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PROBLEMS OF ADAPTATION  
TO LONG RANGE LARGE SCALE AERIAL TROOP DEPLOYMENTS

By

Stanley C. Knapp, LTC, MC, FS

September 1970

U. S. ARMY AEROMEDICAL RESEARCH LABORATORY

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<p>This paper discusses the demonstrated stresses and adaptation problems during large scale, long range, rapid reaction time, aerial troop deployments. NATO Exercise, REFORGER I, January 1969, and other recent large scale aerial troop deployments are discussed.</p> <p>Long range aerial troop transport and deployment is a technological achievement of the 1960's that has influenced and shaped international political thinking and military strategy.</p> <p>"Super transport aircraft", capable of around-the-world troop lifts, are a reality in the military inventory. Careful consideration has been given to the aircrews that operate these aircraft. It is necessary to carefully assess the position, role, and regard for the <u>individual soldier</u>, the "passenger", whom all of this aviation technology and engineering supports.</p> <p>Historically, soldiers have proven to be flexible, well-motivated, and capable of great personal and group ingenuity and adaptation in the face of stress. These factors create fighting forces that are able to go almost anywhere, at any time, by any means, and remain efficient and effective.</p> <p>Certain human factors and parameters of personal adjustment and adaptation, however, are relatively fixed or slow. Among them are requirements for sleep, food, fluids, exercise, warmth, shelter, sensory stimulation, recreation, periods of quiet, and physical and psychological support. Man has proven biological or circadian rhythms that are essentially unalterable over prolonged periods of stress, let alone abrupt exposure. Man does not immediately adapt to sudden environmental changes, i.e., sea level to mountainous, arctic to equatorial, tropical to arid, or pastoral to aquatic.</p>			

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## ABSTRACT

### PROBLEMS OF ADAPTATION TO LONG RANGE LARGE SCALE AERIAL TROOP DEPLOYMENTS

This paper discusses the demonstrated stresses and adaptation problems during large scale, long range, rapid reaction time, aerial troop deployments. NATO Exercise, REFORGER I, January 1969, and other recent large scale aerial troop deployments are discussed.

Long range aerial troop transport and deployment is a technological achievement of the 1960's that has influenced and shaped international political thinking and military strategy.

"Super transport aircraft", capable of around-the-world troop lifts, are a reality in the military inventory. Careful consideration has been given to the aircrews that operate these aircraft. It is necessary to carefully assess the position, role, and regard for the individual soldier, the "passenger", whom all of this aviation technology and engineering supports.

Historically, soldiers have proven to be flexible, well-motivated, and capable of great personal and group ingenuity and adaptation in the face of stress. These factors create fighting forces that are able to go almost anywhere, at any time, by any means, and remain efficient and effective.

Certain human factors and parameters of personal adjustment and adaptation, however, are relatively fixed or slow. Among them are requirements for sleep, food, fluids, exercise, warmth, shelter, sensory stimulation, recreation, periods of quiet, and physical and psychological support. Man has proven biological or circadian rhythms that are essentially unalterable over prolonged periods of stress, let alone abrupt exposure. Man does not immediately adapt to sudden environmental changes, i.e., sea level to mountainous, arctic to equatorial, tropical to arid, or pastoral to aquatic.

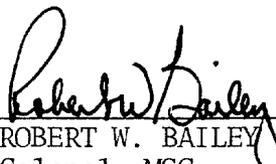
Man's response to these changes or deprivations, until he accommodates, covers a wide physiologic and psychological spectrum. The individual's response from obscure biochemical

alterations to physical and mental degradation are understood to some extent. A good many are predictable and quantifiable. All have the same titratable end point - reduced effectiveness and efficiency.

The individual soldier recognizes these changes as undefinable fatigue, malaise, and loss of physical and mental ability and endurance. The troop commander finds decisions difficult, comprehension elusive, and his troops less than anticipated as a fighting force. The medical officer is met with a plethora of minor physical injuries, somatic complaints, specific subjective symptoms, and objective findings, to which the etiologies remain all too obscure - unless there is an understanding of the stresses to which the patient has been subjected.

There is, however, a paucity of medical concern, knowledge, forethought, and industry in meeting and bridging the interface between advancing engineering technology and our most valuable commodity - the man, specifically our soldiers. With this insight, the observations and recommendations generated by this unusual study and presented in this paper can serve to sharpen appreciation for some of the less known problems of adaptation and acclimatization in aerospace medicine.

