4

Survey of monitoring technologies

Technology supplements rather than substitutes for the human presence in the field. Face-to-face interactions with armed factions and local civilians will always be the basis for peacekeepers to build trust and understanding. However, peacekeepers need all the information they can get to be safe and secure in complex and dangerous environments, and to carry out their monitoring mandates effectively. Human vision and communication are limited in distance, in duration and at night. There is much that technology can do to:

- increase the range, area coverage and accuracy of observation;
- permit continuous (e.g. 24-hour) monitoring;
- increase effectiveness, including cost-effectiveness in some cases;
- decrease intrusiveness;
- record events for transmission and future viewing.

Technical information complements human observation by creating a larger and more detailed picture of the area of operation. The United Nations can easily move beyond the "mark one eyeball", sometimes aided by binoculars, and deploy a variety of appropriate technologies as a standard part of the peacekeeper's toolkit.

The human eye sees only a small slice of the electromagnetic spectrum: visible light of wavelength 400 to 700 nanometres. Instruments are capable of measuring a range that is at least 15 orders of magnitude larger, from X-rays (less than 3 nanometres in wavelength) to radio waves (centimetres to thousands of kilometres). Furthermore, the unaided human eye has limited optical resolution[1] and no capacity for zooming. Electro-

Keeping watch: Monitoring, technology and innovation in UN peace operations, Dorn, United Nations University Press, 2011, ISBN 978-92-808-1198-8

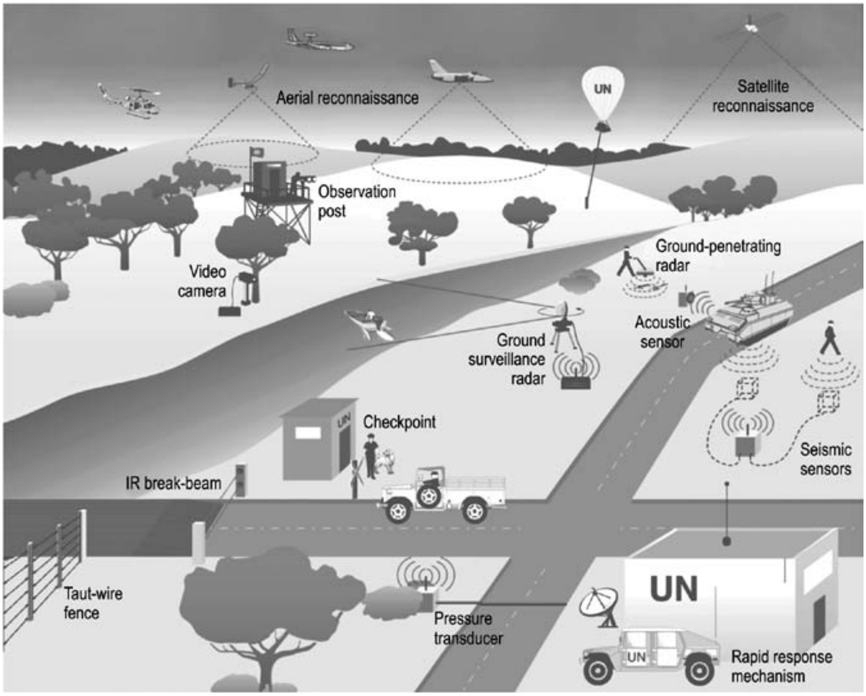

Figure 4.1 Composite diagram showing potential sensors and platforms for peacekeeping.

optical sensors can extend the human capacity many-fold, enhancing observation, interpretation and assessment. Sensors can also record images for wider dissemination.

Besides electromagnetic waves, other forms of energy can also be measured (e.g. acoustic/seismic signals, quasi-static electric/magnetic fields), as can materials (nuclear particles, chemical/biological agents). This chapter focuses on the detectors and technologies that can be most useful, illustrated in Figure 4.1.

The composite diagram in Figure 4.1 depicts a wide range of useful technologies for peace operations. A “top to bottom” explanation reveals the four possible regions to place sensors: outer space, airspace, ground level and underground. From outer space (top right), modern reconnaissance satellites can legally observe all areas of the Earth, with enough resolution to count cars and even people. In the air, helicopters, unmanned and manned aircraft (including radar-equipped planes and jet reconnaissance aircraft), and balloons (tethered, guided or free floating) permit even higher-resolution surveillance of large areas.

Ground observation posts (middle left in Figure 4.1) can be equipped with imaging equipment, such as video cameras attached to high-power binoculars or night-vision devices. For open areas, as often found in buffer zones and waterways, ground surveillance radar can detect intruders or movements of persons, vehicles or boats. For smaller passageways, acoustic or seismic arrays can be used to detect movements, possibly to alert peacekeepers to oncoming vehicles or to initiate mobile UN checkpoints or to trigger a rapid reaction force. Similarly, pressure transducers or infrared (IR) break-beams could alert the United Nations to vehicle movements, especially at night, on roads that have no UN checkpoints. Ground-penetrating radar can help locate buried weapons, mass graves, landmines or underground bunkers or tunnels. Areas that are UN protected or sensitive can be blocked off with taut-wire fences, which not only serve as barriers but also send signals when touched or climbed or cut, indicating the location of intruders to UN guards or forces.

A UN station (bottom right in Figure 4.1) could dispatch mobile patrols or interception forces to respond to incoming information. It could also send the imagery and information gained by the sensors to other nearby stations and to mission headquarters for real-time (or near-real-time) viewing. The United Nations could even use loudspeakers located at sensitive sites to issue voice commands to trespassers, even though the observers and other UN personnel might be far away at the station.

The United Nations has, in isolated instances, used some of these technologies. Some advanced contingents have brought them to the mission as part of their National Support Element. These technologies are covered in detail below, with examples from UN operations, if deployed at all. A summary of potential technologies and their applications is also provided in Appendices 3 to 6. This chapter gives a thorough examination of the technological resources the United Nations has used in the past or could use in the future.

Satellite and aerial reconnaissance

High-resolution satellite imagery was for decades the sole preserve of the superpowers. From the very dawn of the space age, however, UN supporters have envisioned the possibility of UN satellite reconnaissance for peacekeeping and humanitarian purposes (Dorn 1987). In 1981, a UN study even recommended the creation of an International Satellite Monitoring Agency. Though UN ownership of satellites proved far too expensive, commercial companies began selling increasingly higher-resolution and superior satellite imagery at affordable prices with discounts for humanitarian agencies. Since 1999, images of 1 metre resolution or better – a capability once highly classified – have been readily available on the open market.[2]

To capitalize on the host of new satellite imaging applications, European nations in 2000 led the development of an International Charter on Space and Major Disasters (International Charter 2010) designed to provide a "unified system of space data acquisition and delivery to those affected by natural or man-made disasters". This joint endeavour of international organizations, the private sector and the scientific community allows authorized users "to request the mobilization of the space and associated ground resources . . . of the member agencies to obtain data".

One result of this initiative was the creation of the United Nations Operational Satellite Applications Programme (UNOSAT) to harness the possibility of inexpensive data for peacekeeping and humanitarian purposes.[3] Under the motto of "satellite imagery for all", UNOSAT operates a 24/7 Rapid Mapping Service for UN agencies and their implementation partners. An impressive example of its mapping capability was shown during the Lebanon–Israel crisis of July–August 2006. Damage assessments were provided a few weeks after the fighting stopped to assist with rebuilding.[4]

Most commercial satellite imagery does not arrive until two weeks or more after it is ordered by the United Nations. This turn-around time is too long for operational use. So the vast majority of UN-ordered satellite imagery is used to make maps. The United Nations has not moved to near-real-time imagery, which is considerably more expensive. However, such imagery would be extremely useful in countries such as the Democratic Republic of the Congo (DRC) and Sudan, especially in determining the recent locations and movements of militia. Some governments have this capability, but share near-real-time imagery with the United Nations only on a "need-to-know" basis as determined by their own national security criteria. Shorter turn-around from commercial sources is possible, and in the future, as the technology advances, images of current operations should be available and affordable.

