CP 599

TECHNICAL EVALUATION REPORT

by

Jack P. Landolt, PhD
Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue W., P.O. Box 2000
Toronto, Ontario, Canada M3M 3B9

and

Major Hugh J. O'Neill, MD
Defence and Civil Institute of Environmental Medicine
Toronto, Ontario, Canada M3M 3B9

1. INTRODUCTION

The Aerospace Medical Panel (AMP) of the NATO Research & Technology Organization (RTO - merger of the former NATO Advisory Group for Aerospace Research and Development (AGARD) and the NATO Defence Research Group (DRG)) held a Symposium on "Aeromedical Support Issues in Contingency Operations" at the Golden Tulip Hotel in Rotterdam, The Netherlands, 29 September - 3 October 1997. Fifty-five papers, including two keynote addresses, were given from seven NATO countries, Argentina, Australia, The Czech Republic, and Switzerland. These are included in this Conference Proceedings, as is an abstract by an author who was not able to attend the presentations, plus each edited, transcribed Discussion that followed the ten Sessions that form this Symposium. There were 154 registrants for the Meeting.

2. THEME

Contingency Operations constitute a diverse array of operations ranging from peacekeeping (e.g., Cyprus), to humanitarian aid (Bosnia-Herzegovina before Dayton Accord), to peace making/enforcement (Somalia, Bosnia-Herzegovina after Dayton Accord), to full scale offensive operations (Persian Gulf War). Military operations other than war (MOOTW) such as relief from the effects of natural disasters and terrorism also constitute Contingency Operations. These operations usually involve the cooperation of multinational Forces, and/or other government and non-government organizations. They may be conducted in hostile environments; often, far from national support bases, in regions as disparate as the mountainous terrain of Bosnia-Herzegovina and the deserts of Somalia and Kuwait. A lack of host nation infrastructures and the uncertain capabilities for interoperability with non-NATO allies pose additional logistical problems. The resolution of these problems will facilitate the effective and rapid NATO response requirements of Contingency Operations.

The increasing prevalence of Contingency Operations in NATO presents significant and unique challenges to aircrew health, safety and performance as well as to those responsible for promoting aeromedical support. Central to these issues is the fact that greater emphasis must be placed on the application of science and technology to enhance aeromedical support. Rapid response times require, not only the efforts of traditional research and development, but, also, real-time initiatives for addressing the novel operational realities of Contingency Operations. Papers were solicited that addressed both traditional and novel technological solutions that meet the needs of aeromedical support in Contingency Operations.

3. PURPOSE AND SCOPE

The purpose of this Symposium was to review the novel and emerging technological aids that will provide timely and effective medical and human factors solutions for protecting and sustaining combat troops and support personnel in Contingency Operations.

The scope was broad covering several dimensions requiring unique technological solutions in:

- sustained and continuous operations (e.g., long duration flights),
- medical management in remote locations (e.g., casualty care),
- medical information technologies in remote environments (e.g., telemedicine), and
- adapting personnel to challenging environments (e.g., coping with stress).

4. SYMPOSIUM PROGRAM

A Keynote Address by General John de Chastelain (Ret. CF) opened the programme. He spoke to the challenges imposed by the post 'Post-Cold-War' in preparing for Contingency Operations.

The remaining papers were arranged as four Topics in ten Sessions as follows:

A. Topic: Sustained and Continuous Operations
Moderator: Air Cdre A.N. Nicholson, UK
Commandant, RAF SAM, Farnborough, UK

a. Session I - Extended Operations: Effects of Sleep Loss and Fatigue on Performance
Chairman: Med en Chef D. Lagarde, FR

Four papers addressed the issue.

b. Session II - Extended Operations: Non-Pharmacological Management
Chairman: Med en Chef D. Lagarde, FR

Two papers addressed the issue.

c. Session IIIA - Extended Operations: Pharmacological Management
Chairman: Med en Chef D. Lagarde, FR

Five papers discussed the use of stimulants for enhancing performance; another on the effects of anti-emetics for evaluating crew performance.

d. Session IIIB - Extended Operations: Pharmacological Management (Including Use of Melatonin)
Chairman: LCol C. Alonso-Rodriguez, SP

Five papers further discussed the use of drugs, including four on melatonin, for enhancing crew performance.

B. Topic: Medical Management in Remote Locations

a. Session IV - Aeromedical Support Issues: Logistics and Evacuation
Moderator: Air Cdre T.M. Gibson, UK
Director, Medical Personnel, Policy and Plans, RAF Innsworth, UK
Chairman: Maj H. O'Neill, CA

Six papers addressed the issue.

b. Session V - Aeromedical Support Issues: Technological Aids and Solutions
Moderator: Col R. Kilpatrick, US
US European Command Surgeon, Stuttgart,GE
Chairman: Col T.J. Lyons, US

Nine papers in this session addressed a number of technological aids and solutions for use in contingency situations.

c. Session VI - Contingency Operations: The Management of Operational Medical Problems
Moderator: Col R. Kilpatrick, US
Chairman: Maj H. O'Neill, CA

Three papers addressed the issue, with the major focus being on trauma management.

d. Session VII - Contingency Operations: Control of Communicable Diseases

Moderator: Magg Gen CSA Prof R. D'Amelio Direttore Generale della Sanita' Militaire, Roma, IT
Chairman: LCol C. Alonso-Rodriguez, SP

Five papers addressed the issue.

C. Topic: Medical Information
Moderator: None

a. Session VIII - Contingency Operations: Information Management Including Deployment Telemedicine
Chairman: Dr J.P. Landolt, CA

Seven papers discussed the issue, six of which addressed developments in deployment telemedicine.

D. Topic: Adaptation to Operational Conditions
Moderator: Dr D.R. Jones, US
Former Editor: Aviation, Space and Environmental Medicine

a. Session IX - Contingency Operations: Leadership and Management Issues
Chairman: LCol C. Alonso-Rodriguez, SP

Seven papers discussed the issue.

Each Moderator was requested to give a short overview of the topic under discussion including current research areas, problems requiring research, problems requiring resolution and how the Session would help in providing answers.

During the Symposium, four relevant demonstrations and a display were presented, as follows:

- Vital Signs Monitor (**VITSEM**) - A. Nichols, CME Telemetrics, Waterloo, ON, CA - see Paper #31,
- Life Support for Trauma and Transport (LSTAT) Test and Evaluation Unit - Dr F.J. Pearce, Walter Reed Army Institute of Research, Washington, DC, US - see Paper #30,
- Canadian Aeromedical Evacuation Course - Maj. J.M. Robertson, 1 Canadian Air Division, Winnipeg, MB, CA,
- Live telemedical transmission of traumatic radiographic images from Bosnia-Herzegovina to The Netherlands - Capt(N) H.J. Prins, Central Military Hospital, Utrecht, NE - see Paper #54, and
- High-Level Biosafety Containment Facility - LCol G.W. Christopher and the Aeromedical Isolation Team, US Army Medical Research Institute of Infectious Diseases, Fort Detrick, MD, US - see Paper #46.

An informative technical tour of facilities and presentations took place with visits to Central Military Hospital, Utrecht, and the Netherlands Aerospace Medical Centre and TNO Human Factors Research Institute; the latter two both located at Soesterberg.

5. TECHNICAL EVALUATION

5.1 Keynote Address

General de Chastelain, in Keynote Address #1, gave a global overview of the issues facing NATO in its preparation for Contingency Operations in the post 'Post-Cold-War' era. He characterized this era as the period beginning with the recent decision to enlarge NATO with the inclusion of Poland, Hungary, The Czech Republic, and possibly other countries. This era will herald the cooperation of NATO states with non-aligned countries in maintaining peace and stability in Europe and elsewhere.

General de Chastelain believes that, because NATO is a military organization, it is uniquely placed to respond to Contingency Operations and is responding to these challenges today. He cited the main challenge that NATO faces in preparing for Contingency Operations is "... the willingness of member and non-member states to maintain military Forces trained to the professional level required for war." He argued persuasively that the diverse demands of today's Contingency Operations can only be met effectively by "... Forces prepared to the professional standards required to fight." a battle. Other important challenges cited for participating nations to consider related to:

- the requirements for specialized training to accommodate the multiplicity of roles entailed in Contingency Operations;
- an unencumbered rapid reaction capability at high readiness;
- cooperation amongst organizations and the need for standardization in regard to medical support, where practicable, including the provision of an effective capability for aeromedical evacuation;
- enhanced logistics capabilities; and
- the need to interact effectively with non-government organizations including the media.

5.2 Sustained and Continuous Operations

In the post Post-Cold-War era, sustained and continuous operations will take on a more strategic dimension in NATO operations than they did during the Cold War. Air operations will be conducted in all weather, day and night conditions. Mission effectiveness may be encumbered through the stresses of very long duration flights, by technological advances such as operating with night-vision devices, from operator information overload, because of hazardous flight paths such as nap-of-the-earth night flying, and from general workload fatigue. All of these factors will have an effect on maintaining peak performance. Some of the papers on the topic discussed the significance of sleep loss and fatigue on performance; others explored a number of alertness strategies, including pharmacological countermeasures, to minimize performance degradation.

5.2.1 Extended operations: Effects of sleep loss and fatigue on performance

Extended air operations may entail multiple time zone changes, irregular work schedules and stresses related to workload. Such factors will result in circadian rhythm disruption, sleep loss and fatigue. Sleep debt and fatigue are known to be contributory factors to operational errors, and to illness if they are allowed to persist.