APPROVED:

  
ROBERT W. BAILEY  
Colonel, MSC  
Commanding

PROBLEMS OF ADAPTATION TO LONG RANGE  
LARGE SCALE, AERIAL TROOP DEPLOYMENTS

Long range aerial troop transport and deployment is a major operational achievement made possible by technological gains during the 1960's. This capability has influenced and shaped international political thinking and military decision making. "Super transport aircraft", capable of around-the-world, non-stop, troop lifts, are no longer a strategists' dream or a designer's challenge. They are a reality in the military inventory.

The literature is filled with the careful considerations given to aircrews that operate these aircraft.<sup>1-7</sup> Every country engaged in international travel and operating jet airlines with a global schedule, has placed great emphasis and importance on aircrew performance. The circadian rhythms, and disturbances of same, have been the focus of numerous recent international aeromedical studies.<sup>2,3,4,5,7</sup> Formulae have been developed to determine crew rest periods.<sup>8</sup> All this to make the pilot's performance under stress more efficient.

Prior to the "jet age" few people experienced the stress of having breakfast in New York, again in Los Angeles, dinner in Tokyo, and then be expected to conduct after dinner business with clarity, while the internal clock says it's 3 a.m. on a day that no longer exists because of the international date line. Propeller aircraft, except for a few extremely long flights, were too slow and too short ranged for concern. Steamships traverse the earth at a pace slow enough to allow accommodation during travel, and supersonic transports will be fast enough to actually keep pace with the earth on a westward equatorial flight or compress eastward travel time by a factor of two.

Mr. Wiley Post, the renowned pilot, anticipating physiological problems prior to his solo around the world flight in 1933, actually trained himself to accommodate to the stress.<sup>9</sup> He claimed that this training was most beneficial.

Governments and corporations alike have policies concerning the amount of rest or accommodative time

required between arrival at destination and the undertaking of important meetings. Diplomatic decisions or the judgements required of an executive demand perfectly clear powers of reason.

Despite the available knowledge on circadian rhythms and recognition of the problems of long distance travel, little consideration has been given to a peculiar type of passenger - the soldier.

The AGARD/NATO Study on Aeromedical Aspects of Troop Transport and Combat Readiness held in Brussels, October 1968, was one of the first attempts to identify medical problems associated or unique to military deployments.<sup>10</sup> Many recommendations and observations were made. They included:

1. Requirement for good organization of all troop activities throughout the deployment.
2. Proper immunization schedules are a necessity.
3. Motion sickness is a potential problem and should be prevented.
4. Changing climate conditions at point of embarkation and debarkation are important environmental stress factors to be considered. Optimally, troops should be acclimatized to their new environment prior to departure through physiologic and psychologic training.
5. In flight hazards, e.g. decompression and noise should be prevented or at least prepared for through education or training.
6. It cannot be assumed that the period of deployment constitutes a rest. Sleep deprivation might be a serious problem and should be studied.
7. Fatigue, apart from sleep deprivation, is an inherent risk of troop movements of this magnitude.
8. Line and medical personnel have a "human time and distance range" as do airplanes.

## THE STUDY

The Surgeon General, United States Army, in conjunction with the US Army Aeromedical Research Laboratory, sought air lifts suitable for study following the Brussels meeting. North Atlantic Treaty Organization exercise, REFORGER I, January 1969, and the South East Treaty Organization - United States Joint Strike Command exercise FOCUS RETINA, March 1969, were selected.<sup>11,12</sup>

The REFORGER I deployment was eastward and FOCUS RETINA was westward. This provided opportunity for comparison of medical factors in a short period of time.

It was the purpose of the study to identify those specific medical factors of importance during an actual operational deployment. No specific experiments were conducted. Problems for future study were to be identified.

Observers were chosen on the basis of their familiarization with aviation medicine, military medicine, combat troop deployment operations, and transport aircraft. The protocols, questionnaires, and investigatory techniques were chosen for their ability to **identify** operational problems of "real-time" importance. A comparative matrix was then used to weigh identified factors as to their importance in mission accomplishment, troop effectiveness, troop efficiency, and support and logistical requirements.