Unlike satellites, aircraft can provide imagery in hours since they can be leased and controlled directly by the United Nations. The world organization has carried out aerial reconnaissance in several of its missions. In 2006, the UN Mission in the DRC (MONUC) established an "Observation Aviation Unit" as an Eastern Division asset, with four Lama (Alouette) light helicopters, each providing a "glass bubble" around pilot and passenger. When street protests and mobs were a threat in Kinshasa, two of these helicopters were brought to the capital for urban monitoring. In another instance, the United Nations had its first experience tasking uninhabited or unmanned aerial vehicles (UAVs), which were brought by the European Union Force (EUFOR) to help MONUC during the election period from June to November 2006. These UAVs helped spot and track illegal arms imports near the city by the two main conflicting parties. EUFOR also deployed mirage jets with photo-reconnaissance capabilities.

Finally, balloons (aerostats) could serve as another useful observation platform, although such possibilities have not yet been employed by the United Nations. When tethered to the ground they could also serve as a landmark, for example to identify borders. Because aerial reconnaissance is such an effective means of monitoring and because there are so many varieties of aircraft, Chapter 5 is devoted specifically to the subject. In addition, the many uses of geographic information systems, as an integral part of mapping, charting and geodesy, are explored later in this chapter.

Mobile cameras (still and video)

> A photograph describes circumstances, actions and justification much better than written or verbal explanations. All worth-mentioning incidents, events, locations, personalities, equipment and [anything] else must be photographed/filmed for conveying writte[n] message to all concerned.
>
> Guidelines from the Eastern Division Commander of MONUC,
> Maj. Gen. Patrick Cammaert (2005a)

Cameras have been used since the beginning of traditional peacekeeping, though often in a strictly limited fashion owing to the sensitivities of parties, especially opposing armies, that the United Nations has stood between.[5] Belligerents worried that photographs could show changes in their forward positions, which could be used by the other side. They also wanted to hide and deny evidence of their own violations. In modern operations where traditional lines between the parties are more fluid and spread over large areas – or even are nonexistent – cameras are an important tool to provide evidence of violations, which might be presented to the parties or even to a national or international court.

Personal hand-held cameras are now providing evidence of breaches of international law, just as they are of domestic law.[6] As commercial technology becomes increasingly better, higher resolution and less costly, UN field operations will undoubtedly benefit, particularly if ingenuity is used to find new and creative methods and places for their use.

An early innovative approach using simple technology was demonstrated in Cambodia in 1992–1993. Under the 1991 Paris Peace Agreement, the United Nations Transitional Authority in Cambodia (UNTAC) had the right of unrestricted access to information in the offices of government agencies and political parties. UN mission leaders were aware that assassinations of opposing political leaders were probably being planned in the field offices of political parties. To confirm this, UNTAC sent personnel to inspect regional offices. Using photocopy machines placed in the back of trucks, the teams made copies of files and correspondence for later translation from Khmer. The United Nations identified and exposed plots, which helped prevent assassinations and planned violations of the peace agreement, including undermining the elections of July 1993. The UN surveillance practice probably struck fear in the minds of potential perpetrators and limited their ability to communicate their plots with each other. This kind of monitoring operation would be technologically easier today because of the widespread availability of portable scanners, digital cameras and electronic translators. Even cell phones with cameras can be used to photograph and transmit page images.

Cameras and other image-capturing devices are also used in the rapidly unfolding field of biometrics. Biometric technologies permit the unique identification of humans based upon intrinsic traits that can be physical – such as fingerprints, facial features, hand/palm geometry and retina/iris patterns – or behavioural – such as gait or manner of speaking.[7] The United Nations' aviation agency already sets the world standards for biometric machine-readable passports (UN News Centre 2005). For UN peacekeeping endeavours, important applications would be to confirm identities for voting, payroll or access purposes. For instance, the European Union conducted iris scans on Congolese soldiers as a requirement to receive their pay. This ensured soldiers were paid only once per period – to prevent fraud. It also safeguarded against commanders inflating their personnel numbers to receive extra funds themselves. Another application could be to identify known criminals or insurgents who might be applying for positions in local police or military forces or for local UN employment. Such an application requires the development of a large database of fingerprints or other biometrics, which might raise privacy concerns. However, in post-conflict situations it might well be justified. During the siege of Goma in 2008, for instance, many of the rebel fighters who had previously participated in a disarmament, demobilization and reintegration programme renounced their integration into the Congolese army and returned to fight in the bush. They were rumoured to have secretly entered Goma in large numbers intending to seize it, but such infiltration was unverified; biometrics at checkpoints on roads leading to the town during the critical period would have been a small measure to help identify such individuals and make their entry harder.

Another example of a mature monitoring video technology is the license plate recognition (LPR) system, which can be fixed or mobile.

These systems have proved very useful for policing in the developed world. Mobile units are often placed in police cars/vehicles to scan, detect and identify licence plates on cars. Fixed LPR systems capture and automatically report on vehicles travelling through designated zones. The systems store the vehicle information in a database for quick and easy reference. This is particularly useful to find stolen vehicles and persons wanted for felonies. The Washington State Patrol installed a fixed system to check all the plates of vehicles boarding ferries (Port Orchard Independent 2008). They check them for AMBER alerts, reported stolen vehicles, wanted persons and suspected terrorists. One officer of the Arizona Department of Public Safety used an LPR-equipped patrol vehicle to recover more than 400 stolen vehicles over five years (Stockton 2009).

In a UN Police (UNPOL) context, this type of system can perform valuable security and detection functions for intersections and choke points (e.g. bridges), toll or vehicle portals, customs checkpoints and more. For example, vehicles approaching checkpoints or known hotspots would have their licence plate recorded and queried to reveal any enforcement action pending against the owner of the vehicle or simply to identify vehicles frequenting particular trouble areas for intelligence-gathering purposes.

These systems would be especially useful at border points. They could be used to spot vehicles likely to carry contraband and to track down known criminals. At key sites, the cameras can be permanently placed to keep a continuous watch.

Fixed video and motion sensors

Both portable and fixed video cameras have improved vastly in capacity and decreased drastically in size and cost. Additionally, an exponential increase in computer processing power, network speed and storage capacity[8] has created a "revolution" in digital closed-circuit television (CCTV) or, using recent terminology, digital video network (DVN).[9]

Commercially, CCTV/DVN technology has evolved from analogue cameras and recorders to hybrid analogue/digital systems and to fully digitized systems. Digital video recorders (DVRs) allow imagery to be more easily transmitted, stored and analysed. Analytic software within the recorders can detect motion and send automatic email/text alerts upon detection. A further evolution, from which the United Nations should benefit, is the Internet Protocol (IP) camera, which can even be connected to the World Wide Web.

Such IP systems allow imagery to be transmitted and viewed in real time throughout a local area network (LAN). Access can be password protected and signals encrypted before being transmitted. In Iraq it was discovered that insurgent groups were downloading unencrypted video feeds from US UAVs – (Shane and Drew 2009). The United Nations would also have to prevent signal interception through encryption in some of its operations so that imagery is used not to assist aggression but to discover it.

High-definition (HD) IP cameras with smooth imagery – “real-time” rates of 30 frames per second (fps) or more and frames with 1080 pixels – are now becoming inexpensive. IP cameras can connect anywhere on the network, including through a wireless connection or the nearest hard-wired “node”. For cameras with the Pan Tilt Zoom (PTZ) feature, the movement commands are transmitted through the same transmission line as the video signal. Two-way audio is also possible with speakers built into the video camera system, allowing warnings to be made to would-be violators and communications with those seeking assistance. The power needed for the camera can be transmitted over the wire (“Power over Ethernet”) so an additional power supply is not needed. Alternatively, if the device is wireless and removed from power sources, it can be solar powered, though perhaps for only several hours a day.