Stone and Nicholson (Paper #1) opened the session by defining the issues involved in coping with irregularity of rest during round-the-clock operations. They contended that the ability of aircrew to maintain performance with prolonged duty overnight depended greatly on obtaining sufficient sleep during critical rest periods. Even with good sleep, sustaining alertness may be difficult if the duty periods are prolonged and the rest periods are irregular. Short evening sleeps preceding a period of overnight duty, naps during the duty period, breaks in duty and the use of stimulants are some of the ways recommended for maintaining vigilance overnight.

Whitmore, French and Armstrong (#2) assessed the effects of fatigue on aircrew performance during repeated or sustained, simulated bomber missions lasting 36 hours or more. There were strong circadian patterns associated with the speech, cognitive, physiological and subjective fatigue measurements taken. Consistently, aircrew were able to perform their missions successfully, in part, due to the fact they were exceptionally well rested. However, there were indications that, if adequate sleep and strategic napping are not obtained in a real mission, then fatigue levels could be high, and loss of vigilance and inadvertent daytime sleeping may become a problem. The authors recommended ergonomic design changes that are specific to long duration flights (e.g., improved noise abatement in head sets and adequate seat padding for ejection seats) for ameliorating the effects of fatigue on performance.

Mollard and colleagues (#6) also looked at the factors subserving vigilance in long duration flights. In one study, electrophysiological recordings were taken from aircrew during round trips between Africa and France, flying overnight with a twelve-hour stopover before returning to home base. There was a two-day rest period and then the process was repeated. From the data, the authors determined that the main factors contributing to lack of alertness in these aircrew were sleep deprivation, jet lag and boredom. As expected, fatigue and drowsiness increased as the flight progressed. However, in some pilots, fatigue further increased while drowsiness decreased by the end of the flight. These pilots felt more tired and believed that they endured a heavier workload than they had experienced during the first flight. They did not recover sufficiently during the stopover. This suggested to the authors that fatigue and recovery are variable from pilot to pilot. From these experiments, they hope to develop strategies for regulating flight and rest times, and identify effective crew formations for different flight durations.

Chelette and colleagues (#3) compared the performance in trained male and female pilots conducting air combat maneuvers up to +9Gz in a human centrifuge under two conditions: the rested state and twenty-four hours of sleep deprivation. All subjects wore full coverage, anti-G suits and employed positive pressure breathing. Based on the objective measures taken, sleep deprived subjects' ability to perform offensive maneuvers remained unchanged after twenty-four hours without sleep, even though subjective sensations indicated fatigue and a feeling of decreased performance. The authors cautioned, however, that under such sleep loss and fatigue, survival could be compromised in situations requiring more uncertain and spatially demanding defensive maneuvers.

5.2.2 Extended operations: Non-pharmacological management

Researchers at the Netherlands Aerospace Medical Centre addressed the issues of strategic napping and early starts on performance and flight safety of aircrew during irregular work schedules.

Valk and Simons (#4) concluded that, by introducing forty-minute rest periods during long duration operations, the level of alertness and performance in pilots was improved over those who did not sleep. They recommended that cockpit measures need to be instituted to enhance sleep in the resting pilot (e.g., by employing a head rest, eye shades and reclining seat), and improve alertness in the other pilot flying the aircraft during this rest period (e.g., by increasing the level of cockpit illumination). Additionally, for safety purposes, the level of alertness should be assessed in the latter pilot before the rest period commences. In the ensuing discussions that followed the session, indications were given that 'controlled cockpit napping' to relieve fatigue and sleepiness is being considered by some commercial airlines (see Discussion #2 in these Proceedings).

Simon and Valk (#5) contended that work starting times before 0600 hours should be avoided as pilots on such schedules suffered from a shortage of sleep that affected performance. If early starts cannot be avoided, then a compensatory sleep recovery phase should be instituted in order to prevent a cumulative sleep debt from occurring.

5.2.3 Extended operations: Pharmocological management

Non-pharmacological sleep management for enhancing alertness in flight crew may prove to be ineffective or inappropriate. For example, in operations such as night-time, intensive air operations, or long duration flights requiring sustained alertness, non-pharmacological measures are not likely to be practical. Additionally, because of individual differences in aircrew, such methods may not always be reliable. Pharmacological measures, which have quick onset times without significant side effects, hold the promise for maintaining aircrew operational efficiency throughout the flight in situations requiring sustained vigilance.

Paper #7 by Jouvet was to have discussed the neurological basis of the pharmacological management of the sleep - wake cycle. The author was not able to make the presentation; however, he requested that his Abstract to the Technical Programme Committee be included in the Conference Proceedings.

As Jouvet has noted, wakefulness and sleep are regulated by two distinct systems. Thus, there are two different pharmacological methods of controlling the state of wakefulness. One may stimulate the wakeful system with drugs such as dextroamphetamine and caffeine, or one may inhibit the sleep-inducing mechanisms with drugs such as modafinil.

In a previous communication to the AMP, Caldwell reported on the effects of dextroamphetamine in sustaining helicopter pilot alertness in sustained operations under laboratory conditions. That study demonstrated the efficacy of using dextroamphetamine as a viable countermeasure for sustaining operator performance during periods that prevented restorative sleep (see Paper #38 in AGARD-CP-579). In the present study, Caldwell (#8) explored the efficacy of dextroamphetamine (10-mg dose) for short-term sustainment of performance during sustained operations - the final 23 hours in a 40-hour period of wakefulness - in the actual flight of a UH-60 (Black Hawk) helicopter. Results indicated a better performance in most flight maneuvers when comparing dextroamphetamine with a placebo. This comparison showed that there were marked reductions in the subjective feelings of fatigue, confusion and depression, as well as an increased vigour when using dextroamphetamine. No significant side effects were detected. However, in his Abstract to the Technical Programme Committee, mild asymptomatic increases in heart rate and heart pressure were indicated. This is not unexpected given the fact that dextroamphetamine, like other amphetamines, acts on the peripheral nervous system producing deleterious cardiovascular effects when given in sufficiently large doses. Caldwell concluded by supporting the use of dextroamphetamine for short-term operations requiring up to 40 hours of continuous wakefulness. In the discussions that followed the session papers, concerns were raised regarding the compromising of higher-level function through the administration of high doses of dextroamphetamine (see Discussion #3 in these Proceedings).

Lagarde (#9) provided an overview of the current interest in modafinil as a sleep management drug. He stated that it induces good quality sleep in narcoleptic and hypersomnolent patients. Its likely site of action is the anterior hypothalamus. Large doses (600 mg) of modafinil have shown a neuroprotective effect in animals against lesions occurring in the hippocampus from toxic organophosphate compounds. Although limited experiments have been conducted in healthy subjects, all studies have demonstrated the potential of modafinil in sustaining performance during extended operations where there is progressive sleep loss. In particular, the combination of strategic naps and modafinil produces very good levels of vigilance and performance during prolonged sleep deprivation. This combination also seems to enhance post-nap recovery.

Raphel et al. (#10) assessed the dose-related effects of modafinil on spatial cognition during sixty hours of sleep deprivation. Results showed that a dose of 300 mg given over 24 hours is required to maintain effective cognitive performance in most of the spatial abilities investigated. This was the usual case in cognitive tasks requiring visual attention (effective for 60 hours of sleep deprivation) and mental imagery (effective for no more than 42 hours). In their Abstract to the Technical Programme Committee, the authors contended that lower doses are more beneficial for cognitive situations requiring visual - vestibular interactions. No physiological side effects have been associated with the ingestion of modafinil. However, in response to a question from the audience, Raphel indicated that recent experiments have shown an 'overconfidence' factor in sleep deprived subjects taking modafinil. There was no euphoria associated with this effect; nevertheless, there is concern that it may have a deleterious effect on cognitive decision making (also, see J. Sleep Res., 6: 84, 1997).

Slow release caffeine, in capsule form, has been developed by NESTEC in Lausanne, Switzerland to counteract the transitory and deleterious side effects of aqueous caffeine and dextroamphetamine that contraindicate their use as effective sleep deprivation countermeasures. Papers by Sicard et al. (#11) and Doireau et al. (#12) studied the efficacy of slow release caffeine in sleep deprived, male and female subjects during experimental extended operations. The pharmacokinetic parameters assessed were larger in females. This was associated with greater susceptibility to sleep deprivation and less body weight than that of males, and the use of oral contraceptives. Both sexes tolerated the drug well, and alertness and psychomotor performance improved in both in a dose-related manner. One study showed that good cognitive performance can be maintained with 300 mg caffeine (the recommended dosage) for up to 45 hours of sleep deprivation. With this dose, performance is not degraded during sleep recovery.

Jones (Appendix A, Keynote Address #2) cautioned that drugs for extending alertness in deployment missions "... should not be used unless the estimated risk of **not** using them exceeds the risk of using them." Therefore, it would be informative to compare some of the risks in using dextroamphetamine, caffeine and modafinil as sleep management aids. Dextroamphetamine induces serious side effects including cardiovascular and psychiatric disturbances, sleep interference and addiction. Aqueous caffeine causes irritability, diuresis and tremors. Slow release caffeine appears to alleviate the harmful effects of aqueous caffeine, and does not impair recovery sleep. Modafinil does not appear to be addictive nor does it induce drug tolerance. It does not affect recovery sleep and appears to have few physiological and psychological side effects, although the "overconfidence" effect in sleep deprived subjects should be investigated more thoroughly. (See Aviat. Space Environ. Med., 62: 432, 1991 for more details on these drugs.)