The MISSION is paramount to any commander. In this operational environment, where variables could not be controlled; but only judged for their influence on any given factor, it was relevant to relate all medical factors against the totality of the mission.<sup>13</sup>

## THE EXERCISE

Needless to say, the exercises studied were a product of interdisciplinary, interservice, and international cooperation, planning, and effort. The coordination problems were immense. The timing was elaborate. Communication between all levels of command and staff was complex and deliberate. Both exercises had features in common. They were:

1. Large scale - over 1,000 men.
2. Long range - over 5,000 miles.

3. Similar aircraft - C-141 Starlifter.
4. Similar climatic conditions - winter.
5. Similar training of troops - all units moved had previous experience in quick reaction deployments.
6. Following the deployment, "war-game" field maneuvers were to take place.

Other features of the two exercises were distinctly different. They were:

1. FOCUS RETINA.
  - a. Westward - 11 time zones.
  - b. All equipment, weapons, rations went with individual soldier.
  - c. Rapid movement with minimal delays.
  - d. Deployment terminated with a parachute assault and a seventy-two hour field maneuver.
  - e. Longest global troop air lift in history.
2. REFORGER I.
  - a. Eastward - 7 time zones.
  - b. Deployment designed to be precise, leisurely within limits, and with maximal coordination.
  - c. Equipment prepositioned at maneuver site.
  - d. Debarkation and field maneuver were separated by 72 hours.

#### METHODS AND MATERIALS

The observers were integrated into the deploying unit 72 hours prior to embarkation. They were fully briefed on each aspect of the mission from its inception to proposed return. They were given freedom of movement to interview commanders, staff and troops. Each briefing for the troops was attended. Air Force, logistic, medical, and operational support functions were reviewed.

After this orientation, the observers were assigned to a typical tactical unit. In effect, they were absorbed into the most minute aspect of this unit throughout the deployment and subsequent maneuver. Comparative evaluations were then made of information from other units. Terminal briefings and reviews were made of all aspects of the deployment. Specific medical and related factors were investigated.

1. Movement Planning and Preparation

a. Medical staff participation, opportunity for orientation and instructive briefings, planning and preparation.

b. Scheduling of troop activities.

c. Requirements for medical logistics, equipment, facilities, and immunizations.

d. Specific efforts to reduce detrimental psychophysiological factors.

e. Troop briefings of all types.

2. Medical Problems

a. Motion sickness and all associated aspects.

b. Illnesses associated with or coincidental to the deployment.

c. Acute emergencies.

d. Cardiorespiratory problems.

e. Neuromuscular problems.

f. Aerotitis, aerosinusitis and other trapped gas syndromes.

g. Injuries.

3. Psychological Factors

a. Apprehension and anxiety.

- b. Specific fears and phobias.
- c. Psychophysiologic reactions.
- d. Nonphysical fatigue.
- e. Boredom.
- f. Morale.

4. Physiological Requirements

- a. Feeding.
- b. Fluid intake.
- c. Rest and sleep cycles.
- d. Exercise.
- e. Life support items, e.g. oxygen.

5. Comfort and Hygiene

- a. Latrine facilities and use.
- b. Personnel hygiene facilities and use.
- c. Clothing.
- d. Equipment - all aspects.
- e. Seating, shelter and other physical provisions.

6. Environmental Considerations

- a. Heat and cold.
- b. Climatic changes and conditions.
- c. Noise.
- d. Vibration.
- e. Turbulence.
- f. Cabin pressurizations.

g. Safety hazards.

h. Humidity.

7. Circadian Disturbances

a. Effect on performance.

b. Effects on judgement and decision making.

c. Insomnia, diuresis, gastrointestinal disturbances, lethargy, and fatigue.

The extensive nature of the required data acquisition and observations dictated that a logical segmentation of each exercise occur. Distinct categories of activity were identified. Each exercise was divided into the following five phases.

1. Preparation Phase

An indefinite period beginning with the formulation of the exercise and extending to a period 72 hours prior to embarkation.

2. Predeployment Phase

A period of 72 hours immediately preceding embarkation.

3. Deployment Phase

Embarkation until tactical units are reformed after debarkation. Usually debarkation + 1/2 hour.

4. Post-Deployment Phase

The 24 hours following assembling of units.

5. Field Maneuver of Tactical Phase.

Overlaps phase 4 and ends when troops are fully adapted to their new environment.

RESULTS AND DISCUSSION

The significant findings are presented as they influenced the total mission by affecting one man, a unit,

or the entire deployment. Chance or otherwise unusual findings are not reported in this paper. Definitive discussions of specific sets of factors are topics for other papers. The importance, occurrence, or significance of any of the specific factors investigated or reported are shown in Figures 4 and 5.

