outside aircraft, he should transfer controls or coordinate with other crewmembers to ensure obstacle clearance is maintained.

■ NOE mode of flight demands increased scanning outside the aircraft, especially at higher airspeeds (e.g., 40 kt), for obstacle clearance and

closure rates.

■ Increased scanning outside the aircraft is even more critical in contour than NOE flight mode.

■ Crew should scan for visual cues that indicate approaching terrain transition (see Section III-D).

## ADJUSTING SEAT POSITION FOR OPTIMUM FIELD OF VIEW.

For those aircraft and crew positions with adjustable seats, pilots can achieve optimum viewing position by adjusting seat to "design eye point" (DEP). A field expedient procedure follows:

### ■ Step 1

• *UH-60, UH-1, and CH-47.* Position a person directly to the front of the seat for which DEP is being determined (e.g., outside aircraft directly in front of pilot seat).

□ UH-60 and UH-1: Position person 12 feet from nose of aircraft.

□ CH-47: Position person 20 feet from nose of aircraft.

• *AH-1 back seat.* Position a person at 2 o'clock position, a distance of 6.5 feet from right skid toe ring.

■ **Step 2.** Have person crouch down and position fingers such that they just barely touch the ground.

■ **Step 3.** Pilot then adjusts seat until person's fingers can be seen touching the ground.

## OBSTACLE DETECTION

■ Is best when moon is behind aircraft.

■ Is worst when moon is in front of aircraft.

## BAND-PASS FILTER/PINK LIGHT (see Section VII-B)

■ Tends to limit pilot's scan to within area of beam spread; a corresponding reduction in airspeed should be considered.

■ When using pink light, pilot may incorrectly infer terrain transition or change in ground slope based on artificial edge produced by beam. Therefore, avoid fixation near edge of beam and continuously cross-check information on terrain conditions (e.g., slope, texture, transition, etc.) with other crewmembers.

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## SECTION IX

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# RISK MANAGEMENT

**T**here are inherent risks associated with NVG operations that Army leaders should strive to identify and eliminate. The following risk management process is standard; however, it includes risks specific to desert terrain.

## A. DEFINITION

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Risk management is the process of identifying risks associated with a particular operation, weighing these risks against the overall value to be gained, and making risk acceptance decisions.

## B. RISK MANAGEMENT RULES

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- 1. Accept no unnecessary risks (i.e., risk that, if eliminated, still allows mission accomplishment).
- 2. Make decisions at proper level: Leader responsible for the mission should make risk decisions.
- 3. Accept risks if benefits outweigh costs: Risk-taking requires a decision-making process that balances mission benefits with costs.

## C. RISK MANAGEMENT PROCESS

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A five-step process which includes:

- Risk identification.
- Risk assessment.
- Risk decisions and development of controls.
- Implementation of controls.
- Supervision.

A thorough SOP should be written that includes a model where values can be applied to quantify the risk for evaluation and decision making.

The following table depicts an overall comparative risk analysis of the most critical NVG mission considerations in the Southwest Asian environment.

**Higher values (1-5) represent comparatively HIGHER risk.**

MOON		TERRAIN TYPE		
ANGLE (Degrees)	ILLUMINATION (Percent)	DUNE	SCRUB	LAKE BED
0 - 30	0 - 35	5	4	3
31 - 60	36 - 60	4	3	2
61 - 90	61 - 80	3	2	1
61 - 90	81 - 100	4	3	2

NOTE: Contour - Add 2  
NOE - Add 1  
Low level - Add 0

### TABLE USE:

■ When moon angle and illumination level combination is included in the same row, select the risk value for the applicable terrain and adjust for mode of flight (as indicated by the note).

■ When specific moon angle and illumination combination is not included in the same row, identify the risk values for the applicable moon angle and illumination level. Use the higher of the two risk values and adjust for mode of flight (as indicated by the note).

**EXAMPLE:** For a mission conducted in the times at NOE when moon angle is 40 degrees and illumination level is 70 percent: The risk value for 40-degree moon angle is 4, and the value for 70-percent illumination is 3. Select the higher value of 4 and adjust for NOE flight by adding 1, for a total risk value of 5.

### RISK IDENTIFICATION

■ Identify risks associated with all specified and implied tasks. Consideration of basic METT-T

and NVG-specific METT-T (Section IX-D) will help identify risks.

- Thorough operations/mission analysis is required during this step to identify risk in every aspect of the operation.

### RISK ASSESSMENT (EVALUATION/QUANTIFICATION)

- Determine how great the risk is (likelihood and extent of accidental loss).

- METT-T format provides guidelines on issues to consider (such as weather, type of terrain, and illumination levels).