French and colleagues (#13) have developed and tested a rapid and reliable technique for assessing aircrew performance when taking drugs on military duty. Its efficacy was demonstrated by testing two anti-emetic drugs, granisetron (2 mg) and ondansetron (8 mg), both of which were rendered safe to use as protective countermeasures in aircrew in danger of radiation exposure. The method uses a battery of cognitive, physiological and operational measures and metrics to evaluate performance. In the context of this Symposium, this method has significant merit in that it screens for assessing potential drug interactions with circadian rhythms and with the efforts for ameliorating sleep deprivation.

5.2.4 Extended operations: Pharmacological management (including use of melatonin)

The role of melatonin in controlling circadian rhythms was discussed by Brown and Vos (#14), and Steffen and Suhner (#15). Melatonin is secreted by the pineal gland during darkness and cues the sleep - wake cycle, promoting sleep and thermoregulation. It may be administered orally, intravenously, by nasal spray or by absorption through the buccal cavity. It is claimed that melatonin administered orally or through the application of environmental lighting has had beneficial effects in treating delayed-phase sleep disorders from jet lag, shift work and other biological regulation maladjustments, in both normal and clinical volunteers, during the light - dark cycle. Tryptophan, an amino acid precursor of melatonin that is converted to melatonin in the gut, is also effective in treating jet lag. Melatonin (or tryptophan) treatment produces effects nearly identical to those of light. More clinical studies are required on the proper regimen, dosage and pharmacokinetics of melatonin, how it acts on the brain (phase shift adjuster, sleep inducer or both), and its effect on the hormonal and immune systems in both males and females. It would probably be prudent not to use melatonin indiscriminately until these issues were positively resolved. Moreover, very few controlled studies have been done that evaluated performance changes from melatonin administration in aircrew conducting tasks across several time zones.

The differences in circadian rhythm behaviour of aircrew during and after eastward and westward flights that cross multiple transmeridian time zones are an area of concern to fatigue management strategists. Tresguerres and colleagues (#16) investigated urinary melatonin excretion in pilots flying transmeridian flights from Madrid to Mexico and return, and from Madrid to Tokyo and return. In westward flights (to Mexico), melatonin excretion began to resynchronize with the new situation on the second day. In eastward flights (to Tokyo), there was a complete desynchronization of melatonin excretion. Brown and Vos cited contradictory, converse results in subjective evaluations of jet lag in aircrew in transmeridian flights between Auckland, New Zealand and London, UK. That is, in these transatlantic flights, the eastward direction was associated with the more severe jet lag, while in the Tresguerres study, it is the westward direction that was more bothersome. In pilots older than 50 years, Tresguerres noted that melatonin excretion was lower and the excretory rhythm fixed to the place of departure. This may signify an age-related decreased capacity for adaptation to multiple time zone changes. These important results impact on aircrew rest schedules and workloads. In preparation for transmeridian flights, planners of long duration missions may have to take into account flight direction, flight path and pilot age in administering their fatigue management strategies.

Paper #17 was to have assessed the effects of melatonin-induced daytime sleep on alertness and performance during sustained operations. However, the authors were unable to present their paper.

Operational necessities may require aircrew travelling across multiple time zones to commence work immediately on arrival. One option would be to employ melatonin at appropriate times during the flight to try to shift the circadian rhythm to reduce or eliminate the 'grounding' time on arrival before effective work can begin. Comperatore and colleagues (#18) performed studies to provide some answers to this problem. Using females as subjects, they studied the adverse side effects following sleep of a 10-mg dose of melatonin given at two different times prior to the daily sleep cycle. In one study, where melatonin administration and bedtime took place at 2300 hours, participants exhibited significant increases in errors throughout the day during testing on a vigilance test battery. In the second study, where melatonin dosing took place at 1300 hours and bedtime commenced at 1630 hours, there were no significant decrements in performance on the test battery after eight hours of sleep had occurred. For several hours following this period of sleep, however, melatonin concentrations had achieved endogenous levels. In other instances though, in both studies, melatonin concentrations remained well above physiological levels. Consistent with previous findings by other researchers, cognitive performance during such high levels of melatonin degraded significantly. The authors suggested that aviator's grounding time after melatonin administration must take into account not only drug half-life, but also the time of testing and the requirement for normal sleep. Moreover, for long range deployments across several time zones, melatonin administered during the afternoon may not require a grounding time beyond the time travelled to the destination.

Sicard (#19) described a study by the French that evaluated the hypnotic drug, zolpidem, for its potential in optimizing rest periods during daytime wakefulness in sustained operations. Subjects belonging to ground air force personnel and navy fighter pilots received the drug (10 mg) at 2200 hours and 0100 hours, respectively. The subjective quality of sleep was better with zolpidem when compared to that of a placebo in all subjects. Moreover, there were no residual side effects observed, leading the author to believe that zolpidem can be used operationally. (Although only an abstract is included in these Proceedings, more details on this study are provided in Aviat. Space Environ. Med., 64: 371, 1993.) A comment from the audience referring to an independent analogous study supported these conclusions.

5.3 Medical Management in Remote Locations

The emphasis in treating the sick and injured in Contingency Operations will be on stabilizing and removing them as quickly as possible while providing medical care en route to rear echelon combat areas or to assigned areas in the case of local disasters in MOOTW. More likely than not, the aeromedical mode using helicopters or short-take-off-and-landing aircraft will be best suited for in-theatre types of evacuation in most Contingency Operations. Papers on this topic addressed the issues from the point of view of aeromedical logistics and evacuation, and the use of technology in trauma and communicable-disease control management in austere locations. In particular, Major General P. K. Carlton, Jr. and his team from Wilford Hall Medical Center, Lackland AFB, Texas made major contributions to this topic (11 papers), promoting a number of different strategies for enhancing casualty care in such contingency situations.

5.3.1 Aeromedical support issues: Logistics and evacuation

Typical of the kinds of experiences and deficiencies that one might expect in Contingency Operations are those reported by Dines (#20) following her recent posting as a medical officer to the United Nations Special Commission (UNSCOM) to Iraq. She commented on the challenges of harsh climate, the physiological and logistic difficulties in providing NBC protection, the poor local medical infrastructure, and the lengthy evacuation and supply chains. The relative importance of each of these challenges will change over time and remedial measures will evolve accordingly. (This underscored the importance of documenting the 'lessons learned' in each Contingency Operation.) Managing sanitation and heat exposure were the key to minimizing morbidity. Routine medical briefings were given to minimize the occurrence of preventable diseases. Rotary- and fixed-wing aircraft employed for evacuation were often delayed by administrative problems or for political reasons. In these types of environment, the coordination of effective aeromedical evacuation is essential for saving lives and boosting morale. Medical logistics rely extensively on the effective use of information technology. For example, the inappropriate substitution of medical items by suppliers was resolved by using a CD-ROM catalogue and e-mail to obtain the exact items from the suppliers. As in all contingencies, planning and flexibility are the key to the success of the operation.

Aeromedical evacuation was the subject of a recent AGARD/AMP Symposium. The focus was on interoperability, coordination, and standardization of procedures, command and control, and training in planning for evacuating casualties in multinational operations (AGARD-CP-554). In this Symposium, Gibson (#21) has expounded on some of the factors influencing operational medical planning up to, and beyond, aeromedical evacuation. The components that must be addressed include:

- the development of operational concepts according to:
  - a government's willingness to commit forces to MOOTW,
  - the requirement for novel force structures,
  - casualty estimates,
  - interoperability with allies willing to take lead-nation tasking, and
  - a pervasive, inquiring media that fuels public expectations of quick success and low casualty rates;
- the judicious use of new technologies including:
  - weapons with greater wounding capability,
  - enhanced personal protective clothing and equipment, and
  - enhanced medical treatment capability;
- the application of operational medical doctrine according to the:
  - availability and location of surgical/medical support,
  - requirements for and development of casualty treatment regimes,
  - decisions regarding stabilization and surgery before or after evacuation; and
  - lessons learned and changes made as a result of previous Contingency Operations.

Gibson regarded medical staff involvement in operational planning from the beginning to the final stages of the mission as the most important aspect of medical participation in Contingency Operations. Without such involvement, there is a great danger that non-medical planners may make inappropriate or wrong decisions that could seriously affect the outcome of medical support operations.

Hersack, Carlton and Farmer (#22) discussed some impediments in meeting medical readiness in future Contingency Operations. Of significance were:

- the political realities of a decreased defense budget and a reduced military force, and
- the operational constraints imposed by a limited lift capability and time-distance problems in moving field hospitals and medical supplies to forward areas.

These restrictions have necessitated changes in US casualty care policies and practices (further discussed also by Hersack et al. (#23) and Miller (#24)). For instance, this results in a smaller medical presence in the forward battlefield area with a greater emphasis placed on casualty prevention. Also, there has been a change in US military policy from 'treat and return to duty' to 'evacuate and replace'. This necessitates frequent aeromedical evacuations from the forward area to free critically-needed bed space. Moreover, it entails movement of stabilized patients who continue to be seriously ill. (Current practices dictate that only stable patients undergoing convalescence should be moved to definitive care centers.) This implies that far-forward resuscitative surgery will become an essential requirement of casualty care. Additionally, continuous en-route patient care from point of first contact to point of placement in a definitive care center will be part of this new medical strategy.