### Preparation Phase

Prevention of medical problems was best accomplished during this phase. Medical briefings on climatic changes, sanitation and health problems to be expected, aeromedical factors of the air lift, and availability of first-aid or medical help were vital.

Medical review of all personnel with significant illness or injury with regard to deleting them from the deployment served to avert potential problems. Programs of physical fitness and acclimatization were beneficial.

A good medical annex to the operations and logistical plans was vital to ensure efficient support and coordination of medical activities. Organic medical personnel must be familiar with the tactical aspects of the deployment as well as medical support and facilities available at each refueling stop and destination.

Manifesting qualified corpsmen on each aircraft with first aid supplies helped in relieving troop apprehension, and lessened the responsibilities of the aircraft crew. Proper identification of the corpsmen was important so he could be recognized and best utilized.

Immunization schedules did not pose a problem. Records were checked and inoculations administered, if needed, at the first manifest call.

### Predeployment

Last minute medical coordination and communication with all levels of the staff was critical in this 72 hour phase. Paramount was a full appreciation for the nature of all en route and destination medical support.

Rotation of troop personnel, without medical coordination, was found to make the following difficult: the

briefings, immunization checks, medical records review, and predeployment physical examinations on ill or profiled patients. The last item was critically important when the deployment ended with an assault.

The need of rest during the last 24 hours prior to embarkation was underestimated. Freedom of all but critical duties was important in alleviating fatigue during the air lift. Troops who "went-out-on-the-town" adapted far less well than those who did not. Alcoholic beverages consumed in the last 24 hours were contributing factors in motion sickness and sundry medical problems seen later.

When the period between awakening and embarkation was kept to a minimum, fewer problems occurred. Meals during this period conforming to the time of day assisted in maintaining circadian rhythms. Breakfast meals at 1800 were detrimental as were hi-caloric or rich foods.

Preheating or cooling of the aircraft, minimum waiting outside the aircraft and exposure to extremes of climate, adequate latrine facilities, and abundant hot or cold fluids as the climate dictated were necessary routine provisions.

### Deployment

A polar projection of the deployments is depicted in Figure 1. The sleep, eat, and circadian cycles of each deployment are shown in Figures 2 and 3. The time shifts and rate of shift are demonstrated by the parallel line separations and slope respectively.

The operational plan did not indicate any stops en route for the staging of troops. All stops were for aircraft refueling, change of aircrews, or staging of aircraft intervals. Both deployments had varying unprogramed extended periods on the ground en route because of adverse weather at destination.

The westward air lift was coincidentally and temporarily staged after all time zones were crossed and circadian aberrations were maximum. The staging was long enough to aid in a remarkable amount of adaptation.

The eastward air lift was variable in amount of time staged. In general, it was not long enough for adaptation and only increased circadian aberrations or delayed useful sleep.

Inability to rest or sleep because of high density seating and equipment storage, high ambient noise levels without acoustic protection, and absence of space to recline were the single most significant contributors to medical problems seen in this and subsequent phases. The westward air lift was affected more than the eastward because of the use of troop seats instead of airline type seats, greater amount of personnel equipment and the longer flight duration.

Had not a weather delay occurred during the westward air lift, 51 hours without useful sleep would have been experienced. With the delay, 36-48 hours was the time without sleep. Aircrews were rotated so that their average sleep loss was 14-16 hours.

On the eastward deployment, one complete night of sleep was lost. Over one half of the aircraft used airline type seats. This remarkably increased the amount of sleep obtained en route.

Numerous high caloric in-flight and refueling stop meals served at local time instead of circadian time, significantly contributed to problems seen. Inadequate supply of acceptable fluids contributed to the situation. Moderate dehydration was also an important finding. The low environmental humidity contributed to upper respiratory drying, chapped lips, and nose bleeds.

High density seating, large amounts of personal equipment and bulky clothing hampered proper exercise or simple stretching when troop seats were used. Muscle cramps, and various neuromuscular symptoms were reported frequently.

#### Post-Deployment

Weather conditions at origin and destination were similar, as were topography features and elevations. Therefore, no unusual stress was imposed by the environmental change per se unless the exposure was prolonged or unusual.

Identified problems during this phase were not unique. Similar ones are met by even the casual international air

traveler. Long periods of waiting, with boredom when already fatigued and irritable, were common. Dissynchronous activity when compared to personal circadian rhythm, e.g., sleep, eat, work cycles was distressing. Marginal comfort, hygiene, and latrine facilities for large populations are always irritating. Availability of liquid refreshment in the form of hot beverages was important to the maintenance of good morale. Food was not desired by most troops.

