

## Operational Aviation Medicine

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The personnel Aviation medicine is focusing on in the first line are all crew members on board of aircrafts. This specialty wants to treat or prevent conditions to which aircrews are particularly susceptible, applies medical knowledge to the human factors in aviation and is thus a critical component of aviation safety. Additionally the AeroMedical Evacuation field may be called a subdivision of Aviation Medicine, where flight physiologic effects on patients and their traumas or diseases are of concern.

The military applications of this specialty directly support the full spectrum of air and space operations, including the Aeromedical requirements for aviation personnel, the medical risks for flight passengers, the standards for a qualified aeromedical evacuation, and the ergonomics and human factors applicable to health, fitness and safety (1).

### GENERAL CONCEPTS AND PRINCIPLES

1. Military Aeromedical services are responsible for organizing, training, and equipping their medical forces to provide rapid and flexible response in support of their operational military personnel and to operate effectively also within a coalition force, using standardized and interoperable methods, across a broad range of missions, including expeditionary, peacekeeping, and humanitarian missions.
2. Aviation Medicine is most effective in the sense of supportive and preventive medicine when employed in a proactive manner; anticipating, recognizing, and controlling factors adversely impacting human health, safety and performance, including environmentally extreme conditions or threats from NBC agents.
3. Aeromedical services deliver four basic effects in support of military air operations: ensuring fit and healthy forces, preventing casualties, restoring health, and optimizing and enhancing human performance.
  - a) Ensuring a “Fit and Healthy Force” by: providing specific specialty care and expertise required to ensure the success and safety of aircrew, including mishap investigation and safety activities; utilizing methods including Aeromedical standards development and application, health education, immunization, chemoprophylaxis and provision of health protective devices.

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- b) Preventing casualties by: conducting threat analyses of aviation in a complex environment with a variety of health risks like nutrition, environment, physiological factors, fatigue, disease transmission, injury by chemical, biological, radiological, nuclear or explosive (CBRNE) exposures; by advising leaders and by assisting in mission planning; executing an effective occupational health and industrial hygiene program to enhance protection of aviation personnel from work-related illness or injury.
  - c) Restoring health by: providing casualty care management to aviators and operational support personnel as well as routine health care under any circumstances; being modular and flexible when deployed, able to be rapidly movable to any location to establish preventive and clinical services; delivery of advanced care en route for critically injured/ill patients, including adult and pediatric intensive care and care of those with contagious diseases; providing specific expertise in the planning and execution of medical responses to mishaps, operational incidents and mass casualties, and ensuring the safety and appropriateness of Aeromedical evacuation.
  - d) Optimize Human Performance by: scientifically employing principles of preventive medicine and health promotion to improve overall physical, psychological and social health and performance of individuals, thereby enhancing quality of life.
4. Chain of command: Aeromedical personnel must have direct access to their operational counterparts to provide timely and accurate consultations and recommendations regarding the health, safety, and performance of those personnel executing the air and space missions.
  5. Reliable and interoperable communication systems are imperative. Definitely, Aeromedical information technology systems have to ensure the safety of personal data to exclude the misuse by unauthorized individuals.
  6. Aeromedical Evacuation Command and Control should be established by the theatre commander to coordinate overall medical evacuation requirements with airlift capabilities.

A further and essential objective is aeromedical research and the development of objective occupation selection criteria, evidenced-based medical standards, and the tools and techniques necessary to optimize levels of individual physical performance and cognitive abilities. Aviation Medicine is engaged in all phases of aircraft weapon system acquisition thereby providing consultation and design expertise to ensure the interface between the human and the system is safe and effective. This includes expertise to educate and inform workers and leaders, to optimize activities both in flight and in ground support and to ensure aircrew and ground crew safety. This may be achieved by providing the expertise in training and familiarization of aircrews with the aviation and space environment, including the use of oxygen systems, life support equipment, the education about the effects of G-forces and the use of G-protection systems, disorientation in flight, and the use of enhancements to vision such as night vision devices. This significantly contributes to maintaining situational awareness and flight safety.

**Planning Considerations (Execution)** should comply with NATO's essential operational capability goals, such as mobility, interoperability, flexibility, survivability, sustainability, rapid augmentation, command and control and multinationality.

- Aeromedical intelligence and threat analysis: collecting, analyzing capabilities and gaps, evaluating and interpreting medically relevant information to provide operational air commanders with recommendations regarding medical threats, to favor force strength and operational mission accomplishment.