IP-type systems contain purposeful redundancy. A single error in the system cannot cause a system-wide disruption. Like the Internet more generally, the system is designed to find alternative routes to convey information. A comparison of analogue, IP and HD-IP cameras is provided in Table 4.1, showing the evolutionary progress in such systems.

Most IP cameras contain internal motion sensing through software that will start a recording only when detecting motion in the field of view. Some video software (e.g. Video IQ iCVR) allows customers to search for a person or vehicle of interest simply by clicking on their image. Video IQ automatically searches across terabytes of video from any of the Video IQ cameras and encoders on the network, though the result is highly dependent on the quality of the imagery.

To protect privacy within certain areas of the camera view, “masks” can be assigned internally so sections of the camera image are deliberately degraded. This allows the camera operator to hide certain areas from the viewer (for example, an entrance to a washroom) or from other parties.

At the high end, video cameras have high optical zoom capability (in the range of 120 times magnification) and can operate in very low or no-light conditions, with humans still identified at distances up to 3,000 metres.[10] High-quality HD cameras are now available at a low cost, as low as $100–200.[11] They come in small (pocket) sizes and are easy to operate and connect to computers to upload imagery.

Video systems became more common on UN premises after the tragic 19 August 2003 bombing in Baghdad. As a safety and security measure,

Table 4.1 The evolution of commercial video cameras

	Analogue	Analogue + DVR	IP video	High-definition IP video
Video quality	Good	Poor, generally	Very good (640 × 480)	Excellent (1920 × 1080) HD 1080i
Frame rate (images per second)	High (30 fps analogue)	Low (5–10 fps)	High (30 fps)	Very high (30–60 fps)
Storage capacity	Limited; tape-based	Fair; limited by proprietary nature of system	Very good; utilizes MPEG-4 compression	Excellent; utilizes new H.264 standard
Archival capability	Poor; magnetic tapes eventually degrade	Fair; manufacturer must have designed archival feature	Very good; video files are in standard format, easily archived	Very good; video files are in standard format, easily archived
Number of simultaneous users	Limited; can add only up to the point of signal degradation	Limited; only 5–10 viewing users at any given time	Limited only by system/network capacity, 30+ users	Limited only by system/ network capacity, 30+ users
Number of cameras per system	Limited by the number of wall monitors installed	15–30 cameras per server, typically	Virtually unlimited	Virtually unlimited
Analytic capabilities	None; "mark one eyeball"	Limited; motion-based recording	Advanced; depends on software package	Advanced; depends on software package
Degree of "openness"	Somewhat open	Not open; usually a proprietary or "black box" solution	Generally open; video streaming is based on open standards	Generally open; video streaming is based on open standards
Degree of difficulty for remote viewing	Very difficult	Difficult; requires specialized software	Easy; requires only a web browser	Easy; requires only a web browser
Security	No security	Limited security (username/ password)	Very secure (encrypted/ authenticated)	Very secure (encrypted/ authenticated)

Note: I am indebted to my knowledgeable research assistant, Gordon Hawkins, who provided the initiative and a lot of help in putting together this table.

UN field missions were given the go-ahead from UN headquarters to purchase video camera systems (CCTV/DVN). Such systems are now widely used to monitor the perimeters and some internal spaces in the headquarters and camps of many UN field missions.[12] However, the world organization has little experience of installing cameras outside UN premises.

Installing fixed cameras to view conflict areas has tremendous potential but has been little explored in peacekeeping. By contrast, other types of operations and organizations have taken such initiatives. The United Nations Monitoring, Verification and Inspection Commission (UNMOVIC) installed remotely controlled cameras inside and outside Iraqi factories to verify the non-production of weapons of mass destruction in Iraq.[13] The Organization for Security and Co-operation in Europe Mission in Kosovo (OMIK), which is a distinct component of the United Nations Interim Administration Mission in Kosovo (UNMIK), installed a network of some 130 cameras in or near its buildings, all electronically linked to its mission-wide LAN. More importantly, in the divided city of Mitrovica, two of its PTZ cameras keep a 24-hour watch on a bridge that is the site of frequent contention between ethnic communities. Any gathering of crowds can be observed remotely from the OMIK Operations Room or from any computer on the network, including at OMIK headquarters.[14] Imagery of swelling and violent crowds can trigger intervention by peacekeepers.

The United Nations Peacekeeping Force in Cyprus (UNFICYP), which monitors the "Green Line" that separates the two main ethnic communities on the Mediterranean island, is one of the few UN missions to use CCTV to monitor hotspots. Under a new concept of operation titled "concentration [of forces] with mobility", military leaders argued in 2004 that UNFICYP would be more effective with a mobile response force using monitoring technology (UN Secretary-General 2004; see also the case study in Chapter 6). They advocated a shift from static observation posts to mobile patrols and CCTV/heliborne surveillance, arguing that this approach would require fewer peacekeepers, enhance both operational efficiency and force protection, and create savings in personnel, logistics and administration. It took four years but, in 2008, the United Nations had six cameras observing sections of the Green Line in Nicosia, the divided capital of Cyprus. UNFICYP also had 100 CCTV cameras to guard various UN bases and facilities.[15]

The quality, range, resolution and built-in features of commercial CCTV cameras are rapidly improving, while the costs are decreasing, leading to an increase in their utility and appeal. For instance, many CCTV systems can now automatically detect movement or another stimulus within the field of view. This can alert and dispatch peacekeepers to known hotspots.

Motion detectors can be used not only to raise an alert but also to turn on illuminators at night. They can be used to detect and deter prowlers or other intruders into UN camps or protected/monitored areas. Detectors can be fine-tuned to go off only when people approach. Older motion detectors often had the challenge of differentiating humans from dogs, cats or even tree branches blowing in the wind. Today's passive infrared sensors are keyed to the temperature of the heat coming from the human body: infrared radiation of wavelength 9–10 micrometres. Typically a household motion detector costs only $20–30 and can activate a video camera. Such detectors are also available in solar-powered and ruggedized form ($50–200), which means they can be left alone for long periods of time.

Cameras can also be installed inside vehicles. For instance, some are installed in taxis in various cities around the world to deter violence against drivers, with snapshots or video of passengers stored in an inaccessible part of the vehicle or transmitted in real time to a central location. The imagery can be shared with police should the need arise. This has been a powerful deterrent to violence and vandalism. But in some cases such cameras have become a target of attacks themselves, though they can be hardened and made vandal-proof or disguised to evade notice. Another innovation is the "Talking CCTV" camera, which has a speaker that allows police to interact and warn would-be violators. After detecting illegal or suspicious activities in remote locations the police can verbally issue "orders" to wrong-doers. They can also provide directions to lost persons and helpful instructions to UN personnel. If the camera is night-capable, this can be done at all hours.

Night vision

Hostile elements often use the cover of night to conduct illegal activities. As mentioned in the previous chapter, these include: attacking civilians, digging mass graves to hide atrocities; pushing cease-fire positions forward to gain advantage; raids across lines of control; laying landmines and improvised explosive devices (IEDs); preparing ambushes; and breaking sanctions though arms and people smuggling.

For all such cases, night-vision equipment (NVE) is an invaluable tool for the peacekeeper. The most effective type is a thermal imager that detects infrared (IR) radiation, particularly in the 8–14 micrometre (far-IR) wavelength band, from warm bodies at distances up to 5,000 metres and from vehicles up to 10,000 metres. Such devices can also peer through smoke and dust, though not as easily through fog and clouds. Thermal imagers can enable peacekeepers to spot warm bodies hiding in jungle growth or rubble (though not behind glass windows). Some thermal devices are heavy, but others can be worn as goggles, facilitating foot patrolling and night driving (for example, in aid convoys), spotting targets, as well as keeping track of other peacekeepers. Unfortunately, the United Nations has very few of these IR devices because of their high unit cost (over $5,000), although some are brought to the operations by participating militaries. Rather, the United Nations depends on a simpler form of night vision: image intensification.