Both Hersack et al. (#23) and Miller (#24) described a mobile aeromedical staging facility that incorporated a critical care aeromedical transport team (CCATT) which augments, but does not replace, aeromedical evacuation aircrew in providing continuity of care during high casualty patient movement. (The CCATT consists of a physician specializing in intensive care, a critical care nurse and a cardiopulmonary technician. It uses medical equipment commonly used in the intensive care units in medical centers. Between missions, the CCATT works out of a regional central medical facility.) To overcome the limited lift capability, Hersack, Carlton and Farmer recommended that modular medical units and man-portable elements be used for providing essential medical care in a timely manner in the forward area. Trauma and critical care training for both aircrew and health care workers should be given to resolve problems arising from the stresses of flight during evacuation.

Paper #25 was to have described the logistics involved in deploying an air mobile, advanced surgical center to The Former Republic of Yugoslavia. However, the authors were not able to give this paper.

Carlton and Pilcher (#26) described the concept of a Mobile Field Surgical Team (MFST), a five person unit, that brings surgical care directly into the evacuation system. Advanced man-portable, surgical equipment is used to perform surgery for combat casualties. Major trauma can be treated under very austere conditions. The team can move quickly and set up wherever it is needed; i.e., en route, in forward areas, the area of greatest need, before other units arrive, etc. The team carries no more than 600 pounds (270 kg) of surgical equipment for treating trauma in remote locations. The MFST and CCATT concepts were successfully tested in the resuscitative surgery and critical care of injured civilians following a cargo aircraft crash into Manta, Ecuador in 1996.

5.3.2 Aeromedical support issues: Technological aids and solutions

Contingency commitments in austere regions rely increasingly on novel technological aids and solutions to enhance medical support and medical logistics. New developments in modular components, miniaturization, information and display technologies including signal acquisition and processing, microcomputerization, power sources, sensors and materials have all contributed to the development of a series of practical medical devices and facilities for providing intensive care medicine in austere field locations or during aeromedical evacuation. Many of these are commercial-off-the-shelf (COTS) procurements that are modified for field use.

Papers #27, #28 and #29 discussed device developments that have enabled far-forward and en-route intensive care medicine to be applied that is comparable to that of a hospital intensive care unit. These devices include capable mechanical ventilators, cardiac and respiratory monitors, and precision infusion pumps/syringes. Patients have been safely cared for and moved with severe respiratory failure, with arterial lines in place, those that are hemodynamically unstable, and some that require continuous drug and substance infusions. Point-of-care (POC) laboratory testing; i.e., testing at the patient 'bedside', is being investigated as a means of rapid and accurate diagnosis of blood products to enable quick and effective treatment of critically ill patients in the field and during extended air evacuations. Instruments that can analyze arterial and venous blood gases and conduct electrolyte, glucose, hemoglobin and thrombosis/hemostasis determinations are commercially available. The technical requirements for a POC device is that it must be less than ten pounds, use small quantities of blood, use battery power sources having minimal life times of four to six hours, and be easy to calibrate. Current POC devices can be expensive, and problems with extremes in temperature and (potentially) barometric pressure, and the requirement for continuous accuracy may limit their usefulness in the field. Experiences were described using POC devices during transmeridian transportation of critically ill patients in Operation JOINT ENDEAVOR and the Korean Airline crash in Guam in 1997.

An inability to adequately monitor vital signs or provide therapeutic needs during ground or air transport to a definitive care treatment facility is a major impediment to moving marginally stable or unstable post-surgical patients. Pearce and colleagues (#30) described a transportable, stretcher-based, mini-intensive care unit that incorporates resuscitative and life sustaining capabilities into a universally adaptive platform for trauma management and patient life support under such conditions. The system, called the Life Support for Trauma and Transport (LSTAT), is comprised of a lightweight, composite base unit, a NATO standardized stretcher and a canopy that covers the patient. The system base contains a pressure compensated ventilator, oxygen source, suction capability, three-channel infusion pump, blood chemistry analyzer, environmental controls providing patient thermoregulation and protection from biological and chemical agents, onboard computer, power converters, batteries and a physiological monitoring system. Medical parameters, system performance data, and user interaction information are continuously monitored and logged by an on-board computer. Physiological data can be displayed on local displays or on remote, wireless hand held or head mounted displays. Provision is made for storage of up to 72 hours of physiological and systems data that can be up-loaded to a local or remote host computer. These data can also be communicated to the receiving hospital during evacuation for review by physicians to aid in their medical preparations for subsequent treatment. The system is applicable to both military and civilian operations. In discussions following this paper, concerns were raised regarding the weight of the LSTAT, and how this could be resolved.

Dyck and Nichols (#31) described a vital signs monitor (**VITSEM**), that is based on microprocessor technology, which monitors heart rate, body temperature and blood oximetry continuously, and blood pressure as required during critical care treatment in the field. The device is inexpensive to manufacture, robust, hand held, and operates on batteries for 12 hours of continuous use. The current version measures 14.7 cm x 9.3 cm x 5.4 cm and weighs 390 g. Information is displayed on a digital, backlit display. The device has performed well in two demanding conditions: in the noisy environment of a helicopter used for aeromedical evacuation, and in conjunction with a casualty bag in an NBC environment. Notwithstanding this good performance, care needs to be taken when reading blood pressures with the current **VITSEM** in vibration environments. The device is available commercially from CME Telemetrix, Waterloo, Ontario, Canada, and is currently being evaluated by the Canadian Forces.

Mason (#32) discussed the conceptual development at Brooks Air Force Base of an advanced system for transporting patients having unstable spinal cord injuries, and extremity and cervical traction requirements during aeromedical evacuations. The system envisioned will provide traction and kinetic therapy through incremental side-to-side rotation comparable to that available in permanent medical facilities. The system is expected to be versatile and robust enough to be used also for patient treatment of multiple trauma, burns, chest wounds, pulmonary complications and postoperative conditions.

Mason and Elsass (#33) reported on developments of an advanced hybrid oxygen system that will ensure the availability of medical grade oxygen wherever required. The oxygen system is a two component unit: a molecular sieve for generating gaseous oxygen and a cryogenic unit for liquefying the oxygen. The system will produce and liquefy 99% pure oxygen at 33 l/minute. A total of 20 l of liquid oxygen will be stored. The fielded system will weigh less than 400 pounds (180 kg), occupy less than 20 cubic feet (0.55 m^3) of space and require electrical power less than 220 volts AC at 400 Hz. The current laboratory version does not meet these specifications yet. The fielded system will be located at the mobile aeromedical staging facility (see Papers #23 & #24), on-board aeromedical evacuation aircraft and at other remote facilities.

Advances in miniaturization and computer technology have led to the development of commercially-available smaller and more versatile mechanical ventilators. In particular, some of these ventilators incorporate modes of ventilation that improve patient tolerance to mechanical ventilation. Grissom and colleagues (#34) tested the performance of the Univent Model 750 and Univent Eagle Model 754 ventilators on a test lung at altitudes from 600 to 16,000 feet (180 to 4900 m). Although both models performed well, the autocalibration feature of the Model 754 made it more suitable for aeromedical evacuation. Unless recalibration of the Model 750 is conducted with each change of altitude, tidal volumes greater than predicted will be delivered which might be detrimental to patients with poor lung capacity. The Model 754 portable ventilator weighs less than 13 pounds (6 kg) (Aviat. Space Environ. Med. 68:285, 1997).

Ultrasound has become a very important diagnostic tool in medicine. Advances in technology have enabled hand held systems to be developed, which have good imaging qualities, and are suitable for field use in remote locations. Van Dalen (#35) described field experiences of The Netherlands Armed Forces in the ultrasound examination of blunt traumas and the detection of foreign objects in injured patients during peacekeeping operations in the Former Republic of Yugoslavia. He predicted that small, portable ultrasound imagers will soon become part of the armamentaria of diagnostic equipment used by field trauma units.

5.3.3 Contingency Operations: The management of operational medical problems

The quick stabilization and treatment of the traumatized patient in the combat area has always been the main goal of the military physician given that some eighty percent of deaths occur within sixty minutes - the so-called golden hour - of receiving a severe injury. In Contingency Operations the goal is to move skilled, critical care workers rapidly into the combat or disaster areas. These people must have the tools, preparedness and flexibility required to conduct trauma procedures quickly and as simply as possible. Papers in this session addressed some specific ways of managing trauma in such operations.

To accommodate the political realities and operational constraints of today's Contingency Operations on medical readiness, the US Air Force has introduced the concept of MFST, a five-person surgical unit that provides on-the-spot trauma surgery in very austere conditions (see comments to Paper #26). In Paper #36, Carlton and colleagues described some simulation procedures that they conducted to facilitate resuscitative surgery by the MFST. Evaluations undertaken were field disinfection techniques, trauma surgery using only equipment and supplies from an MFST backpack, surgery on anesthetized traumatized swine using night vision goggles in a near-dark environment, and an assessment of the use of thermal imaging in medical care. Important lessons were learned; e.g., that resuscitative surgery without the benefit of infrared illumination in a light-limited environment is impractical. Additional simulation and testing of MFST equipment and concepts will be conducted before field implementation occurs. Such validation procedures are necessary steps for evaluating team capability and competency in different kinds of contingency situations.