- Aeromedical planning includes both deliberate and crisis action planning processes. Development of doctrines in NATO should assume a multinational environment and attempt to maximize standardization and interoperability of personnel, processes and equipment, thereby integrating all aeromedical components with each other, as well as with other conventional medical assets.
- The “After-Action Requirements” such as lessons learned should place emphasis on those with broadest application to the wide variety of potential future scenarios.

## AEROSPACE MEDICINE IN THE GERMAN ARMED FORCES

The German Air Force has established an Aeromedical service which complies with the mentioned operational requirements and is executed according to the principles of evidence-based medicine and quality management.

The certified flight surgeon in the squadron is the core element of this system. He or she has to fulfill several prerequisites to serve in this function.

The first step in the career is the successful completion of the basic flight surgeon course including aero physiological training in the hypobaric chamber at the German Air Force Institute of Aviation Medicine. Based on this qualification and after working as a physician in a medical treatment facility supporting a flying unit for a minimum of 12 months, and regular participation in the emergency response team under supervision of a certified flight surgeon, the next educational step is the advanced flight surgeon and certification course including:

- Qualification as an Aeromedical Examiner (AME) of the armed forces,
- Familiarization with tropical and travel medicine,
- Training as an Aeromedical Evacuation Coordinating Officer (AECO),
- Training as a crew leader (Medical Director) for AirMedEvac and
- Familiarization with the principles of occupational medicine.

Completed follow-on training in the field of general and family medicine, occupational medicine or internal medicine is also a fundamental qualification prerequisite. The Surgeon General German Air Force decides about accepting other medical specialties on an individual basis.

**Table 1: Training of a Flight Surgeon in the German Armed Forces**

			<b>SenOff MC, Flight Surgeon</b>
			Av Med II
			Flight Surgeon Paper
			Specialty GP/Internal medicine
		<b>SenOff MC, Physician AECO</b>	PEER Training
		AECO	AECO
	<b>SenOff MC, Physician AvMed</b>	MedOff AirMedEvac	MedOff AirMedEvac
	SLP English	SLP English	SLP English
	2 yrs clinical experience	2 yrs clinical experience	2 yrs clinical experience
	Emergency Med	Emergency Med	Emergency Medicine
<b>Physician of Flying Unit</b>	Av Med I C	Av Med I C	Avn Med I C
Av Med I A+B	Av Med I A+B	Av Med I A+B	Avn Med I A+B

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Additional elements are search and rescue specialist qualification or comparable qualification including post proficiency training, a certificate of a valid aerophysiological training and periodical refresher courses during the assignment as a flight surgeon, physical fitness for military flying and out of state deployments and its maintenance during the assignment as a flight surgeon, (the flight surgeon is required to participate occasionally in some flights with aircraft types of the wing), preparation of a scientific paper in aerospace medicine or related areas, survival training and language training in English (SLP 3332).

Only after completion of these training modules the physician will be awarded the military occupational specialty as a Flight Surgeon by.

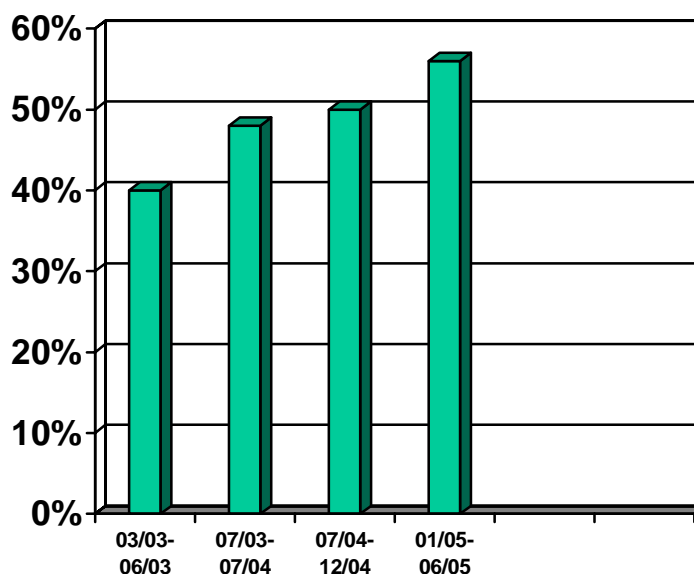
The Surgeon General German Air Force is responsible for the aeromedical service of Army, Air Force and Navy. He enacts regulation and orders directive doctrine for aeromedical assessment, training and aeromedical research, thereby working in close cooperation with the Central Medical Service in operational and mission related issues.