Image intensifiers detect visible light and sometimes near-IR but not far-IR (heat) radiation. The devices "amplify" the ambient visible light before it reaches the eye. Standard off-the-shelf intensifier tubes have a light magnification factor of 25,000 or more. To be effective, there must be sufficient ambient light from either the night sky or artificial sources. Illuminators operating in the near-IR part of the spectrum are sometimes added to the devices so that nearby objects can be viewed more clearly in reflected light. Although the human eye cannot see when the illuminator is on, persons using this technology can see objects much more brightly because of the light they reflect. For distant objects, image intensifiers add extra hours of vision around dawn and dusk. Under ideal conditions (for example, a cloudless night with a full moon), a sentry using a third-generation image intensifier can spot humans moving 1,500 metres away. The UN-owned equipment standard requires "an effective range of 250 metres", considerably less than the standard of 1,000 metres specified in the United Nations' Contingent-Owned Equipment (COE) Manual. The cost of these image intensifiers varies from $300 to $3,000 per monocular or set of goggles, depending on the generation and quality.

The UN Department of Peacekeeping Operations (DPKO) owns several hundred night-vision devices, mostly binoculars, almost all of which are currently deployed in missions.[16] Most peacekeeping operations (PKOs) possess about 20 or so UN-owned devices, with four – the United Nations Operation in Burundi (ONUB), the United Nations Mission in Liberia (UNMIL), MONUC and the United Nations Mission in Sudan (UNMIS) – having over 50 devices each, still a small number compared with the thousands of personnel in a mission, many of whom should be doing night patrols and operations, as well as acting as night sentries. The UN devices are all second generation,[17] except for a single third-generation device, which the Property Management Unit database lists as in "fair condition".[18] Generation 2+ typically cost the United Nations just under $2,000 for binoculars. Though DPKO has tried to procure third-generation devices, it has so far been denied the required US export licenses.

Contingents are usually requested to bring their own NVE in accordance with the vague standards of the COE Manual. The NVE usually come in the form of headgear (goggles) but they can also be found as monoculars, binoculars or weapon sights. They are mostly image-intensification systems with some near-IR capability. Thermal systems are also brought to some missions by individual nations (mostly developed nations).

The United Nations does not have its own means for recording imagery from NVE. The Mi-35 attack helicopters flown in the Eastern DRC are equipped with fourth-generation forward-looking infrared cameras, but these are national (Indian) assets, and the digital video recordings from the cameras are not generally shared with the United Nations. Similarly, when EUFOR deployed to the DRC, its special forces brought fourth-generation devices, though these were not shared with the United Nations. EUFOR also brought night-vision sights from tube-launched, optically-tracked and wire-guided (TOW) anti-tank missile launchers.[19] These had an impressive range of over 4 km to view a person. In an earlier UN mission in Bosnia, peacekeepers took the night-vision sights off TOW launchers, brought for protection, in order to use the sights for observation, given the lack of proper night-vision equipment. Another important technology for both day and night detection – radar – was not deployed by the United Nations in Bosnia.

Radars

Though seldom used by the United Nations, radars have tremendous potential for keeping peace, just as they have for fighting wars. Whether deployed on the ground or on boats, aircraft or satellites, they can greatly increase situational awareness through imaging or tracking the movement of objects either on the ground, in the air or underground.

Ground surveillance radars (GSR), for instance, can detect a moving person or vehicle at up to 10 km, as long as there is an unobstructed line of sight to the target. Suspicious movement detected by the radar could then trigger investigations by patrols. As an example, the United Nations Interim Force in Lebanon (UNIFIL) set up US-supplied ground radar devices in the 1980s to detect infiltration along critical sections such as the Litani River and the Israeli border, and in Israeli controlled-areas. In spite of a large number of false alarms, mostly caused by animals, the system proved valuable. European states also deployed radars to Lebanon in 2006 to observe movements: land-based radar (Cobra systems), air-based radars on jets and helicopters and sea-based radars on frigates and patrol boats. These radars greatly extended the range and night capacity of UNIFIL.

GSR was also deployed by the Irish Quick Reaction Force during its deployment (2003–2006) with UNMIL. Two Advanced Man-portable

Surveillance and Target Acquisition Radar (AMSTAR) units were brought from Ireland. Various naval radars were also used by the UN Iraq–Kuwait Observation Mission (UNIKOM, 1991–2003) along the tense maritime border, particularly to observe freighter traffic in the seaways near Basra.[20] Unfortunately, there are no UN reports on the use or functioning of this or other UN-owned or UN-controlled radar systems. When the contingents left, they took both their equipment and their knowledge with them.

Other ground-based radars are available to identify and track mortar and artillery fire. For a short period, the United Nations Protection Force (UNPROFOR) in Bosnia obtained such units to locate the origins of mortar fire. In some cases they revealed disturbing evidence of atrocities inflicted by one group on its own members, presumably in order to garner international sympathy.

Air surveillance radars have proved essential for accurate detection of airspace violations, which are common in war-torn areas. Already in the 1960s, the United Nations Operation in the Congo employed two such radar sets, but the current mission in the Congo (MONUC/ MONUSCO[21]) has not yet used them, despite calls from mission leaders. Only in 2006 did UNIFIL gain the capacity for airspace surveillance radars, despite a long history of unauthorized aerial intrusions by aircraft from Israel. In the past, airspace monitoring was done by the naked eye. "Violation reports" were issued when two UN military observers of different nationalities identified a plane in the sky using nothing more sophisticated than binoculars.

During the 1990s, the North Atlantic Treaty Organization (NATO) carried out very sophisticated and effective monitoring of UN-mandated no-fly zones in the former Yugoslavia using its AWACS (Airborne Warning and Control System) aircraft. Every second week, the UN Secretary-General circulated documents with long lists of airspace violations, totalling many thousands of violations a year. When NATO took over operations in Bosnia, the sophisticated JSTARS (Joint Surveillance and Target Attack Radar System) aircraft complemented AWACS by detecting ground movements and providing radar imagery.

Synthetic aperture radar (SAR) is of special interest in military operations because of its ability to image day and night in all weather conditions and from high altitudes, even above clouds. A SAR consists of a modestly sized but high-power radar transmitter/receiver on an airplane or satellite. The radar achieves a high spatial resolution of a few metres by exploiting the motion of its platform and coherently processing the return signals from the ground. The system achieves a resolution many times more useful than the actual physical aperture of the radar antenna. The resolution is limited fundamentally only by the radar wavelength. SAR imagery from commercial satellites, such as RADARSAT, has helped the United Nations to confirm large refugee movements in places such as the Eastern DRC.

Ground-penetrating radar (GPR) would be particularly useful to detect weapons buried underground and to locate hidden tunnels or hiding places. Metal detectors can reach only a certain depth, whereas GPR can go deeper. Such radar technology is also useful in detecting hidden graves, which is important for human rights work and is already in wide use for geology, archaeology and civil engineering.

The United Nations has used hand-held radar guns, normally for vehicle-speed measurement and enforcement, in a few of its missions. These devices cost less than $100 each and can be useful at checkpoints, in demonstrations during local police training and to monitor the speed of the United Nations' own vehicles.

Through-wall vision/radar systems have not yet been used in UN operations, although the "radar scope" is an emerging and proven technology for high-risk police and military operations. A current, commercially available unit is about the size of a laptop computer and can detect people behind common wall materials, even enabling a count to be made of people in a room. It can image (two-dimensional) static objects and detect movement at a range of up to 20 metres. It can also give information about room dimensions. Video from the devices can be broadcast wirelessly to a remote display. It is described by one manufacturer as ready to go at the push of a button with no warm-up time or complicated boot-up procedures. Only minimal training is required to operate the device.[22] Domestic police examples include a broad range of tactical entry operations including: rescuing hostages; apprehending suspects barricaded inside an apartment; executing a high-risk warrant of arrest; and unobtrusive surveillance.

