3. ARMED FORCES, MILITARY TECHNOLOGY

MILITARY ASPECTS OF WEATHER SUPPORT

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Abstract
This article aims to show automatic mobilesystemsfor atmospheric measurementsused by the armed forcesas a part ofcombat support. The author has paid attention to historical parameters of the impact of weather on military operations and the need to possess current weather data for the planned operationsarea. The author points out that the most important aspect of the systemof hydrometeorological supportfor combat operations is obtaining data and making measurements outside of permanent military bases.

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Introduction

The impact of weather on military operation, in particular on the operation of contemporary armed forces, has long been recognised. In addition to the evaluation of a number of various parameters when planning combat operations,it is vital to take into accountthe weather conditionsvarying in various intervals.Increased military operations always requireaccurateinformation on current and predictedweather conditions. It concerns mostly, but is not limited to, air force operations.

The execution of operations by special forces unitsalways require accurate meteorological data,especially the ones organised in places where oftentimes there are no stationary weather stations, such as near aircraft landing areas in random terrain, in particular near water crossings or natural disaster areas, or when securing other operations, e.g. armed forces relocations, military missions, etc. Preparing credible weather forecastsrequire data retrieved not only from stationary measurement systems, but also very accurateadditional measurements of the state of the atmosphere in its ground level and relevantstrata.

When analysing the history of wars, it is easy to notice the importance of weather impact on military operations. Knowledge of the weather conditions, taking into acc ountclimatecharacteristics,had often direct or indirect impact on whether a battle ended in a victory or defeat.

The truth of that statement was found out by both Napoleon Bonaparte, the emperor of France, during Russian campaign, as well as later by German commanders during the Operation Barbarossa.In those cases it had not been taken into consideration that heavy winter, snow and ice are natural obstacles that would not allow for regular provision supplies for the fighting army. Both operations ended in defeat. The weather also posed an obstacle when the Operation OVERLORD was planned. The operation, planned for 5 June 1944, known in history as the biggest Allied landing operation – the Normandy invasion- almost failed because weather conditions had not been taken into consideration while planning.The planners had simply overlooked them.It turned out, however, that the whole operation, or at least its key objectives were in danger of failure because of very unfavourable weather conditions. A storm on the Atlantic and overcast sky, low cloud bases, precipitation and poor visibility made any seaborne and airborne operations virtually impossible. It became evident then, how extremely important an accurate weather forecast can be, whenprovided by meteorologists, predicting a short improvement in weather, a so-called weather window, which allowed the commander of Allied forces, General Dwight D. Eisenhower to make the right decision and launch the Normandy invasion.

Anotherexample was the situation of the United StatesThird Fleet on the Pacific. The formation under the command of Admiral William Halsey consisted of: 13 aircraft carriers, 8 battleships, 15 cruisers, 58 destroyers with numerous supply and supportvessels. On 17 December 1944, as a result of communication problems (which tend to happen every now and then), despite the American meteorological service having correctly predicted the coming storm, the Third Fleet read the meteorological data wrong, in particular the data concerning the stormdirection, andwrong decision was made and the ships were sailed into the heart of the typhoon – and there was a lot to be afraid of. It was a massive storm of incredible strength, with windsof 230 km/h and waves reaching 20 m. The typhoon caused severe damage to the ships and three destroyers unfortunately met their tragic end sinking together with their 790 crew members[1].

The provided examples seem to confirm unambiguously that neither armed forces units, nor other uniformed public services can fulfil their tasks well without the knowledge of current and forecasted weather conditions. Due to the fact that there are rarely any weather stations at the locations of planned operations that would provide the needed data, it is necessary to use mobile (portable) hydrometeorological measurement systems and mobile weather stations. It constitutes theobjective of this paper's research.The presented contents include the compilation of research results concerning:

1) the historical context of weather impact on military operations;
2) possibilities of weather support for operations in modern conditions;
3) mobile systems for hydrometeorological support and their usability in modern military and non-military operations.

As early as during World War II a need was recognised for obtaining weather data from particular locations without measurement stations or places located within enemy territory.The movement of air masses from the west to the east is predominant inthe northern hemisphere, therefore the knowledge of atmospheric conditions in places west of the operation locations is required whenpreparing weather forecasts. It has not been always possible, German war machine in particular had problems with obtaining the data.