#### Field Maneuver or Tactical Phase

Because of the unprogramed delay on the westward air lift; and deliberate delay in beginning this phase after debarkation on the eastward air lift; significant reportable findings are absent.

#### SUMMARY AND CONCLUSIONS

The aberrant rest, eat and exercise cycle was the most significant individual finding that had potential for affecting the totality of the mission as it was performed. Staging-adaptation delays with the primary intent of sleep acquisition is imperative. These are best programed either as close to the destination as possible or immediately after the maximum time shift occurs. A 16-18 hour delay is optimum. Ample space in the aircraft for movement, and programed physical activity during refueling stops is necessary.

Medical planning, coordination, and indoctrination were found to be the best preventive measures. A complete understanding of the physical, operational and logistical situation and interplay of the medical support with each situation is an absolute necessity.

Ambient noise abatement, environmental climate control, comfort facilities and low density airline type seating are the primary requirements of the deployment phase as observed. Provisions for sleeping on board en route will alleviate many problems seen.

It is necessary to carefully assess the position, role, and regard for the ultimate weapon; the individual soldier. He is not a machine, piece of cargo, or casual global traveler. Modern technology and philosophy must be designed to support him.

Historically, soldiers have proven to be flexible, well-motivated, and capable of great personal and group

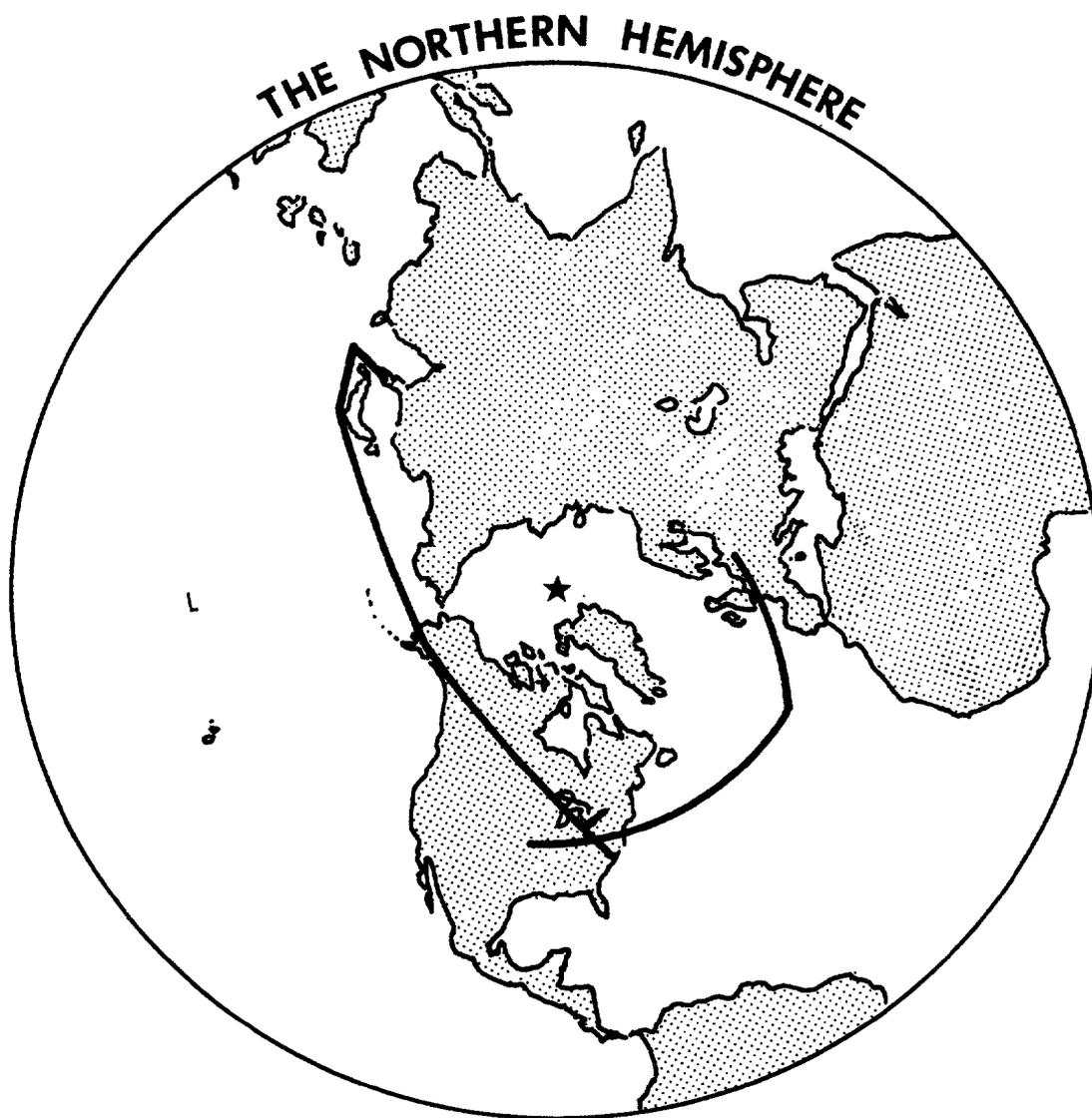
ingenuity and adaptation in the face of stress. This creates a fighting force willing to go anywhere, anytime, by any means, and remain efficient and effective.