In peacekeeping, this technology could be used to view rooms into which UNPOL or UN military forces are about to enter, with force if necessary. In Haiti, the United Nations has liberated kidnapped people from their captors and has conducted cordon and search operations to arrest gang leaders in their hideouts. For such cases, the through-wall vision system would be useful to anticipate threats and reduce collateral damage.

Communications monitoring

To supplement the extended "eyes" of the United Nations using visual, infrared and radar remote sensing, peacekeepers have on rare occasions had electronic "ears" (radios with frequency scanners) to listen to radio and electronic communications. This controversial practice is not routinely employed in peace operations for privacy and other reasons. In some circumstances, however, it is entirely warranted – for example, when peacekeepers are being attacked or held hostage. Such monitoring has selectively but effectively been employed in several of the United Nations' large PKOs and much more extensively in NATO operations. The first documented use was in the UN Operation in the Congo (1960–1964), where the practice developed casually. In Northern Katanga, a battalion commander established an improvised radio interception system using a commercial receiver and local tribesmen as translators. Later in that mission, a more sophisticated interception system with a code-breaking capability was established to stop miscreant activities by mercenaries supporting secession in Katanga (Dorn and Bell 1995: 11). For the vast majority of operations, however, electronic interception has not been used. In the NATO-led Implementation/Stabilisation Force in Bosnia and Herzegovina and Kosovo Implementation Force, by contrast, advanced electronic intelligence platforms were routinely used to capture messages sent by radio, even those transmitted by frequency-hopping techniques. Of course, national laws should be respected during such undertakings, as discussed in Chapter 9.

The United Nations needs to be aware that its own communications are liable to be intercepted. Whereas NATO or EU operations deploy secure communications systems as a matter of course – secure satellite phones, radios, fax, etc. – as EUFOR did in the Congo in 2006, the United Nations does not. In fact, the commercial cell phones used by MONUC personnel were generally known to be monitored. The United Nations did conduct sweeps to detect bugs in some mission headquarters offices, but in general its counter-intelligence capability is very limited.

Acoustic and seismic sensors

Acoustic sensor systems enable sound (in the audible range and beyond) to be detected. Some systems can be simple and improvised. For example, in UNPROFOR, one-way radios were used as acoustic sensors inside weapons storage sites that were under UN lock and key. The understaffed UNPROFOR could not guard them 24/7. When parties broke into the sites, which happened frequently, the sensors captured the sounds of the heavy vehicles (for example, the starting of a tank engine). The signals, sent by radio, then alerted staff in the United Nations' local headquarters. In some instances, the weapons were recovered.

Seismic systems monitor low-frequency waves propagating through the Earth caused by either underground stimuli such as explosions or surface activity such as vehicles or even footsteps. Because the ground tends to attenuate seismic waves, the detection ranges of geophones are typically small (tens to hundreds of metres) for most kinds of surface disturbance. For underground explosions, the ranges can be much larger, depending on the detailed characteristics of the soil and the frequencies being sensed. Unattended ground acoustic sensors were successfully used in the United States' Sinai Field Mission (SFM) in 1976–1980. The sensors complemented remotely operated video cameras (both visible and IR) to notify watch stations of intruders moving through the strategic Giddi and Mitla passes. In areas near the passes where geological conditions were less favourable for seismic/acoustic detection, strain sensitive cables were laid across the terrain. Strain gauges then measured the deformation of the cable and the nearby ground by an intruder. The SFM was created and manned by the US government but closely coordinated with the United Nations Emergency Force II. By technical means, some 90 minor violations over nearly four years of observation were detected and resolved (Kontos 1980; Vannoni 1998). The United Nations, even 30 years later, still has not employed ground sensors, at least not to the level used by the SFM in the 1970s.

Ultrasound probing involves sending high-frequency sound waves through an object. The attenuated or reflected signals can then be used to characterize the contents of the object. Such probing was used by inspectors in Iraq to deduce whether munitions were empty or were filled with bulk, powder or liquid, something essential to know before starting to drill for testing and destruction. No examples of uses in peacekeeping have been uncovered.

Chemical, biological and nuclear sensors

Chemical agent monitors or "sniffers" are widely used in airports to detect explosives in luggage and hand baggage. Most systems are based on gas chromatography/mass spectrometry. These devices are becoming more compact, transportable and sensitive thanks to commercial instrument development. The large chemical/biological analytical toolbox is rapidly expanding. Sensor kits for biological agents have been developed commercially for testing air, water and soils. A number of research programmes are developing advanced chemical sensing for landmine detection, though the technology has yet to move from the prototype to the field in the form of inexpensive and widely available devices.

The three UN inspection bodies in Iraq – the United Nations Special Commission (UNSCOM), UNMOVIC and the International Atomic Energy Agency (IAEA) – have had substantial experience with chemical, biological and nuclear detectors. In UNSCOM, nuclear radiation detectors were essential not only to uncover the Iraqi nuclear weapons programme but also for the personal safety of the inspectors, especially during visits to destroyed nuclear sites. Geiger counters and gamma detectors are the main sensing devices, although for arms control many other sensors are also used. Several UN PKOs have used hand-held narcotics and explosives detectors, mostly in UN-assisted airports and the entrances of UN buildings.[23]

Positioning systems and "blue tracking"

In military parlance, "blue tracking" means following the movements of the mission's own or friendly forces. In UN peace operations, the term is appropriate not only because of the United Nations' identification with the colour blue, but because the tracking capability is much needed for UN safety and effectiveness. To best protect and make use of UN personnel, it is essential to know where they are. Of course, tracking other forces is also important, for example red (hostile), green (friendly) or white (other).

In one of the most successful applications of technology in modern peacekeeping, the United Nations has deployed a vehicle fleet management system using Carlog devices to monitor the movements of UN vehicles in most UN missions.[24] The Carlog device, which is permanently fastened to the vehicle dashboard, automatically identifies the driver (who must swipe his licence card through the Carlog reader and enter a pass code to start the engine), the location and the route (thanks to an offline Global Positioning System, or GPS), distances travelled, driving behaviour (such as speeding, harsh braking or over-revving) and the time of day (by the second). When speeding occurs, the Carlog's built-in alarm system beeps and displays a flashing notice, often frustrating speeding drivers. After accidents, the Carlog records can be reviewed to produce a vehicle event history and to see if drivers might be fully or partly responsible. Persistent speeders may be reprimanded or even have their licence revoked. The Carlog display also reminds drivers of the next scheduled maintenance period. Used in conjunction with the FuelLog system, it keeps track of fuel and calculates gas mileage.

According to DPKO transportation officials,[25] the proven benefits of the Carlog system are extensive. These include: reduced accidents and injuries, reduced repair costs, improved driving performance, better fuel efficiencies, more regular vehicle maintenance (improving vehicle reliability), reduced paperwork (no manual trip-tickets), a reduced number of unauthorized trips, improved vehicle security (by use of the ID pass codes and swipe cards) and better vehicle allocation management. On top of all that, Carlog allows for route planning and analysis to determine the most efficient routes and has provided the United Nations with the assurance of knowing where its vehicles have been.

The Carlog system does not continuously transmit the vehicle's location to a central data station in the mission. The radio frequency transmitters in the vehicles are too weak for that. The stored data are transmitted in a burst when the vehicle is within 150 metres of a receiving antenna, usually located at main UN facilities. With an upgrade to FleetLog3 it would be possible to conduct real-time vehicle tracking, which is widely used by trucking companies in the developed world. The FleetLog2 system used in MONUC costs about $500 per device.[26]

Besides Carlog, the standard HF communications system in UN vehicles also has a tracking option using GPS.[27] The current location of the vehicle could be displayed automatically on a screen in the car and/or on a computer map in an operations centre. The system can also produce an audible warning when vehicles approach a user-defined exclusion zone (for example, national borders), but this feature has not yet been activated in UN missions.