Paper #37 was to have considered the field management of severe thoracic injuries. However, the authors were not able to give this paper.

Major vascular injuries to the extremities present a significant challenge to the military surgeon in the field. Without prompt restoration of blood flow to an ischemic limb (6 hours or less), amputation is almost assured. Reconstructive surgery of the arteries is technically demanding, time consuming and resource intensive. The use of temporary arterial shunts is an alternative to surgical reconstruction. Dawson and colleagues (#38) used anesthetized pigs to test patency and flow rates through silastic shunts placed after division of the common iliac artery. Patency was maintained for 24 hours using a non-heparin-bonded shunt. Results showed that limb blood flow on the shunted side was maintained at 40 - 70% of that of the control side. Oxygen extraction in the shunted limb increased to compensate for the moderate decrement in blood flow, thereby, preventing any major ischemic damage. The authors recommended using 4 mm x 5 mm tapered, reinforced shunts for most peripheral human arteries; 3.5 mm x 4.5 mm shunts for upper extremity and other smaller arteries. The efficacy of the method still needs to be demonstrated in humans in trauma conditions.

Blood products must be refrigerated and they have a shelf life of only thirty days. This becomes a serious problem in remote regions where refrigeration is difficult to maintain, and where facilities for blood grouping and blood typing are unavailable. In an attempt to circumvent such problems, several organizations are working towards a blood substitute that they expect to be basically non-toxic, universally compatible, that essentially free from risk of disease transmission, bind and release oxygen like normal blood, and have a long shelf life, particularly at ambient temperatures.

Magnin and Carmichael (#39) described their product **Hemolink™** - a highly purified, stroma-free human haemoglobin - as having the potential of an effective blood substitute in remote regions, during difficult air evacuations and other military situations where emergency and trauma care are required. Pre-clinical trials in dogs and rats have established that **Hemolink™** is an effective oxygen carrier and volume replacement fluid. No renal or other end organ toxicity was demonstrated at the dosage used. In experimentally-induced haemorrhagic shock, **Hemolink™** restored vital sign parameters to normal values in these animals. Phase I clinical trials in human volunteers have demonstrated that **Hemolink™**, up to a dose of 42 g of haemoglobin, is a safe blood substitute. Side effects were few and not serious, with the main one being a 15% increase in arterial blood pressure which may be beneficial in trauma situations where hypotension is a problem. Phase II surgical trials, where blood loss in individuals is a factor, have commenced; future trials will assess trauma and other intensive care issues.

Papers #40 and #41 were to have discussed new lung protective and treatment strategies to reduce Acute Respiratory Distress Syndrome (ARDS), a common cause of morbidity and death. However, the author was not able to give these papers.

5.3.4 Contingency Operations: Control of communicable diseases

Infectious diseases are a leading cause of death worldwide. The military represents a population at special risk. Deployment to remote regions during Contingency Operations may expose NATO troops to infectious diseases that are uncommon in many of their respective countries and to which they will have little natural immunity. This is particularly the case in tropical regions where the terrain and weather conditions support a multitude of endemic disease pathogens such as those causing malaria, dysentery and Ebola virus infection. The rapid deployment of troops into regional areas where there are such serious disease pathogens may compromise the operation if there is not sufficient time to employ effective countermeasures to prevent contacting the infectious diseases. Good field hygiene and proper sanitation practices are essential in containing diseases but these may be dependent on geographical locale and operational demands. Many examples can be cited where local health care, sanitation and safe water are not available. Deployed troops are also at an increased risk of getting human immunodeficiency virus (HIV) infection and the acquired immune deficiency syndrome (AIDS) in these remote regions, both in the field from contaminated blood and from social situations, that will have to be addressed. Additionally, there is always the threat of rogue nations introducing intentional disease pathogens into the theatre of operations for which there are no adequate antidotes, and this must be considered in contingency commitments.

The persistent and mutable nature of re-emerging infectious diseases, such as the tuberculosis bacterium, and/or the vectors spreading them, such as the anopheline mosquito spreading the malarial parasite, are a continuous problem to those controlling infectious diseases. Developing new drugs to combat these pathogens is expensive and drug companies are reluctant to invest the large funds required to conduct the research and clinical trials in an uncertain world economy and where there are likely to be poor monetary returns. Because of these factors, the military has taken the initiative in fighting infectious diseases in some countries. For example, new antimalarial compounds were mostly discovered in US military laboratories in response to the need for protecting US service personnel operating in tropical regions.

The above two paragraphs are a background to the thrusts described by authors in this Session for the prevention and containment of infectious diseases in Contingency Operations.

The World Health Organization (WHO) is responsible for the worldwide monitoring and control of infectious diseases; this includes surveillance of both military and civilian populations. D'Amelio and Heymann (#42) described a cooperative venture between the WHO and the military for the creation of a network of watches for monitoring infectious diseases in the military that is complementary to its existing civilian counterpart. Seventy-six countries replied positively to an initial questionnaire requesting an indication of the presence of a diagnostic laboratory and/or a notification system for infectious diseases in their military populations. This was followed up with a second questionnaire to the countries responding that requested more detailed information on:

- the diagnostic capabilities of the laboratories,
- the characteristics of the notification system,
- whether a diagnostic schedule for infectious diseases is mandated on recruitment, and
- any compulsory vaccination schedules.

Forty-seven countries replied to the second questionnaire.

Some interesting results were obtained from the surveys of D'Amelio and Heymann. Of countries replying to the first survey, at least 70% have a diagnostic capability and just over 80% have a notification system. Over 75% of respondents to the second survey have a diagnostic capability in at least four of the areas of bacteriology, virology, parasitology, immunology and molecular biology. Regarding a notification system for infectious diseases, just over 50% of countries responding have a computerized surveillance network. On recruitment, more than 80% of countries screen for tuberculosis and/or syphilis, while 55% screen for HIV infection accompanied sometimes by screening for other viral diseases such as hepatitis A, B and C viruses. Forty percent of nations screen for parasitic diseases on recruitment. The compulsory vaccination schedule for the military is mixed: a few countries have no basic immunization schedule; others focus mainly on immunization against tetanus and diphtheria toxoids, and typhoid fever. In NATO countries, Canada leads the way in the immunization requirements of its military personnel (9 vaccination types), followed by Italy and The Netherlands (7 each), and the United States (6). The results of these surveys represent an important first step in a global network for the monitoring, detection, containment and treatment of both endemic and intentional infectious disease outbreaks in both civilian and military populations.

Armed Forces are at an increased risk of acquiring HIV infection and sexually-transmitted diseases (STD) during deployment. The HIV risks are primarily related to sexual activity and drug injection; however, the safety of field blood supplies may also be a concern. Kingma (#43) recommended some measures for decreasing the risk of these infections in deployed troops. These include:

- civil - military collaboration in prevention and care;
- training medical care workers in prevention education;
- repetitively briefing troops on preventive measures;
- emphasizing the avoidance of high risk STD and HIV areas;
- promoting an STD health-care-seeking attitude;
- providing accessible STD counselling, testing, and other essential services;
- teaching universal precautions and blood safety procedures;
- creating a non-stigmatizing atmosphere for troops that are HIV positive; and
- providing continuous care and support to troops that are HIV positive or have AIDS.

Kingma also discussed the pros and cons of mandatory and voluntary testing and screening for HIV infection in the military. He did not support excluding HIV positive individuals from occupations on the basis of HIV infection alone. He recommended that, in those instances where neurocognitive performance impairment has implications for safety, whether occurring from HIV infection or not, appropriate periodic skills assessments relevant to the individual's occupation should be conducted. For example, this would be the case for pilots flying high performance aircraft in which some neurocognitive impairment may compromise critical decision making. He recommended using tests based on neurocognitive evaluations from computerized simulators such as **CogScreen** which mimics real-life conditions and detects subtle changes in cognitive functioning. (The application of **CogScreen** in assessing return to flying in head injured aviators was the subject of Paper #13 in a previous symposium - see AGARD-CP-579.).

Steffen (#44) noted the wide differences in immunization practices of countries participating in peacekeeping operations. He felt that this was due primarily to a lack of knowledge of the requirements for immunization in the peacekeeping regions, a lack of coordination amongst health care managers, and the lack of sufficient financial support to adequately address the issue. He has proposed that priorities in immunization must be based on the estimated incidence rate of various vaccine preventable diseases; consideration of the actual severity of symptomatic infection and other factors usually should play a secondary role. In support of this recommendation, he noted the following:

- Impaired hygienic conditions are the rule rather than the exception in these missions.

- In such conditions for personnel not immunized, the risk is greatest for hepatitis A, hepatitis B, typhoid fever and measles with the annual incidence possibly exceeding 1 (or even 10) per 1000 individuals.
- The risk of yellow fever, poliomyelitis, Japanese encephalitis, and plague may be rare in some places but substantial in others.
- Cholera, diphtheria, tetanus, tuberculosis and rabies are a lesser, though worldwide, risk.
- In some missions, immunization against influenza may be required.
- In the near future, emerging gastrointestinal infections such as enterotoxigenic *Escherichia coli*, rotavirus and others causing traveler's diarrhea (the most frequent infection at monthly incidence rates of 10 to 80%) may require vaccination programs.