There are certain human factors and parameters of physiologic adjustment that are relatively fixed or slow to accommodate. Among them are requirements for sleep, food, fluids, exercise, warmth, shelter, sensory stimulation, recreation, solitude, physical and psychological support. Man has proven biologic or circadian rhythms that are essentially unalterable over a long period of stress, let alone abrupt exposure. Man does not immediately adapt to sudden environmental changes, i.e., sea level to high mountainous, arctic to equatorial, tropical to arid, or pastoral to aquatic.

Man's response to these changes or deprivations, until he accommodates, covers a wide physiologic and psychologic spectrum. Many of the responses from obscure biochemical alterations to physical and mental degradation are understood. A good many are predictable and quantifiable. All have the same titratable end point - reduced effectiveness and efficiency.

The individual soldier recognizes these changes as undefinable fatigue, malaise, and loss of physical and mental ability and endurance. The troop commander finds decisions difficult, comprehension elusive, and his troops less than anticipated as to fighting force. The medical officer is met with a plethora of minor physical injuries, somatic complaints, specific subjective symptoms, and objective findings, to which the etiologies remain all too obscure - unless there is an understanding of the stresses to which the patient has been subjected.

Interpolation from these exercises is important in anticipating and countering the significant human stress factors imposed by modern technology and strategic concepts. The limitations of man must be realistically realized by the planners. Medicine must have the concern, knowledge, forethought and industry to meet and bridge the interface in a continuing effort to CONSERVE THE FIGHTING STRENGTH.