One of the first attempts wasmade on 8 October 1941 when a group of Luftwaffe observersunder the direction of Erich Eten-

[1] Tadeusz Zawadzki „Wichry Wojny", http://www.polityka.pl/pomocnikhistoryczny; Bogusz Szymański „Armie pokonane przez pogodę", http://www.edulandia.pl/edukacja

newere accommodated on Spitsbergen island. Weather forecasting for the German army improved, but it did not suit the British who made several attempts to destroy the station, but to no avail. The station was functioning until end of May 1942.

Another attempt to obtain unavailable meteorological data was the first combat mission of U-573 that consisted of transporting an unmanned weather station via the Atlantic Ocean. Upon installation, the stationwas to conduct weather observations in the remote area of the northern Labrador coast. Constructed on behalf of the German army by Siemens, the station-Wetter-Funkgerät Land-26 (WFL-26), codename Kurt, was transported in ten cylindrical canisters, each of them weighing ca. 100 kilograms. The systemconsisted of instruments performing basic measurements broadcast via a radio transmitter equipped with a 10-metre antenna.The system wasp-owered by nickel-cadmium batteries that ensured its work for up to six months[2]. Weather readings would be broadcasted during a two-minute encrypted transmission every three hours.The weather station was installed on a hill 400 m from the coast. Installation team also took care of "disinformation" – using the markings of the no longer existing"Canadian Meteorological Service" for the purpose. As part of the camouflage, empty packs of American cigarettes and matches were thrown around the area that would allegedly convince random finders that it was an area of American or Canadian operations. This way the station remained undiscovered for more than thirty years (rediscovered in 1977). Weather station Kurt is now on display at the Canadian War Museum in Ottawa.

Fig. 1. Canadian War Museum – weather station Kurt

Source: http://www.waymarking.com

Conclusions and experience gained on the Labrador coast were extended to the entire armed forces. Fourteen stations of this type were deployed in arctic and subarctic regions (Greenland, Bear Island, Spitsbergen and Francis Joseph's Land) and five stations were deployed in the Barents Seaarea. Another attempt was also made to install a station in the North America. However, the system did not reach its destination due to the U-867 submarine having been sunk in September 1944 in Norway, north west of Bergen, in a British air raid.

Another example of German automatic weather station constructed for Luftwaffe was the *Kröte*. It consisted of a Stevenson screen placed on a three-metre mast. The screen held temperature, humidity and air pressure sensors. Batteries, control instruments, a clock and 20 Watt Lorenz S 22664/IV transmitterwere housed in steel drums

2 Piekałkiewicz J., Kalendarium II wojny światowej, Janki nearWarsaw 1999.

installed on the mast. Data was broadcast 4 times a day via a wire antenna stretched at a height of 5-6 m. Batteries ensured the station's work for up to 3 months.

Development of modern technology, information technology and communication systems allowed the construction of many types of automatic and mobile measurement systems, as well as mobile weather stations that in addition to performing a full range of measurements, allow meteorologists to work 24hours a day. Currently, the systems are highly specialised and designed to meet the needs of the systems'users. There are systems for hydrological, meteorological and aerological measurements. Apart from this classification, the systems are divided according to their use or type of user. There are the following meteorological measurement systems:

- hydrological;
- for air forces;
- for artillery;
- forchemical units;
- for airborne forces.

The systems were developed with the following objectives in mind:

- mobile systemsproviding the same quality weather measurements as stationary systems;
- easy system installation and deinstallation (one-man installation and operation is often required);
- providing power from independent sources, including operation for a specified period with no external power supply;
- systemsbeing lightweight and compact;
- the ability to transport the system with the use of standard transportation means (e.g. by car, by train, by plane or on a ship);
- operation in difficult conditions (high and low temperatures, high humidity, high level of contamination);
- automation of selected operations (e.g. sending meteorological or aerologicalmessages);
- the ability to send data to many recipients via wired and wireless networks.

Mobile and automatic weather stations

Mobile systems allow for measurement of the main parameters of the state of the atmosphere. These systems are intended for ground measurements.