Williams (#45) assessed the degree of compliance with anti-malarial preventive measures (chemoprophylaxis and personal protection) in deployed USAF troops during Operation ASSURED RESPONSE, the mission to evacuate foreign nationals following the breakdown of civil order in Liberia. Before departing, all troops received a medical threat briefing, doxycycline for chemoprophylaxis, and, as protective measures, DEET insect repellent and permethrin spray as a clothing insect repellent. In spite of extensive attempts emphasizing the importance of complying with these anti-malarial measures, only 88% of personnel took their doxycycline regularly, and only 24% used all preventive measures. An even lower rate of doxycycline compliance (79%) was recorded in US Army personnel deployed for the same Operation. Moreover, no USAF personnel, but four US Army individuals contracted *Plasmodium falciparum* malaria, a major disease pathogen associated with significant morbidity and mortality in this region. Differences in compliance between the two groups was partially associated with differences in attendance at the pre-deployment medical threat briefing (attendance USAF: US Army = 2:1). Williams discussed strategies for improving compliance, and ways of reducing exposure to malarial mosquitoes (e.g., keeping personnel in well-screened areas at night whenever possible). As is the case for AIDS and STD prevention, this study showed that military commanders and health care personnel must be trained appropriately, and be proactive and apply behavioural change strategies throughout all phases of troop deployment to ensure that good preventive compliance measures are maintained.

The rapid identification and characterization of highly lethal and communicable disease agents, whether indigenous or introduced, is essential for implementing proper preventive measures and providing for optimal patient care. The US Army Medical Research Institute of Infectious Diseases (USAMRIID) has developed a high-level pathogen containment facility that accompanies an Aeromedical Isolation Team (AIT) to remote regions to evacuate patients suspected of having highly contagious infections (Christopher and Eitzen (#46)). This portable containment facility enables a rapid diagnostic assay of a number of pathogens to be done *in situ*; as well, it provides standard clinical laboratory support during air evacuation. Containment of pathogens from the point of patient retrieval to arrival back at USAMRIID is controlled by maintaining the sealed facility under negative air pressure. Patient care monitoring and substance infusion can also be conducted during transport. The AIT is a rapid response team consisting of a physician, a registered nurse and four to six medics, trained in minimizing the risk of disease transmission. AIT deployment will occur in instances requiring basic research and clinical investigation of unidentified pathogens, and where patient isolation is mandated to prevent further disease transmission. The USAMRIID can deploy two AIT teams simultaneously. Each team can take care of one patient.

5.4 Medical Information

Critical to the success of Contingency Operations is the issue of keeping the number of casualties as low as possible. In part, the public in the NATO countries demands this as a condition to entering hostilities. As always, the military surgeon is expected to stabilize the casualty quickly, and diagnose and treat the injury or infection as soon as possible. There is also the aspect that medical personnel from some NATO countries must support very long deployment missions such as that in Bosnia-Herzegovina, while still treating casualties as if they had occurred in a local, major industrial center where critical care facilities and resources are readily available. There are several information technologies under development that lend themselves to aiding battlefield trauma and disease management more effectively, starting as far forward as possible in the combat zone and continuing during aeromedical evacuation. Of these technologies, telemedical applications, portable diagnostic imaging, and computer-based, medical information management tools are the most prominent.

5.4.1 Contingency Operations: Information management including use of deployment telemedicine

Medical information management in the NATO context should commence with the all-Service, seamless tracking of all ill or injured personnel during treatment and evacuation using advanced data processing and decision support systems in each Contingency Operation. Hughes (#47) addressed the issue from the perspective of the US Department of Defense Medical Global Command and Control System (MGCCS). Seamlessness and interoperability are conducted across all levels of command and medical care, contingency or other commitment, data acquisition platform, and systems integration. The MGCCS is part of a larger, all-Service, global, command and control system that collects, processes and tracks information from the point of entry through all stages of deployment. The MGCCS employs the US Transportation Command (TRANSCOM) Regulating and Command and Control Evacuation System (**TRAC^{2}ES**), an interactive graphics and map-oriented user interface having algorithms employing artificial intelligence techniques to plan, monitor, coordinate and remove impediments for improved patient care and evacuation. A **TRAC^{2}ES** World Wide Web site enables in-transit patient treatment information. (See Paper #11 in AGARD-CP-554 for further details on **TRAC^{2}ES**.) The ensuing discussions following the session focused on;

- the need for a NATO Standard for medical information exchange on an electronic format; and
- the requirements for, and security of, medical information stored on a Smart Card, the latter of which contains personal information and forms part of the MGCSS concept (see Discussion #9 in these Proceedings).

Deployment telemedicine uses real-time voice, video and data communication links to diagnose and treat patients remotely using resources *in situ* for patient care. New advances in telecommunications and computer technologies have lowered the cost and driven the military to using telemedical technology in remote locations for enhancing health care delivery. Specifically, some of the crucial components of modern telemedicine systems include: high-speed analog-to-digital data conversion, compression and transmission capabilities; satellite and microwave communication links; high resolution, hand-held video cameras; miniaturized microphones; portable imaging devices; and powerful personal computers that are used for various clinical consultations. Physiological data such as echocardiograms, electrocardiographic and electroencephalograhic recordings, and X-ray and ultrasound images can be stored and then forwarded with high resolution between field stations and major medical centers where they are replayed for interpretive purposes. Of course, much of telemedical consultation also will involve real time, interactive video consultation between health care workers (Farmer et al. (#51)). In that regard, portable video teleconferencing units that enable personnel in forward-area medical facilities, such as those in Bosnia-Herzegovina, or intermediate-staging field hospital to communicate with specialists in major medical centers are being assessed for feasibility. The practicality of doing minimally-invasive surgery remotely by telemedical techniques is being seriously explored.

The cost of telemedicine - including capital equipment - in treating patients on-site in military operations must be balanced against the cost in air lifting patients to hospitals far from the region of conflict or disaster; e.g., air flights from Bosnia-Herzegovina to the United States or Canada. Telemedical consultations also abrogate the inherent risks to both patient and evacuation crew from travelling over difficult terrain, in bad weather and through land mines. Of course, telemedical applications are being considered for patient care in the air in long-range (greater than 10-12 hour) aeromedical evacuations where health care workers may not include a physician (Farmer et al. (#51)). In that regard, there are some major impediments to realizing air-to-ground telemedicine as an effective means of augmenting critical care. Particularly noteworthy are problems of equipment interference with aircraft navigational systems, and the need for standardization of clinical treatments and equipment interfaces. Using COTS technology, making equipment highly portable, being 'user friendly' and easy to maintain, and incorporating emerging advances in computer hardware and software will do much to enhance telemedicine as a viable means of patient care in Contingency Operations (Morris and colleagues (#50)). One must also factor into the equation of cost-effectiveness the speed with which telemedical consultations between physicians can provide relief to both physician and patient in the diagnosis and treatment of suspected infectious diseases, poisonous snake or insect bites, and other traumatic possibilities.

Some indications of the effect of telemedicine on the cost and quality of medicine delivered has been given by Walters (Milit. Med. 161:531-536, 1996). This retrospective analysis from deployed military medical units in Somalia, Haiti, Croatia and the Former Yugoslav Republic of Macedonia demonstrated that telemedical consultations positively affected diagnosis in 30%, treatment in 32% and the overall patient status in 70% of cases. This study also emphasized the importance "of a formal organizational infrastructure that ensures proper training, develops standard operating procedures, and enables efficient equipment maintenance." Evans and colleagues (#48) in this Symposium spoke to the evolution of such an infrastructure noting that for the development of a global military and civilian telemedicine network, test beds, demonstrations and symposia will be required to establish proof of concept.

Paper #49 was to have discussed the use of telemedicine as a cost-effective emergency medical service linking several hospitals in the Baltic countries. However, this paper was not presented.

Macedonia and colleagues (#52) described a portable telemedicine system, **MUSTPAC**, that is designed largely from COTS components for remote field hospital use. The system is built around a three-dimensional ultrasound imager that permits immediate visualization of internal bleeding, damage to solid organs and penetrating injuries. Scanning the volumetric data set obtained by the imager with a 'virtual probe' enables a conventional two-dimensional diagnostic interpretation to be made. The system requires very little training and can be used by inexperienced operators. It operates in a store-and-forward fashion over low bandwidth, communication links. Expanded versions will include video teleconferencing capabilities. The unit can operate for short periods on batteries. Production models weighing 27 kg are envisaged. The current **MUSTPAC** was tested in Bosnia-Herzegovina.

Wilford Hall Medical Center in San Antonio, Texas has conceptualized the development of a modular, portable, diagnostic imaging system, ***StatRad***, for use in remote locations, that would be integrated digitally with major medical centers (Freckleton and colleagues (#53)). As envisaged, ***StatRad*** would consist of a multi-mode system employing ultrasound with Doppler capability, X-ray technology, fluoroscopy, and axial computerized tomography. Digital images would be stored locally and/or transmitted elsewhere for radiographic interpretation. Using Internet and CD ROM computerized resources, ***StatRad*** could be used for medical teleconsultation with physicians in remote medical centers, and enable reference medical information to be accessed by forward deployed, health care workers. The realization of ***StatRad*** as a portable imaging unit will require significant additional development.