The organizational element of a flight surgeon office consists of

- 1 Senior Officer MC, Senior Certified Flight Surgeon (Lt Col)
- 1 Senior Officer MC, Aviation Medicine (Capt / Maj)
- 2 Medical NCOs, Aviation Medical Assistants
- 2 Medical NCOs, Medical Equipment Technicians (Air Transport Units only)

The reliable presence of the flight surgeon both on the home base and during missions is a prerequisite for mission accomplishment. The actual time of presence of the flight surgeons in their home unit is influenced by an increasing absence rates due to mission deployments, exercises, training, and Strategic AeroMedevac.

**Table 2: Absence of a Flight Surgeon in GAF Flying Units  
(2003 - 2005)**



Furthermore, the main focus of work within the context of NATO is to provide subject matter experts in the field of Aviation Medicine and to serve as delegates of the Aeromedical Panel (AMDP) of the NATO Standardization Agency. This panel is a subordinate body under the Air Operations Working Group, which reports to the Military Committee Air Standardization Board. The 27 STANAGs promulgated through this panel promote standardization and interoperability of Aeromedical operations and equipment, in direct support of the military aviator in the sense of an operational aviation medicine.

## MISSION DEPLOYMENT

The overall standard for the Medical Care of German Soldiers in Out-of-Area Missions is: Wounded, injured or sick soldiers must receive a medical care which in its result meets the medical standards in Germany (Surgeon General of the Bundeswehr (Sep 27, 95).

Operational Aviation Medicine starts with the work at home. It is an interdisciplinary and continuing process, including medical care, aeromedical assessment and examination at the home base. This work has to be continued during the special circumstances of deployments.

Particular consideration has to be applied to the special characteristics of medications, immunizations and chemoprophylactic measures for flying personnel due to possible side effects of the applied substances and their impact on flight safety and mission effectiveness. A temporary restriction for flying duties is usually required for at least 24 hours after vaccinations and for 3 to 6 days after living virus vaccinations (e.g. MMR, Yellow Fever).

Major tasks of flight surgeons deployed with their units are aeromedical surveillance and health care for the flying personnel, providing emergency medicine capabilities in Role 1, establishing the mishap response team, advising squadron leaders continuously and to take part in aeromedical missions on demand. The senior flight surgeon has to be ready to act as the Medical Director on board.

The flight surgeon has to provide the link between medical policies and wing mission. The knowledge of aviation medicine is necessary but not quite enough in this context. On top he or she must also speak the line language, which means knowing about the flying schedules, maintenance issues, familiarization with mission specific requirements and personnel protection equipment. Mission support is enhanced when flight surgeons are full partners and effective advisors trusted by the wing commander and his team.

The Flight Surgeon serves as an essential and crucial element in a professional AeroMedevac system. Training both for flight surgeons and assistance personnel must comply with national standards and NATO requirements, as they are defined in STANAG 3204 (2). Aeromedical personnel is obliged, whenever possible, to fly in the status of additional crew members and has to be trained on all relevant aspects of the aircraft type.

The training of personnel in the GAF is tailored to the different tasks.

- Senior Officer MC, Physician, AeroMedevac 10 days
- Medical Asst. Personnel, AeroMedevac 10 days
- Intensive Care Personnel, AeroMedevac 5 days
- AECO 3 days
- Flight Physiology, AeroMedevac, Refresher 1 day

Besides specific academics lessons the training includes Flight Physiology, familiarization with the medical equipment, in-flight training and flight safety training.

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Especially the ongoing developments of SAR / CSAR in asymmetric scenarios require mission orientated and professional procedures, adaptation of medical equipment to new standards and operational requirements, system integration of medical equipment into new aircraft and establishment of functionality in order to perform “Joint Med Force Command” missions.