**FIGURE 1**  
**POLAR PROJECTION OF**  
**DEPLOYMENT ROUTES**

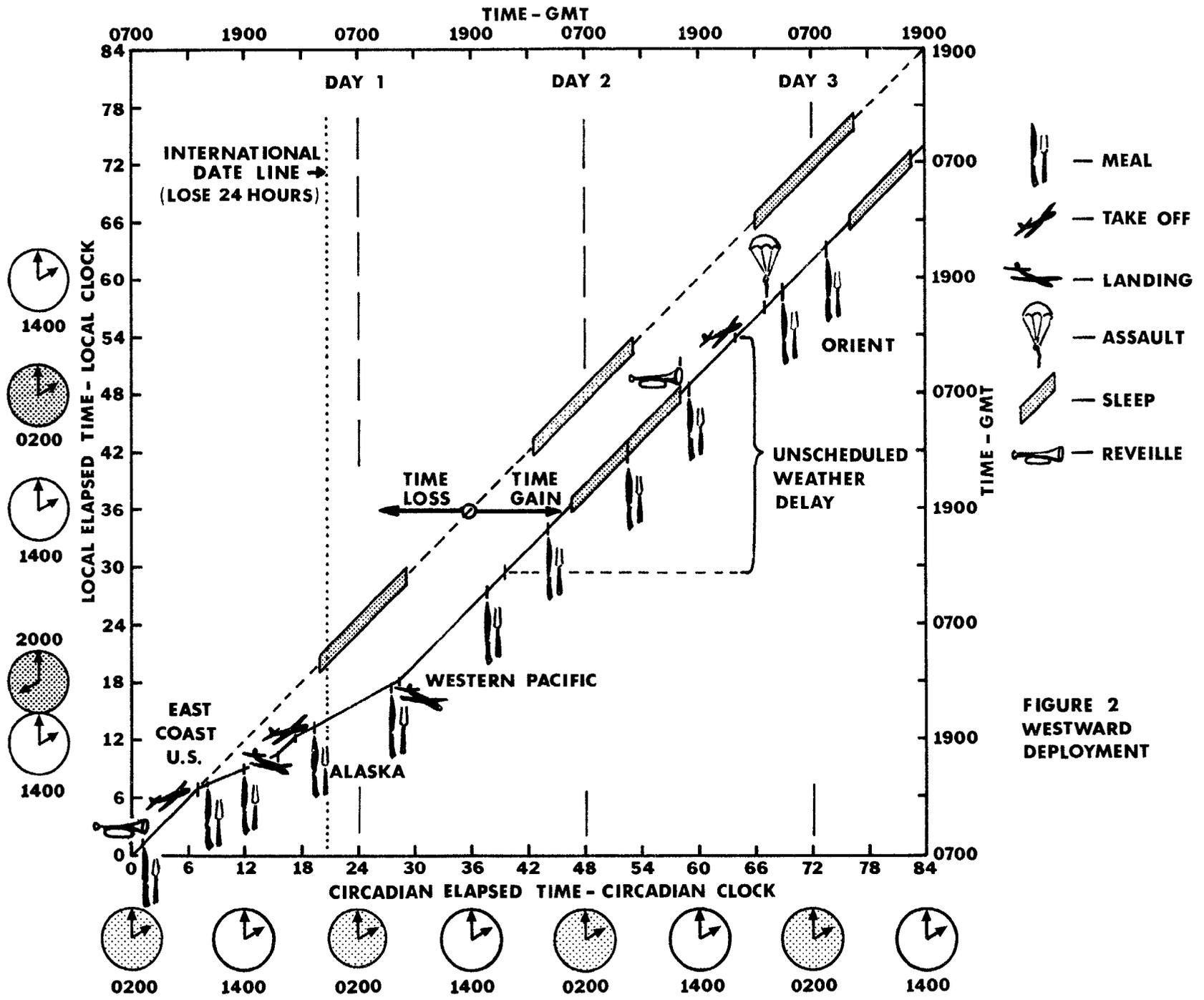
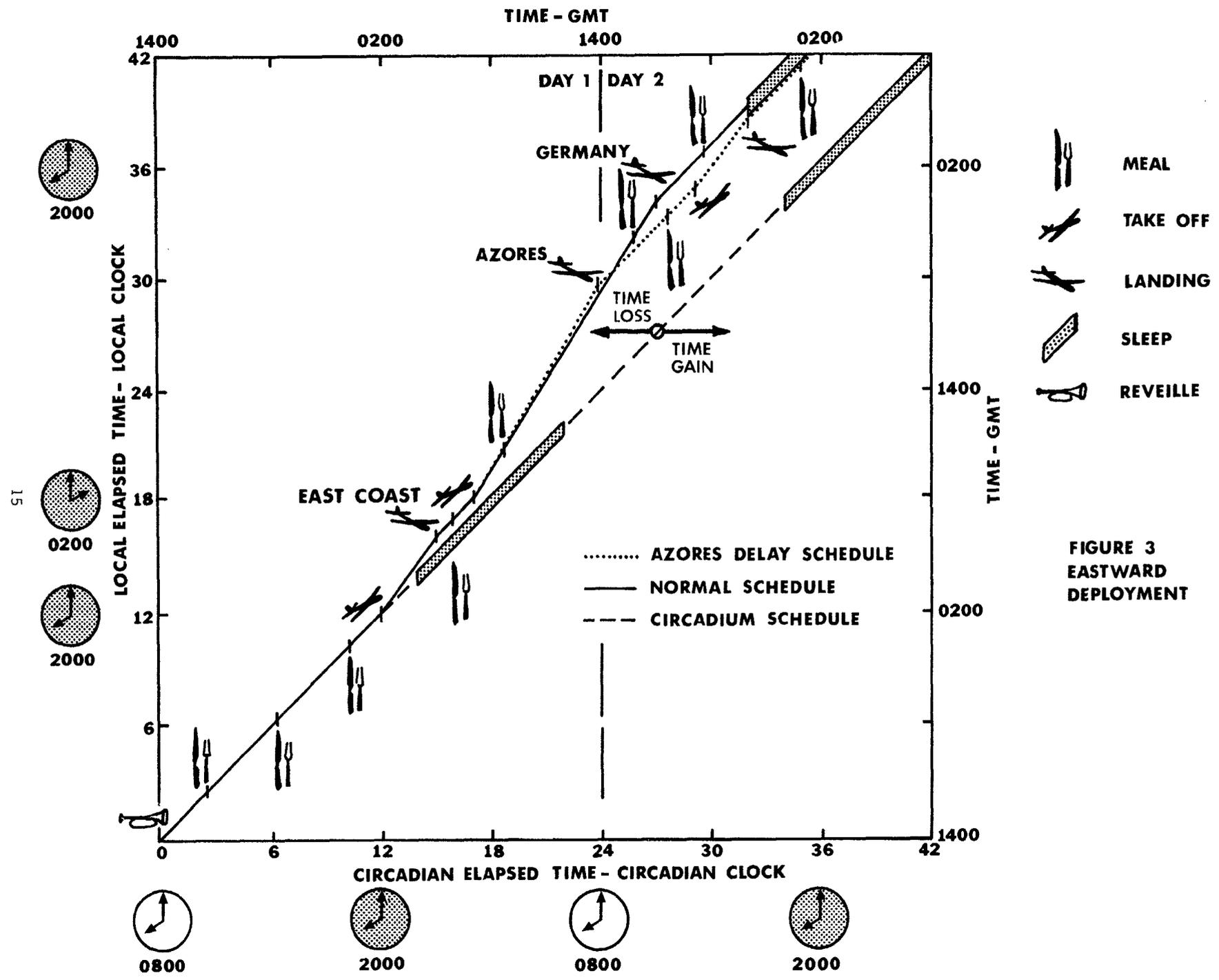