Prins (#54) described some basic concerns with deployment telemedicine as experienced by The Netherlands Armed Forces that are applicable to other countries relying on this form of casualty care management in austere locations. These were identified as follows:

- Telemedicine will never be a substitute for medical or surgical experience in the field.
- Telemedicine should be used very sparingly; e.g., for consultation only, during acute situations, where there are large numbers of casualties.
- Telemedicine was not readily accepted by the field surgeons due to:
  - psychological reasons,
  - the low level grade of injuries that can be diagnosed radiologically with current systems,
  - the inexperience in diagnosing from a monitor screen,
  - the unsatisfactory quality of the video prints,
  - too low a bandwidth to transmit real-time video images, and
  - difficulty in maintaining communication connections between the field hospital and the central hospital in The Netherlands.

The first two concerns are self evident; the last one will be largely addressed through proper training, greater experience and improved technological developments.

5.5 Adaptation to Operational Conditions

Frequently, Contingency Operations involve the deployment of troops to remote regions in unfamiliar surroundings for extended periods of duty. Sometimes, this takes place in operational environments where there has been no previous experience, such as those where the military is helping civilian agencies in humanitarian relief activities or where the rules of combat are not clear as in Somalia where different warring factions imposed their own territorial claims. Also, a lack of host nation infrastructures may mean that, initially at least, troops will have to be self-sustaining and rely on their own initiatives. Of course, there is also the lack of familiarity of terrain and weather, and the constant threat of infection and injury that are an ongoing concern to deployed troops. All of these are stressful conditions requiring adaptation to operational conditions if the mission is not to be compromised. There are also the stresses associated with being away from home and loved ones for extended periods of time, and the eroding morale problems that occur over time in all conflicts or natural disasters. All of these factors require exceptional medical leadership entailing the use of a diversity of acquired skills for dealing with the stresses imposed on the deployed troops. Papers on this topic discussed not only the leadership issue but also the significant stressors, stress - strain relationships and some coping strategies for adapting to different operational conditions in Contingency Operations.

5.5.1 Contingency Operations: Leadership and management issues

Moloff (#55) described some of the challenges imposed by Contingency Operations on aeromedical personnel and capabilities, noting that the nature of these operations may be uncertain and the planning for them may be limited due to a variety of factors including the ill-defined nature of many of these missions. He stressed the importance of utilizing national and international data bases, rapidly accessing information through a variety of computer oriented and human sources, and, above all, remaining flexible mentally and physically if solutions are to be realized. He noted that aeromedical expertise will be a component of all future Contingency Operations.

Salisbury (#56) focused on the lessons learned in delivering health care to the multinational, NATO-led Implementation Force (IFOR) in Croatia. Some of the more important lessons learned included the following:

- Multinational medical staff training and joint exercises are essential.
- Standardization of, and compliance to, medical documentation by nations must be mandatory.
- Bilateral agreements between nations must be signed before deployment, if possible, to assure adequate medical support.
- A medical authority must be established early to provide advice to commanders and medical units.
- Medical intelligence must be available and timely to assess risk to health and establish unit effectiveness.
- NATO medical staff must have at least one dedicated communication system that covers the entire theatre of operations.
- Centralized tracking is essential to access patient status and coordinate evacuation.
- To enhance their return, patients must be evacuated to in-theatre medical facilities, and not out of theatre.

In Keynote Address #2, Jones discussed the issue of medical leadership in handling stress-related mental health problems. He noted that experiences from the Vietnam War regarding post-traumatic stress disorder (PTSD) have legitimized the study of the psychiatric effects of war on individuals. Consequently, much recent work has explored the relationship between acute stress and combat fatigue, and how to cope with the consequences of PTSD which may continue on for many years. To reduce the long-term effects of PTSD in peacekeeping missions, Jones recommended briefing troops before they leave that something may happen to them as a result of combat stress that may last a long time and may even require post-mission referrals. He also recommended providing immediate interventions to symptomatic individuals during operations and returning them to duty as soon as possible. He classified mental health problems as being of two types: 'acute adjustment disorders' which occur during active operations, and 'personality disorders' which happen when operations wind down.

Jones noted that lessons learned from previous operations and the recent psychiatric literature suggest that medical leadership requires that:

- stress-related care must be anticipated from the announcement of mobilization until troops have been reintegrated into the community following return from duty;
- health care workers must be prepared to be self-sufficient for at least 24 hours following deployment;
- a well-equipped ambulance may serve as an excellent portable dispensary;
- the use of local communication services must be learned quickly;
- a clear chain of command must be established;
- flexible leadership must be maintained; and
- past lessons learned may be tempered by technology changes and troop demographics.

Jones' paper gave valuable insights into the role of medical leadership in coping with stress from the perspective of 28 years of active experience as a military flight surgeon and psychiatrist. His paper should be mandatory reading for all health care workers and commanders that are part of a deployment mission in Contingency Operations.

Medialdea Cruz and Rios Tejada (#57) explored the stress factors in Spanish Air Force personnel assigned to humanitarian and peacekeeping duties. In order of frequency, family separation, language barriers, shift work, sleep deprivation, difficulties in communicating home, adverse climates, risk of physical injury, and the potential for disaster were the major stressors cited. Psychosocial stressors were more prominent than physical ones, leading the authors to propose that this should be taken into account in the selection criteria for peacekeeping and analogous duties. No evidence of PTSD was found.

Murphy and colleagues reported on recent

Canadian experience relating to stress in peace support operations in Bosnia-Herzegovina and Haiti (#59), and the current model employed by the Canadian Forces to assess stress and performance (#58). In the first paper, significant stressors, stress-strain relationships and moderating factors including satisfiers and coping styles were discussed. Psychological/behavioural strains were more prevalent than physical strains. Gender differences in coping strategies were evident in the data from Haiti but not in the sample from Bosnia-Herzegovina. The main satisfiers or motivating factors in peacekeeping commitments that may act to moderate the effects of stressors were humanitarianism, professionalism, personal development, social interactions and the novelty of the deployment. The model in the second paper incorporated stressor, intervention, moderator and outcome components at the individual, group and organizational levels. Data collection from the model is at an early stage.

Paper #60 was to have discussed the merits for and against having aeromedevac personnel as air crew versus having them as passengers. However, the authors were not able to give the paper.

Radova (#61) described the motivations of the three categories of Czech volunteer units that entered NATO-led IFOR and Stabilization Force (SFOR) services as follows:

- Foreign mission veterans joined primarily to enhance their professional skills and gain new experiences; joining for the financial aspects, though important, was a secondary reason.
- Active-duty Czech Army soldiers serving for the first time in a peacekeeping mission joined for financial reasons, but career enhancement and personal satisfaction also played a part.
- After-duty volunteers (from previous Czech Army services) joined primarily for financial reasons.

6. CONCLUSIONS

There is every reason to believe that Contingency Operations will become even more prevalent in the post 'Post-Cold-War' era than they have in the past. In fact, they will likely form the major focus of future NATO operations as General John de Chastelain indicated in his Keynote Address.

From a medical standpoint, the major impediments to an effective health care strategy in Contingency Operations may include any of the following logistic, support and environmental factors which may be interdependent in many instances:

- Hostile environment
- Harsh climate
- Deployment of health care facilities and supplies to forward areas
- Movement of seriously ill patients out of forward areas
- Lengthy evacuation and supply lines
- Poor host nation infrastructures
- Interoperability problems with non-NATO allies, and non-government organizations and consultants
- Maintenance of low casualties
- Impaired hygienic conditions
- Infectious disease management, both indigenous and introduced
- Battlefield and MOOTW trauma management
- Stress disorder management, both acute and chronic
- Sleep-loss and fatigue management to unnatural work conditions
- Indigenous population interactions
- Familiarization and adaptability to new technologies
- Accommodation to an inquiring and omnipresent media
- Decreased defence budgets
- Reduced medical personnel

These factors were addressed in this Symposium in terms of their impact on the following four broad areas:

- Sustained and Continuous Operations
- Medical Management in Remote Locations
- Medical Information

- Adaptation to Operational Conditions

6.1 Sustained and Continuous Operations

Key points noted regarding this topic included the following:

- Extended air operations involving multiple time zone changes, irregular work schedules, and stresses to workload will become the norm for air crew in Contingency Operations.
- Sleep loss and fatigue during extended operations affect performance. The judicious use of quick-acting pharmacological measures without having significant side effects, possibly combined with crew rest strategies such as strategic naps will be required to maintain sustained alertness. For some operations, such as intensive, night air operations, non-pharmacological measures are not practical.
- Modafinil and melatonin continue to demonstrate promising sleep management properties for maintaining air crew effectiveness during extended operations. The properties of these and other promising drugs used as sleep management tools should continue to be assessed and not used indiscriminately until more is known. In particular, the "overconfidence" phenomenon associated with modafinil should be investigated further as this may have an affect on cognitive decision making. Similarly, how melatonin works on the brain in terms of circadian rhythm adjustments and sleep induction, and the associative side effects on the immune and hormonal systems need to be established more thoroughly before this becomes an accepted method of prophylaxis.
- Early results suggest that the hypnotic drug, zolpidem may be a good sleep management tool having no deleterious side effects.
- The extent of, and recovery from, fatigue and sleeplessness varies from individual to individual. To optimize workload performance without compromising operational efficiency, strategies should be developed to identify individuals and effective crew formations to handle different flight regimes in extended operations.