A good example for applied operational aviation medicine is the quick response to the high altitude challenges during ISAF. Flying operations require CH-53 helicopters to climb over the Hindukush up to 18,000 ft MSL for more than 30 minutes. For flights above 12,000 ft MSL, the use of oxygen delivery systems is mandatory. However the helicopters were not equipped with such systems. Conventional oxygen delivery systems are not suitable due to their considerable weight and volume. In a common approach between unit, flight surgeon and Aviation Medicine Institute, a market survey and a research project were initiated to test a system of oxygen bolus breathing, which is characterized by reduced volume and weight, improved oxygen exploitation rate and considerably reduced need for oxygen. The results of the test course showed, that bolus breathing achieved arterial saturation levels according to sea level, the system ensures oxygen supply at altitudes up to 18,000 ft and functions either at rest or under mild physical and mental effort.

Based on these findings, the equipment was introduced for use in helicopter flights at altitudes above 12,000 ft.

## HUMAN PERFORMANCE ENHANCEMENT

There is an extraordinary increase in information available within minutes and seconds, corresponding with changes of required piloting skills, mission characteristics and mission time. After 27 hours of sustained wakefulness, research has shown that crews will have the same degraded performance as persons with a Blood Alcohol Concentration (BAC) of 0, 05% (3). After 24 h hours of sustained wakefulness, performance degradation is comparable with persons who have a BAC level of roughly 0, 10%, corresponding with the status of legal intoxication.

Acute sleep deprivation degrades visual perception, complex motor, and simple motor flight performance. Complex motor impairments strongly correlate with visual perceptual impairments (4).

There is an ongoing debate on different approaches to enhance human performance especially during sustained operations. Different procedures are in use and are implemented in doctrines and policy letters. The spectrum reaches from sleep management to application of pharmaceutical agents. The next table serves as an excellent example for this issue.

**Table 3: Fatigue Management in combat**

	Whiteman AFB	FOL	Combined
Mean sortie duration (hours)	35.3	16.9	29
Pilot			
age (years)	34.9	36.1	34.8
flying experience (hours)	1290	1486	1404
long-duration experience (hours)	79	86	75
Stimulant use (percentage of sorties)			
Dextroamphetamine	57%	91%	70%
Caffeine	54%	28%	46%
Sleep			
in-flight nap	90%	13%	66%
pre-flight use of sedatives	54%	32%	48%



Measures to enhance human performance should primarily include mission-specific diet, exercise, rest and fatigue management before implementing the regular use of pharmaceuticals, especially those with potential side effects.

Naps, as soon as possible, are very useful as a first line fatigue management tool. Environmental conditions are important and 30-min post sleep inertia has to be obeyed and to be matched with operational requirements.

Well accepted pharmacological approaches include the application of hypnotics, melatonin and slow release caffeine. The use of stimulants like dextro-amphetamine is controversial and the substance is not officially approved by national authorities in several countries.

Hypnotics are effective for crewmembers not flying or being deployed during flight to induce sleep to coincide with the nocturnal rest period at the destination location. The substances are effective during recovery due to their promoting effect on sleep. Hypnotics with short duration of effectiveness (Zolpidem, Zopiclone 5-6 h; Zaleplon 3-4 h) should be preferred. There are no reports of unwanted side effects of these drugs on daytime alertness.

Melatonin has been proven to hasten resynchronization, but there are unwanted side effects on alertness 4 to 5 hours after taking the drug. However, the utilization is more and more controversial. Melatonin is a hormone and the effects on mid and long term are unknown.

A USAF-French AF Joint study (Pegasus operation 1998) compared slow release caffeine with melatonin on sleep, vigilance and rhythms following a 5-time-zones flight. The results showed better results for caffeine on maintained vigilance and hastened resynchronization.

An excellent overview of fatigue in military aviation and US-approved pharmacological countermeasures was presented by Caldwell et al (5). When considering the use of medications for aid in operational context, it should be kept in mind, that drugs are not a substitute for good work and rest scheduling. Sleep-promoting and alertness-enhancing compounds should not be administered to personnel indiscriminately or in the absence of proper medical supervision and that there has not been a drug of any description that has been found capable of indefinitely postponing the basic physiological need for regular and daily restful sleep.

Further investigations and ongoing research even take into account the use of anti-diuretics like Desmopressin to avoid discomfort due to bladder distension during sustained missions (6). Urination in flight might be a safety issue. A full and distracted bladder may cause decreased situational awareness, increased chance for nausea and thereby an increased potential for mishaps. It encourages dehydration by reduced volume intake, which additionally leads to lower G-tolerance (3% dehydration = 40% reduction in G-tolerance). However, those approaches should be considered very carefully because of the potential side effects like drug induced dehydration producing for example headaches, which are of operational significance or side effects like hyper coagulation by influencing factor VIII.