FIGURE 2  
WESTWARD  
DEPLOYMENT



**FIGURE 3  
EASTWARD  
DEPLOYMENT**

	Total Mission	Preparation Phase	Predeployment Phase	Deployment Phase	Post Deployment Phase
<u>Planning &amp; Preparation</u>					
Medical Staff Actions	+++	+++	+		
Orientations	+++	++	++		
Coordinations	+++	++	+	++	++
Logistics	+++	+	0	0	++
Equipment	++	●	+	+	++
Troop Training	+	++			
Briefings	++	++	+		
Scheduling	++	+	++	++	
Immunization	+	+	+		
<u>Medical Problems</u>					
Motion Sickness	●			+	0
Emergencies	0				0
Cardiorespiratory	●			+	+
Gastrointestinal	●			+	+
Neuromuscular	+			++	
Trapped Gas	●			+	0
Injuries	0				0
<u>Psychological Factors</u>					
Anxiety	●		●	●	
Fear & Phobias	●		+	+	
Psychophysiologic	●		+	+	+
Fatigue	+			++	++
Boredom	+		++	++	
Morale	●	●	●	●	●
<u>Physiological Requirements</u>					
Food & Fluids	++		+	+++	+
Rest & Sleep	+++		+++	+++	+++
Exercise	++			++	
Life Support	●			●	

Legend

- 0 - Not Reported or Observed
- - Reported, No General Significance
- +
- ++ - Presence or Absence - Moderate Importance
- +++ - Presence or Absence - Critical Importance

Figure 4. Importance or significance factors on the major parameters observed or examined. Consideration is given to the effect on each phase and the total mission.

	Total Mission	Preparation Phase	Predeployment Phase	Deployment Phase	Post Deployment Phase
<u>Comfort &amp; Hygiene</u>					
Physical Facilities	++		++	++	+
Clothing	●		+	+	+
Equipment	+		++	++	
Seating	+++			+++	
Shelter	+		++		+
<u>Environmental Considerations</u>					
Heat & Cold	+		++	+	+
Climatic Changes	+++	+++			+++
Noise	++			++	
Vibration	●			●	
Pressurization	0			0	
Humidity	+		+	+	+
Safety	●		●	●	
<u>Westward Circadian Disturbances</u>					
Effect on Physical Performance	+			0	+
Judgements	+++			0	+++
Decisions	++			0	++
Insomnia	+++			++	+++
Lethargy & Fatigue	+++			++	+++
Other	+			+	+
<u>Eastward Circadian Disturbances</u>					
Effect on Physical Performance	●			●	●
Judgements	+			●	+
Decisions	+			●	+
Insomnia	+				+
Lethargy & Fatigue	++			+	++
Other	●			0	●

Legend

- 0 - Not Reported or Observed
- - Reported, No General Significance
- +
- ++ - Presence or Absence - Moderate Importance
- +++ - Presence or Absence - Critical Importance

Figure 5. Importance or significance factors on the major parameters observed or examined. Consideration is given to the effect on each phase and the total mission.

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