6.2 Medical Management in Remote Locations

Key points noted on this topic included the following:

- Effective aeromedical support in Contingency Operations is dictated largely by a sound operational medical doctrine in regard to patient treatment and evacuation. Furthermore, providing extensive operational planning, being flexible, effectively using advanced technologies, especially, communications technology, as well as implementing lessons acquired from previous operational experiences are essential.
- Political realities and operational constraints in most countries dictate a smaller, but more versatile medical presence in the forward battlefield area. Rather than waiting for patients to stabilize, critically ill or injured patients will be evacuated aeromedically to out-of-area definitive care centers. Far forward resuscitative surgery will become a vital part of this new essential-care-only doctrine for in-theatre medical operations.
- To accommodate the increased need for evacuation requires highly trained critical and surgical care workers to move quickly, bringing modular and man-portable medical equipment and shelters to set up wherever needed; e.g., en route, in the forward area, etc.
- The provision of good critical care medicine en route or in far-forward areas increasingly depends on novel advances in technological devices and solutions. This includes point-of-care laboratory and clinical devices for bedside blood composition analysis and precision substance infusion; stretcher-based transport systems which incorporate vital signs monitoring and trauma management capabilities; effective transportable mechanical ventilators; and diagnostic portable imaging equipment.
- Severe trauma management in the field is contingent on having the necessary tools, experience and teamwork to act quickly and

decisively. This requires that procedures, equipment and team competency be extensively validated beforehand by way of animal studies or other simulations of trauma management in contingency conditions.

- Promising developments in blood substitutes, lung protection strategies and field resuscitative surgery will greatly facilitate trauma resuscitation management in Contingency Operations.
- NATO troops exposed to unusual infectious diseases for which they have negligible natural immunity are at a particular risk in acquiring lethal infections. The response of the World Health Organization to include the military in its worldwide surveillance program is an important step in controlling and containing these disease pathogens.
- Immunization programs based on the estimated incidence rate of various vaccine-preventable diseases in the area of conflict or disaster might be a more cost-effective approach to assuring immunization in deployed troops than one based on the severity of symptomatic infection in the region.
- The apparent lack, in many instances, of troop compliance with infectious-disease preventive measures during troop deployment is a concern. New disciplinary strategies and behavioural change programs need to be developed, validated and promoted to assure implementation. In this regard, a strong proactive medical leadership is essential.
- The rapid diagnosis and characterization of potentially highly lethal and communicable diseases for which there are no effective countermeasures is essential. The concept of an air-transportable diagnostic laboratory and pathogen containment facility in combination with a rapid response aeromedical team as developed by the US Army Medical Research Institute of Infectious Diseases to isolate the patient and conduct basic clinical research, is a viable method of minimizing the risk of disease transmission during air evacuation.

6.3 Medical Information

Key points noted on this topic included the following:

- Shared medical data among decision makers for the purpose of patient care must be a seamless operation applicable to all levels of command. This includes making use of command and control assets such as **TRAC^{2}ES**, telemedical advances, portable imaging devices, Smart Cards, portable computers and Internet computerized resources to achieve this objective.
- The facilitation of a global military and civilian telemedical service that is financially self-sustaining requires a step-by-step approach by building up an organizational infrastructure to ensure standard operating and medical procedures, standardization and maintenance of workable equipment, and proper training.
- Digital data compression and transmission techniques, portable video cameras and imaging devices, and powerful personal computers - much of it using COTS equipment - are beginning to enhance deployment telemedicine as a viable and cost-effective means of patient care in remote locations.
- Advanced man-portable, diagnostic imaging systems employing ultrasound, x-rays and other modalities at remote locations are key components to an effective telemedical strategy. They allow immediate visualization of trauma injury which enable good specialist interpretation by major medical centers.

6.4 Adaptations to Operational Conditions

Key points noted on this topic included the following:

- Aeromedical personnel will be part of all future Contingency Operations. They must be involved in all phases of operational planning. They will be required to adapt to unfamiliar surroundings, and, with the aid of computerized resources, assimilate and act on complex data quickly. Above all, they must provide flexible health care leadership in all stressful situations.

- The psychiatric effects of combat and other traumatic events may be permanent if coping strategies are not implemented at the appropriate time. Troops must be briefed before action takes place, and stress-related care given to symptomatic individuals during and, possibly, long after operations have ceased.
- There is evidence that psychosocial stressors are more prevalent than physical stressors in peacekeeping operations. Medical support and combat units should be selected that have a high capacity for coping with such stressors when participating in these and analogous types of missions. Some training for coping with stress should be a prerequisite to deployment. Gender differences in coping with stress may require different strategies.

7. RECOMMENDATIONS

7.1 Capturing Lessons Learned from Contingency Operations

Contingency Operations are complex and unique according to many factors such as the nature of the hostilities or actions taken, the place where the actions occur, the type of terrain occupied, the time of year of the operation, whether there is participation with NATO or non-NATO allies or both, and the behaviour of indigenous populations towards the occupying Armed Forces. These and other factors all have an effect on in-theatre medical care, and medical logistics including aeromedical evacuation. They impact on the varied requirements for medical management in remote locations; i.e., on the treatment of battle casualties, on managing endemic and communicable diseases, and on handling acute and chronic stress. These may require innovative, real-time technical solutions, which should be recorded since these experiences may be largely lost or forgotten with the passage of time, once the action is over.

A recurring theme in this Symposium has been the importance of lessons learned from past Contingency Operations. A number of examples may be cited. Dines in her paper on the UNSCOM operation in Iraq referred to the evolving nature of each mission and the challenge of accommodating to these changes. Gibson spoke of the implications of failing to apply lessons learned from previous operations. Jones warned that changes in technology and troop demographics temper dependence on past lessons. Salisbury cited numerous medical lessons learned from IFOR peace support operations.

The new RTO/Human Factors and Medicine (HFM) Panel (combines AMP and DRG Panel 8) has at its disposal a number of options for ensuring that medical lessons learned from past operations are captured, retained and upgraded for future NATO Contingency Operations. As a start, a computerized data entry and recording system must be developed and maintained to register the collective experiences of health and casualty care workers in each NATO Contingency Operation. A Workshop comprised of health and casualty care workers, field experienced in NATO Contingency Operations, should be held by the new RTO/HFM Panel to identify key collaborators, discuss the issues, identify the areas, and define the relevant parameters for pooling post-operational information into a comprehensive data base. This could form the basis of a subsequent Working Group that would develop the knowledge base and provide analyses of lessons learned for consideration for future operations. Most of the speakers and participants at this Symposium could contribute to such a Working Group. For example, the valuable efforts of D'Amelio and Heymann in developing a computerized network for the surveillance of infectious diseases could be one component of such a data base.

The information obtained from the Working Group could be distributed to the NATO countries and their allies, at timely intervals, by briefing the Committee of the Chiefs of Military Medical Services in NATO (COMEDS); and by making presentations at the annual NATO Flight Surgeons Course at Ramstein AFB, GE, at the Aerospace Medical Association Meetings in North America, and at other fora where such instructional knowledge and experiences would facilitate international cooperation and promote health and casualty care. Essential lessons learned from this cooperative effort should be published in the appropriate open literature for the benefit of others. Also, training centers and industrial concerns in each country would benefit from this material. This information should be available to field medical units telemedically via the Internet. Such information could be disseminated to United Nations agencies such as the World Health Organization, and others such as Médecins Sans Frontieres that may wish to share the knowledge obtained to provide effective solutions for contingency commitments.

A Knowledge Watch could be instituted following termination of the Working Group to continue collecting international experiences from evolving NATO Contingency Operations in order to maintain and enhance a workable data base for future dissemination of this critical information. This Watch could consider not only new developments in technology as they relate to health and casualty care, but also the experiences gained in medical support issues. The challenge is there for the new RTO/HFM Panel to exploit!

7.2 Limitations on the Use of Technology in Contingency Operations

Finally, a few words should be said about placing too much reliance on technology for enhancing Contingency Operations. Much hope is being placed on new advancements in technologies to address deficiencies in manpower and the requirement of rapid response and mobility in NATO Contingency Operations. Without a doubt, new developments in materials, sensors, displays, information processing, communications, and biotechnology will significantly enhance disaster medicine and alter the way in which it is conducted. However, the question arises as to what happens when equipment, systems and concepts based on these elaborate technologies break down, are sabotaged, or are rendered useless from missile attacks? Will back-up spare parts be available for each critical item of equipment if there is a permanent malfunction? Will 'high-tech' solutions be promoted when 'low-tech' solutions are sufficient? Will power sources to operate equipment be readily available, sufficient, portable and compatible? Will COTS medical equipment be enduring and compatible with the military systems with which it must interface? Will military physicians be required to become systems engineers to conduct their operations? One is reminded of these issues after having heard the excellent contributions to this Symposium by Farmer, Lawlor, Pearce and their respective colleagues. Overriding all of this is the confusion and associated uncertainty - the 'fog of war' - which is an inevitable consequence of any military operation. Technology must be tailored to reduce chaos and ambiguity, it cannot further contribute to uncertainty! These examples illustrate some concerns that occur when too much reliance is placed on technology (or the wrong kind of technology) and not enough effort is placed on basic and long-standing critical care. Military physicians and surgeons must be flexible and innovative, but should never be placed in the position that technology dictates the primary mode of diagnosis and treatment. At best, technology should be used in an adjunctive manner.

8. ACKNOWLEDGEMENTS

We thank Mrs N. Wisteard for preparation of this manuscript, the handling of the Discussions in these Proceedings and general administrative assistance.

DCIEM No. 98-P-01