Fig. 2. Vaisala weather station

Source: Vaisala materials.

Fig. 3. Mobile weather station

Source: COMET materials.

Armed forces of the Republic of Poland are equipped with more and more modern mobile measurement systems. Basic versions of the instruments measureair pressure, temperature, humidity, as well as wind direction and speed. They are equipped with high-accuracy and high-resolution sensors. Vane anemometers are being replaced with ultrasonic ones that are equipped with an inbuilt compass and GPS unit. Such anemometers do not require geographical orientation and in a situation where such an anemometer is placed e.g. on a ship, appropriate software will be able to calculateactual wind – taking into account the movement of a sensor. Mobile measurement systems are also equipped with extensive communication systems (Bluetooth, radio modems) that allow to send data to many users not only via a permanent Internet connection.

According to user needs (e.g. support for the operations of the air forces or chemical units) mobile weather stations are equipped with additional sensors. Among thosethere are ceilometers – determining the height of a cloud base (modern laser sensors detect at least four layers of clouds), visibility sensors, lightning detectors, rain gauges. Appropriate software allows to visualise and archive your data.

Systems for measurement of ground-level wind parameters

Fig. 4. TAMAYA TD-4 theodolite for measuring upper-level winds

Source: Vaisala materials.

Fig. 5. PilotRadiosondeMeteomodem upper-level winds measurement system

Source: COMET materials.

When providing weather support forairborne forces, air forces, parachute jumps or glider flights it is necessary to measure theground level wind parameters up to the altitude of ca. 3 km. The measurements are performed mainly in two ways – with a theodolite and with the use of special radiosondes equipped with GPS.

The theodolite method makes use of an accurate theodolite tracking of a balloon filled with hydrogen or helium. The measured azimuth and elevation angles are calculated by a specialised application that provides the wind direction and speed on various levels above the ground.

The GPS method focuses on hanging the radiosonde under anascending weather balloon and the radiosonde sending its current position and altitude, which allows to calculate the parameters of upper-level winds.

Both methods have advantages and disadvantages. The theodolite method is not dependent on the availability of the GPS signal, but is restricted by the presence of clouds (when the balloon enters the clouds it becomes impossible to make any measurements) and requires an additional light sourceattached to the balloon at night to allow the observation. The GPS method is not restricted in this way, but is dependent on the GPS signal and the fact that the radiosondes send their observations via a radio signal, which might be regarded as a restriction during armed conflicts.

Mobile aerological stations

Modern meteorology, in particular numerical models for weather forecasts, require a lot of data and not only from the ground level. Measurements performed through as thick as possible part of the atmosphere (in favourable conditions up to the height of ca. 30 km), which can be done by measuringthealtitude profile(temperature, pressure, humidity, speed and direction of wind). Aerological stations in Poland are located in Legionowo, ŁebandWrocław. Meteorologists in Poland would obviously wish a denser networkof aerological stations, but performing continuous measurements two or four times a day is expensive. Therefore, the Armed Forces of the Republic of Poland are equipped with mobile aerological systems that allow to perform thesoundingat any place and time.

Basically, atmospheric sounding can be done with the use of two methods, both consisting inlaunching a balloon with an attached radiosonde. In the first method (radio theodolite), the radiosonde is equipped with pressure, temperature and humidity sensors, and transmitting radio signal is tracked by an antenna from the ground, allowing to calculate the direction and speed of wind on various levels. Appropriate software allows to visualise the measured parameters n a way that is useful for a meteorologist.

Fig. 6. Radio-theodolite atmospheric sounding system "BAR"

Source: AVIOMET materials.

In the other method, the radiosonde launched to measure temperature and humidity is equipped with a GPS sensor that transmits the position and altitude in real time. This system has one advantage over the previously described one: the antenna receiving the signal is significantly smaller and the whole system caneven be transported by apassenger car. The software provides graphical visualisation of sounding data allowing to prepare more accurate forecasts. Such systems are also among the equipment of the military weather service.

Fig. 7. Meteomod aerological measurement System

Source: COMET materials.