Real-time vehicle tracking by a central facility, although not available in peacekeeping, could be particularly useful for trips out of radio contact and for retrieving stolen vehicles. In UNPROFOR, an advanced system with uplinks to the INMARSAT satellite communications system was set up by one of the contingents to track aid and supply convoys in the mountainous region of the former Yugoslavia. Tracking and transmitting devices in cars could be helpful for rescue or other forms of assistance.

Radio frequency identification (RFID) tags can permit the tracking of the movement of almost any type of object, from pencils to vehicles, within well-defined spaces. Microwave RFID tags are already being used in the personal automobile market for long-range access control for high-end vehicles. RFID has many potential UN applications for tracking packages, equipment and even personnel (under certain conditions), and for verifying disarmed weapons in storage, among other possibilities. The rapid rise of GPS devices, wireless technologies, GPS-equipped phones and online connectivity will make such innovations increasingly easier and cheaper over time.

Cell phones and smartphones

Commercial telecommunications have made tremendous strides in recent decades worldwide in both military and civilian applications.[28] Between 2002 and 2009, cell phone subscriptions jumped globally from 1.0 to 4.1 billion, with over 60 per cent of the world's population having access (Jordans 2009). Figure 4.2 shows the growth in both the developed and

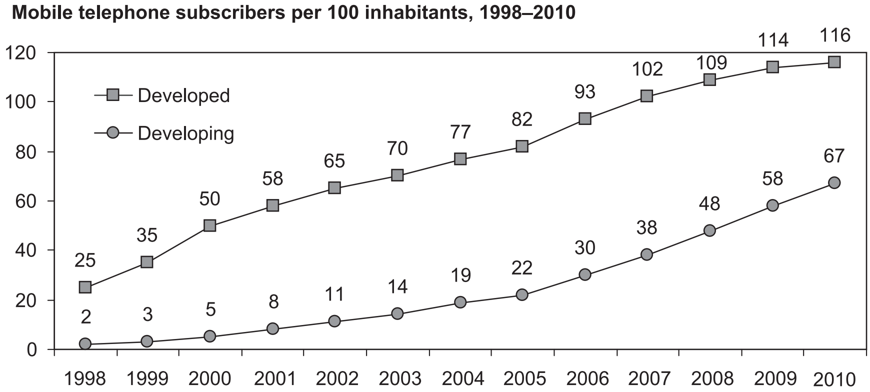

Figure 4.2 The dramatic increase in cell phone usage over one decade in both the developed and the developing world.
Data source: International Telecommunication Union, "Key Global Telecom Indicators for the World Telecommunication Service Sector", <http://www.itu.int/ITU-D/ict/statistics/at_glance/KeyTelecom.html> (accessed 7 January 2011).

the developing world. The devices have revolutionized the way societies communicate. They are now being used to grow businesses, transfer funds, increase personal mobility and provide better security to women and men all over the globe, where help in an emergency might be just a phone call away. They have enabled democratic movements to face authoritarian regimes, bringing about revolutionary changes in various parts of the world, especially in the Middle East and North Africa.

Cell phone systems are even available in some of the remote areas where UN peacekeepers are sent. Cell phone subscriptions have grown faster in Africa than in any other region of the world – from 54 million in 2003 to almost 350 million in 2008 (Poropudas 2009). In Haiti, the cell phone coverage rate rose from 6 per cent to 30 per cent between 2006 and 2010, despite a low 52 per cent literacy rate and widespread poverty. Fierce competition has lowered prices, increased services and widened area coverage in the developing world. Cell phones cheaply convey text messages (SMS, short for Short Message Service) around the world, although long-distance phone calls remain relatively expensive. (Where Internet connections are available, free voice and video conferencing is widely used, e.g. via Skype.)

The range of potential applications to peacekeeping and conflict monitoring is unlimited, but some examples demonstrate what has already been achieved. Cell phones are now widely used to alert conflict management professionals (local police, UN centres) and the wider population to perceived threats to safety and security. In Haiti, the United Nations has a hotline to receive reports of violence and kidnapping. In Jos, Nigeria, a messaging system (FrontlineSMS) transferred text message security alerts to subscribers, including civilians, police and crisis management teams. One message read “Jos is tense, please avoid downtown today”, creating a timely warning system based on the most ubiquitous communication tool in the region (Blyth 2009).

Election monitoring is a standard practice in UN operations for areas emerging from conflict, where elections are often hotly and sometimes violently contested. Election monitors and officials at polling stations have frequently used cell phones to call in or text their reports of election irregularities to field offices. The phones can provide video results of fraud, as in the 2009 Afghanistan elections, where UN officials had to void over 1.1 million ballots. In Sierra Leone’s 2007 elections, the first after the bloody 10-year civil war, volunteer election monitors sent real-time reports to information hubs supported by the United Nations and non-governmental organizations (NGOs), both local and international. The National Election Watch (NEW) had thousands of volunteers across the country collect data on procedural irregularities, violence and ballot counting. The NEW headquarters in Freetown aggregated, processed and visualized the data. This allowed the organization to announce with confidence, and in a timely manner, that the Sierra Leonean elections, conducted after a tense and often violent campaign, had been largely free and fair.[29] International monitors, including the United Nations’ peacebuilding office in country, echoed that conclusion.

The technique of “crowdsourcing” uses a larger segment of the population (a “crowd”) to report on events, such as elections and violence. Ushahidi, which means “testimony” in Swahili, is a prominent platform, first created to track violence after the 2007 Kenyan elections. It has developed crisis maps to show locations and details of violence in the DRC, Haiti, Lebanon, Afghanistan and the Gaza Strip. Ordinary citizens can provide SMS and voice information on human rights abuses, outbreaks of violence and damage to infrastructure. Information is placed on geographical maps such as Google Maps, as shown in Figure 4.3 for earthquake-stricken Haiti.

Such systems have allowed UN and NGO workers, security staff and others to make decisions with greater clarity, since they allow users to get an idea of the trajectories of conflict in near real time (Loudon 2010). For example, if crowdsourced maps indicate a rise in violence at a particular village or on a particular street, UN protection forces can more rapidly determine where best to deploy scarce resources. However, there is a natural resistance within the United Nations to work with crowdsourced data since they do not usually come from identified or verified sources. Advocates of crowdsourcing systems respond that it is hard to falsify an event given the large number of sources, especially if pictures or videos