- Consider use of a risk matrix or decision guide for all or part of the operation. They can provide a quick overview of the risk situation.

### RISK DECISIONS AND DEVELOPMENT OF CONTROLS

- Determine which risks are acceptable. (The benefits of taking a risk must outweigh the possible cost of the risk.)

- Identify actions to eliminate or reduce risk (controls). Reduction methods range from hazard awareness to development of detailed operational procedures.

- List and prioritize alternate courses of action.

- Ensure risk management decisions are made at the proper level. (The leader responsible for the mission should make risk decisions.)

### IMPLEMENTATION OF CONTROLS

- Knowledge of risk controls, down to the individual soldier, is essential for successful implementation and execution.

- Integrate controls (developed in previous step) into selected courses of action to reduce risk to lowest possible levels and still accomplish the mission.

### SUPERVISION

- Enforce controls and standards.

- Determine effectiveness of controls. Correct supervision will identify those control measures that are not effective or hinder mission objectives.

## D. NVG-SPECIFIC METT-T CONSIDERATIONS

The following METT-T considerations specific to night/NVG desert operations are provided to provoke thought about issues to consider in risk management actions. They are not all inclusive.

### MISSION (complexity and difficulty)

- Raise awareness levels of leaders and aviators, to include ground elements, on NVG desert operations and associated limitations.

- Advise OPCON, attached GS, and/or separate units of NVG-specific requirements.

- Exchange unit NVG lessons learned and put in writing.

- Establish a command climate that promotes safety.

- Enforce standards—make on-the-spot corrections.

- Deploy standardization/safety personnel with unit.

- Establish a deployable library (training, standardization, maintenance (e.g., unit messages)).

- Compare NVG mission risk assessment for Southwest Asia versus home station. (There are some significant differences between the flying environment in Southwest Asia and flying at the National Training Center (NTC) (e.g., lack of visual cues). Aviators must not assume that prior training at NTC is sufficient.)

- Develop a plan for re-establishment of ground reference.

- Establish inadvertent IMC procedure for area of operations.

- Emphasize that brownout conditions are prevalent in bivouac sites.

- Conduct a survey of the area of operations at once; route reconnaissance for NVG hazards becomes critical.

- Establish hazards maps and include NVG-related hazards (e.g., dunes, terrain transition areas, etc.).

- Establish restricted flight areas.

- Include hazards/obstacles in mission-crew

briefings.

- Identify and brief in detail critical tasks for each mission.

- Note that NVGs are helpful in AH-64s during multi-ship operations to track other aircraft and overcome IR cross-over conditions (FLIR).

- CH-47s—

- Must use reach pendants to hook up load.

- Should sling HMMWVs side by side instead of tandem rig in order to avoid interfering with radar altimeter operation.

- Should plan to operate at altitude of 100 feet AGL or higher during all external load operations.

- Increase emphasis on—

- Extended cross-FLOT missions.

- Resupply conducted under NVG.

- A2C2 NVG-specific issues.

- Use of AN/AVS-6 instead of AN/PVS-5.

#### ENEMY

- Limited ability to detect aircraft IR lighting (band-pass filter, position lights).

- Aviation assets not trained to fight at night.

**TERRAIN** (all aspects of physical environment; e.g., type terrain, weather, illumination)

- Desert flight considerations (see Section III: NVG Terrain Flight).

- Illumination considerations (see Section II: Illumination).

- Visual illusions (see Section IV: Visual Illusions).

**TROOPS** (supervision, experience, training, equipment, etc.)

- Increase unit emphasis on cockpit crew coord-

dination and scanning.

- Establish structured/planned in-country training programs:

- "Crawl-Walk-Run" training progression: Day flights—high-illumination flights—low-illumination flights.

- Establish training routes in all types of terrain.

- The most experienced NVG pilot is at risk if not given proper in-country training.

- Expect longer NVG missions.

- Expect to require more NVG-qualified crews.

- Crew endurance

- Initially, expect circadian rhythm/acclimatization to have a major impact on unit's ability to conduct NVG operations.

- Improve crew rest by providing separate accommodations for day and night crews.

- Due to high reflectance of sand, protect eyes from sunlight during the day to prevent potential adverse effects on vision.

- Crew selection

- Battle-roster crews are a must.

- Experience is key to success—the more demanding the mission, the more experienced the crew.

- Total crew ability, not just individual crew-member proficiency, should be considered.

**TIME** (available for planning, preparation, and execution)

- Allow as much time as possible for detailed mission planning.

- Allow more time for task accomplishment (use reverse planning sequence).

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## SECTION X

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