Fig. 8. Automatic aerological measurement RobotRadiosonde

Source: Meteomodem materials.

Both systems allow to prepare meteorological messages in accordance with the WMO and NATO standards that can be made available on the data exchange network.

Another difference is the method of detecting pressure and determining the altitude of individual measurement levels. In the GPS method altitude is measured and the pressure calculated accordingly, whereas in the other method the pressure is measured and altitude – calculated. Both methods are in accordance with the WMO[3] requirements.

Wherever it is necessary to perform aerological sounding and permanent staff cannot be sent, such solution asthe RobotRadiosonde automatic station can be used. The station allows to launch the balloon with the radiosonde automaticallyin appropriate intervals determined by the user and the data is sent to the recipient anywhere in the world.Man simply has to load the station once in every few days.

Mobilemeteorological stations

Mobile metrological stations allow a full crew of meteorologists and observers to work round the clock. They are fully autonomous, equipped with instruments to help perform afull range of measurements of the state of the atmosphere (automatic weather stations, mobile aerological stations or systems for measuring ground-level wind parameters). The stations are equipped with communication systems allowing to receive and send weather data. Sitting in a heated and air-conditioned room, forecasters are able to prepare forecasts providing complete weather support. Field weather stations are equipped with an independent power supply system permitting long-term operation without an external power supply. Apart being equipped with specialist instruments, the space for the meteorologists' work has been modelled after the best campers and has many amenities allowing soldiers to stay there for long periods of time. The off-road vehicle can access virtually any location.

Mobile metrological stations are used to support the operations of the air forces outside their permanent bases, airborne operations or other tasks that require accurate measurement of atmospheric conditions and weather forecasts.

[3] The World Meteorological Organization with headquarters in Geneva.

Fig. 9. Mobile metrological station

Source: COMET promotional material.

Compact weather stations

Weather service units and airborne units are equipped with compact Kestrel weather meters. Despite their small size, they are equipped with fully professional sensors, such as: anemometer, thermometer, hygrometer (for measuring the moisture content in the atmosphere), barometer andcompass.

Fig. 10. KESTREL 5500 weather meter

Source: Kestrelmeters promotional material.

Thanks to the instruments, the meters have numerous very useful features, such as the following:
- Air pressure,
- Crosswind,
- Density altitude,
- Dewpoint temperature,
- Heat stress index,
- Relative humidity,
- Current air pressure (no reduction),
- Temperature,
- Wet bulb temperature (psychrometric),
- Wind chill,
- Wind speed,
- Wind direction.

The measurements of this type of instrument are not as accurate as those of their larger counterparts, but their small size allows for their exceptional mobility. Thanks to the installed software, they can be used by various users in a specific way in most severe conditions. They are used by special forces soldiers, snipers (there are devices dedicated to ballistic calculations), fire fighters.

Trends and directions in the development of weather support systems

The main trends in the development of hydrometeorological support in terms of atmospheric conditions measurements are as follows:

- providing the armed forces with continuousand highly accurate hydrometeorological information;
- the development and implementation of automatic systems that conform strictly to the ICAO[4] and NATO quality standards;
- the development of software for the systems enabling broader interpretation of data which allows to calculate the state of the atmosphere parameters impossible to obtain through direct measurements.

[4] International CivilAviation Organization.

Development prospects for mobile automatic measurement systems

The development of measurement technology enables more and more automatic measurementsof the atmospheric conditions. Modern systems are also able to measure such parameters as visibility, cloud base altitude, as well as cloudiness and ice conditions on runways, the latter two being particularly difficult to measure without human involvement. In future, the entire range of measurements should be performed with lesser and lesser human involvement.

Weather surveillance radars play an important role in weather support. Modern mobile Doppler weather radars would improveweather support considerably. Weather surveillance radars enable accurate alerts concerning particularly dangerous weather phenomena within Cumulonimbus or the wind shear phenomenon. Therefore, it would be very beneficial to equip the service with mobile Doppler weather radars that are widely used e.g. by the American armed forces. Unfortunately, good quality radars are expensive and their operation costs – excessive.

Fig. 11. Mobile weather radar

Source: http://www.nssl.noaa.gov/tools/radar/mobile/

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