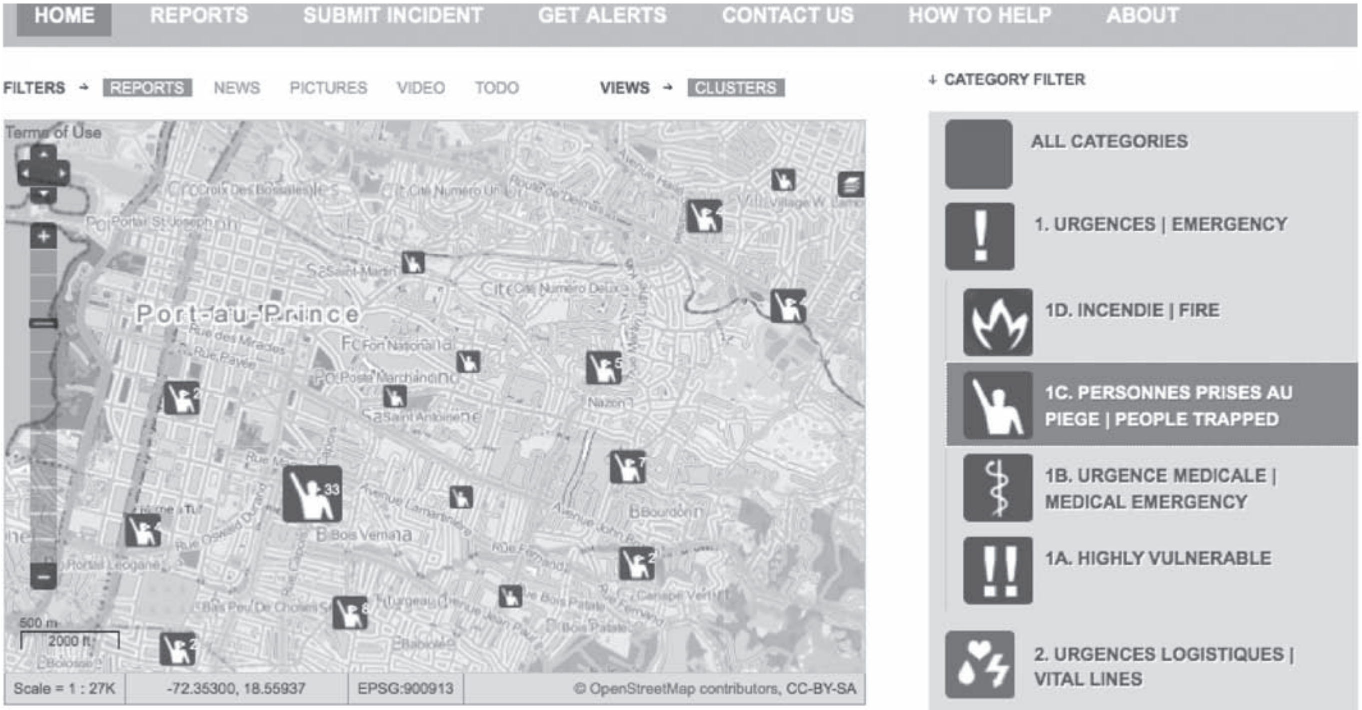

Figure 4.3 Map of crowdsourced incident reports of trapped persons in Port-au-Prince, Haiti, after the January 2010 earthquake.
Source: Ushahidi website, <http://www.ushahidi.com/> (accessed 1 December 2010).

are also presented. Such data can, in any case, become triggers for follow-up actions to verify and confirm reports or obtain leads.

More powerful cell phones called "smartphones" vastly increase the communication of information, including by email, Internet, camera, video/voice recorder, GPS and a growing number of online applications for social networking and interconnectivity (for example, Twitter and Facebook). Smartphones can also be attached through wires or wirelessly to a range of sensor systems and transmit sensor data. For instance, sensors that detect deadly chemicals can send their data through smartphones to rapid responders (Erdik 2006).

According to *The Economist* magazine (Economist 2009), by 2015 almost all handsets sold will be "smart".[30] As smartphones proliferate, the level and types of information transferred will increase dramatically, as will the potential for misuse. However, this problem can be intelligently controlled, though not extinguished. Transcription software and voice recognition allow smartphones to provide fairly accurate digitized records for forensic investigation.

Using cell phones or the Internet, peacekeepers in the field could obtain translation from a central translation service instead of relying entirely on a translator travelling with them. Alternatively, they could check the quality of the translations provided by persons who accompany them, especially to detect any translator bias, which is sometimes a grave problem in peace operations in divided societies. Telephonic interpretation services are also available commercially, and automatic voice translation software is making large strides.[31]

Customized smartphone software applications (apps) such as "The Guardian" can help peacekeepers and human rights observers upload still images and video, encrypt both SMS and voice messages, and speak in groups in a walkie-talkie fashion. In the event that an observer or a phone has gone missing, the NGO or UN field station can send an SMS to that phone and receive an automated response with the item's GPS coordinates. With the Guardian system, the phones can also be configured with a one-button erase feature or be accessed remotely by a colleague to delete any evidence if the phone falls into the hands of the perpetrators or their supporters. In addition, there are a growing number of relevant security and encryption software systems for human rights missions.[32]

Smartphones can instantaneously transmit images, sound recordings or video voicemail to secure servers and can have this information "stamped" with the time, the date and GPS coordinates. This can be used to show the location of human rights violations and allow the information to be placed in a geo-referenced database. Although images can be grainy, the resolution of smartphone cameras is rapidly increasing. Smartphones with Internet access can also allow peacekeepers access to virtually unlimited amounts of relevant data on the physical or social environment. Much valuable data can also be gained from information systems custom-built for UN field officials. The United Nations is just starting to do this.

Geographic information systems

Geographic information systems (GIS) are databases that link many types of data (for example names, images, reports and even RFID information) to geographical coordinates, that is, points on a map. Since mapping has long been a vital part of peacekeeping, GIS is already extensively used by DPKO to prepare maps of conflict areas, especially when up-to-date and high-resolution commercial maps are unavailable. GIS offers the potential for dynamic interactive maps,[33] change detection, overlays of selected data, analytical tools and other features.

The development of GIS is a technology-intensive area where the United Nations has made substantial progress over the past decade. The commercial availability of increasingly inexpensive and more accurate commercial satellite imagery and GPS devices, better Internet accessibility and user-friendly software (such as ArcGIS) has facilitated this progress. As a result of a Brahimi Report recommendation,[34] the first GIS units in the field were established in 2001 as pilot projects in MONUC, the United Nations Mission in Ethiopia and Eritrea and the United Nations Mission in Sierra Leone. GIS units are currently found in a dozen field missions, with 10 to 30 personnel in each unit, including military and civilian personnel.[35]

The United Nations is gradually evolving from ad hoc GIS arrangements to standardized structures and procedures.[36] The DPKO Cartographic Section at UN headquarters has developed GIS start-up packages for new missions as well as portable kits for GIS personnel deployed away from mission headquarters. The kits include: laptops and hand-held GIS PCs (personal computers that include GPS receivers), datasets, software, laser range-finders, digital cameras, portable printers and plotters.

The GIS units in the missions are providing much-used mapping services. For example, MONUC's GIS unit in Kinshasa has collected the GPS coordinates for Congolese villages and towns from UN military observers across the country. From these coordinates, it has created maps using geographical names common to the whole of MONUC, previously unavailable in that developing country. In addition to basic maps of administrative territories, tribal regions and UN deployments,[37] MONUC's GIS unit has produced more specialized maps of many types, including:

- dangerous areas – for example, flood or flood-prone areas, areas mined or containing unexploded ordinance, and sectors cleared or uncleared of mines;
- security concerns – for example, incidents of accident/sickness/hostile fire, potential conflict zones, evacuation routes, mustering and regrouping points, checkpoints, security areas of responsibility, liaison offices, security warden zones;
- military locations – for example, Congolese army units, local militias, foreign armed groups, arms trafficking routes;
- disarmament, demobilization and reintegration locations – for example, Regrouping Centres, Integration Centres, Orientation Centres, special child soldier camps.[38]

The costs for a professional GIS service can be substantial. For a large mission, the GIS start-up package (including personnel) is of the order of $500,000. During operations, satellite imagery costs per scene are typically: $300 (low resolution); $1,000 (100 km^2, medium resolution, e.g. from SPOT) and $2,500 (100 km^2, high resolution, e.g. from RADARSAT or Quickbird) (UN Cartography Unit 2006). Prices are decreasing with time.

The very user-friendly GIS program "Google Earth" is available free in the basic version.[39] It is already used extensively for mapping by mission planners both at UN headquarters and in the field. Some databasing using Google Earth is also being done by field observers, although not with real-time adjustments.

Google Earth already includes human rights information on its Darfur map, showing villages that have been destroyed.[40] The information was supplied by the United States Holocaust Memorial Museum. This partnership, named "Crisis in Darfur", used high-resolution satellite imagery released by the Humanitarian Information Unit of the US Department of State in 2007 and July 2009. The data showed more than 3,300 villages damaged or destroyed, primarily between 2003 and 2005. The display compares "before and after" satellite images of attacked villages. The Museum claims to provide "the most detailed picture to date of the scope and nature of the destruction that occurred during the genocide in Darfur and after" (USHMM 2009). It also shows that the level of destruction decreased dramatically after 2006.

Although Google Earth images are usually over a year old and locations are not precisely geo-referenced (typically off by 100 metres), improvements are constantly being made and commercial upgrades and enhancements can be purchased. Eventually, high-quality and high-resolution real-time coverage can be expected at reasonable rates for areas of UN deployment.