STANAG 3527 is the fundamental document in NATO that is to be applied in this context (7). Sleep and alertness management are major issues of attention for the medical support round the clock. Pharmaceutical agents may be used during certain operations to maintain performance and minimize the effects of fatigue. The use of such agents requires careful supervision by flight medical personnel in accordance with national laws, regulations and procedures.

## **CHALLENGES FOR THE FUTURE**

Human-System-Integration in the fourth generation aircrafts and related data management challenge the aircrew. Automated cockpit systems and mixed operations with remotely piloted vehicles flying in controlled airspace have to catch our attention.

New airborne weapon systems like Eurofighter Typhoon, Joint Strike Fighter, but also the new generation of attack helicopters or cargo aircraft with capabilities to perform sustained missions in high altitudes require the continuous assessment and review of Aeromedical standards, aerophysiological training, and psychophysical fitness measures in regard to deployments under complex and difficult circumstances and in the sense of preventive medicine. The operational user expects to utilize the full technical potential of those systems.

This also means that operational medicine is not only obliged to be present during missions and deployments, but also serves as a partner for the operational side during the sensitive testing and introduction phase of new flying systems and personal life equipment to initiate appropriate changes when necessary.

Both, extremely agile aircraft and environmental conditions should be considered as potential triggers of diseases or sudden incapacitation during flight due to acute medical situations caused by pre-existing but unknown abnormalities.

For example, the prevalence of a patent Foramen Ovale of 25% and the hereby associated possibility of a transient elevation in right atrial pressure able to force the foramen open during sustained high-G-maneuvers or a high-G-onset rate started a lively debate, whether an expansion of aeromedical standards and diagnosis would be necessary.

Literature showed that there is not a significant higher risk for cryptogenic strokes, if there are no additional pathological findings (atrial aneurysm). On the other hand an atrial aneurysm in combination with a patent Foramen Ovale is a potential risk for cerebrovascular incidents.

The diagnostic measures in the German Air Force therefore are now focusing on the detection of this abnormality through non-invasive methods like colored duplex ultrasound, while there has been an approach using transesophageal echocardiography for detection of a PFO in the past.

A further aspect in this context is the impact of helmet weight, high-G exposure or ejection forces on the vertebral column, either to cause injuries or to worsen pre-existing abnormalities.

Results of a 5-year MRI screening among helicopter pilots at the German Air Force Institute of Aviation Medicine showed spinal changes in the cervical and lumbar spine of about 70%.

Due to these facts, the MRI screening of the vertebral column in Germany includes all candidates and all active pilots in a 5-year interval. Before beginning with training on Eurofighter and Tiger-helicopters, it must be guaranteed, that no excluding medical precondition exists.

Objectives of applied aeromedical activities are to identify neck injuring mechanisms during ejection, optimal helmet balancing and to investigate the muscle stresses during sustained high G forces with helmet mounted displays. Additionally the flight surgeons are obliged to accompany specific aircraft pilots training programs.

A lot of research has been initiated, for example the sampling of multiple neurophysiologic signals like saccadic eye-movements, papillary movements, high frequency EEG and the integration of those signals with performance prediction models. (8).

Based on own findings, ongoing research and international cooperation is a task and obligation in the sense of interoperability and interchangeability.



## CONCLUSION

The self-commitment of the German Aeromedical Service as a team is to comply with:

- Continuously ensuring professional Aeromedical care and advice at all levels of the forces
- Facilitating Total health and human readiness in aviation
- Providing up-to-date and accessible resources, in times of ever-increasing training requirements and higher ops tempos
- Actively supporting the evolution of new technologies through professional expertise, regarding aircrews as the priority element within the man-machine-system
- Being an integral part of the flying units and making a substantial contribution to flight safety through competence and work
- Conducting mission-oriented, efficient training, advanced training and follow-on training in all major areas of aerospace medicine
- Closely cooperating with other medical services organizations in a comradely way
- Conveying confidence and security through abilities and reliable presence
- Identifying new mission opportunities
- Accomplishing the mission under the aspects of Quality Management
- Contributing the abilities to international alliances through multilateral cooperation, thus ensuring a well-founded aeromedical expertise in the international context anywhere and any time.

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