Despite the progress in GIS, the current capability at the United Nations is quite limited compared with the great potential. The over-reliance on old paper maps means that much of the information in the hands of users is out of date, inaccuracies are not easily corrected and new data are not routinely entered. The creation of a widely accessible UN GIS database to supplement the distribution of paper maps would allow for quicker updating and error correction, user inputs and improvements, and relational linking to other databases. For instance, UN Military Observers could post their daily situation reports, including photos, on a common geo-referenced database so that records could be easily accessed, shared and compared for near-real-time analysis and archival purposes. In addition, these reports could contain electronic links to other documents in the database for quick referencing. Databasing also permits more detailed queries and statistical analysis to see how the reported pieces of information relate in time and space. Furthermore, a GIS database could display inputs in real time from a set of cameras and automated ground sensors to offer continuous monitoring.

Network-enabled operations

Once a GIS system becomes interactive in real time, allowing users from many different locations and functional responsibilities to feed into a common system, it becomes an organic network. If the system also allows observations, orders and instructions to be conveyed along with the technical information, it can provide a capability that the military calls C4ISR: Command, Control, Communications and Computers (C4) and Intelligence, Surveillance and Reconnaissance (ISR).

Many advanced militaries are adopting the practice of "network-enabled operations" (NEO) using computer/sensor networks.[41] Termed "net-centric warfare" in the United States, NEO provides military forces across great distances with a "common operating picture". The network can integrate information from any number of persons and sensors. NEO has been shown to speed up response times to threats and challenges. It also can be used to delegate authority lower in the chain of command, so those most able to respond locally (so-called "strategic corporals") are armed with the big picture to take decisive action in support of the mission. It also allows higher-ups to get a sense of the "tactical" situation. The advantages gained from NEO include greater synchronization and improved unity of command (Lito 2010).

The early promoters of the concept, including US Vice Admiral Arthur Cebrowski, argued that this modus operandi constitutes a "revolution in military affairs" (Cebrowski and Garstka 1998: 1):

> Network-Centric Warfare derives its power from the strong networking of a well-informed but geographically dispersed force. The enabling elements are a high-performance information grid, access to all appropriate information sources, weapons reach and maneuver with precision and speed of response, value-adding command-and-control (C2) processes – to include high-speed automated assignment of resources to need – and integrated sensor grids closely coupled in time to shooters and C2 processes. Network-centric warfare is applicable to all levels of warfare and contributes to the coalescence of strategy, operations, and tactics. It is transparent to mission, force size and composition, and geography. (Cebrowski and Garstka 1998: 9)

Sceptics have pointed out potential drawbacks, including the dangers of information overload and of the networks going down or being destroyed, compromised or misused. These challenges, common to all information-gathering systems, are addressed later in this book. Though manageable, they do need to be addressed when creating powerful networks, especially ones that determine the lethality of a response.

The development of network-enabled operations by the United Nations would more rightly be called an "evolution" in peacekeeping affairs rather than a "revolution", given the slow pace of the United Nations' technological change. But such a new operating method would allow a common picture to be offered to a wide range of participants. Observers at great distances, in the air and on the ground, could share their imagery and insights. This would allow the challenges of distance to be reduced. In particular, network-enabled peacekeeping could help make much better use of the third dimension of space – the air overhead.

Notes

1. The resolution capacity of the human eye is typically described as "0.5 arc minutes" for a "line pair". That is, when two lines are separated by less than 1/120 of a degree from the observer, they can no longer be distinguished as separate. Given that the visible field of view is 120×120 degrees (maximum horizontal and vertical), one can estimate the number of bits of information the human eye is capable of seeing: 120×120×60×60/(0.5×0.5), which is about 300 megapixels. Commercial digital cameras are typically 3–10 megapixels, but advanced photo-reconnaissance cameras can record several orders of magnitude more information.
2. Ikonos, launched on 24 September 1999, was the first commercial satellite with a 1 metre resolution. Since then, several other satellites have been launched with a higher resolution, e.g. QuickBird 2 at 0.62 metres.

3. UNOSAT (<http://www.unitar.org/unosat/>) works on a not-for-profit basis and must be self-supporting. Therefore, images ordered by UN agencies carry a cost based on special prices negotiated with satellite image providers.
4. The UNOSAT Lebanon images are available at <http://www.unitar.org/unosat/maps> (accessed 7 January 2011). Another valuable website for imagery is Google Earth (<http://www.google.co.uk/intl/en_uk/earth/index.html>), though the free public imagery can be three years old. The United Nations is an "Enterprise Client" subscriber, so it can acquire a much larger range of imagery, including recent imagery. The turn-around time is still at least two weeks, though rush orders are possible at extra cost.
5. The issue caused some controversy in Lebanon in 2000 when the United Nations had video of armed groups kidnapping an Israeli soldier. At first, UN headquarters did not know the videotape was in existence and Israel demanded that the tape be given to it for its own investigations. This led the United Nations to consider its policies on cameras in the field. See United Nations (2001).
6. For example, see Crossette (1996).
7. An extensive manual is National Biometric Security Project (2005).
8. Terabyte (1,000 billion bytes) hard drives are now commercially available for under US$100.
9. Originally, the term "closed-circuit television" was used to make a distinction from televisions receiving public broadcasts. Closed-circuit meant that the image feed from the TV went back to a central location and was not openly transmitted. CCTV is now a generic term for a variety of video surveillance technologies, including images viewed on computer monitors.
10. The specifications for the Vumii Discoverii 3000 are given here (see Vumii Inc. 2010). The camera uses lasers to generate illumination.
11. US$ are used throughout this book.
12. The United Nations' CCTV security systems typically cost $10,000–20,000, including four or five cameras and a viewing/recording suite. Extra video cameras can cost from $1,000 to $3,500 each.
13. During the United Nations' verification operations (UNSCOM/UNMOVIC and IAEA) in Iraq prior to 2003, in the presence or absence of inspectors, sensors transmitted imagery and data by radio and telephone landline to the Monitoring and Verification Center in Baghdad, where remote viewing was carried out. For instance, IAEA cameras were able to observe the withdrawal of equipment from one Iraqi nuclear site in January 1999 the day before US bombs destroyed the facility (and the camera as well).
14. OMIK's two PTZ cameras, with a 100× zoom and waterproof casings, cost a total of about $3,000. Many additional features and accessories are advertised for the BioDVN suite, including a face recognition and identification module. See <http://www.security-labs.com> (accessed 10 December 2010).
15. The video surveillance cameras cost $225,500 for 93 cameras (approximately $2,500 each). With the associated equipment (computer, cabling, power supplies, etc.), the total equipment cost was about $400,000. For the maintenance of this CCTV system, DPKO budgeted $40,000 for 2006/7 (UNFICYP 2007).
16. The United Nations is also supplying the African Union Mission in Sudan with 360 night-vision goggles, according to a United Nations–African Union Agreement. See UN Secretary-General (2006).
17. Most are NVS 7-2 (generation 2+) devices from Newcon Optik (<http://www.newcon-optik.com>, accessed 7 January 2011).
18. Property Management Unit database query, Logistics Support Division, DPKO, New York, 27 September 2006.

19. TOW describes a missile technology invented in the 1960s that considerably improved over the decades and is still in wide use, though wireless guidance is now the norm for modern missiles.
20. DPKO's Item Master Catalogue lists a "Racal UNIKOM Radar Set Ground Surveillance System S-Band" from UNIKOM as being in the possession of the United Nations but in the inactive category. The UNIKOM radar was located at Umm Qasr, Iraq. It was used at night in conjunction with a searchlight to spot passing ships, especially oil tankers and freighters.
21. MONUC was replaced by the United Nations Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO) on 1 July 2010.
22. For example, see Camero Inc. (n.d.).
23. MONUC has purchased eight hand-held narcotics and explosive detectors, at a total cost of about $200,000. Other missions having explosives detectors include (number of devices in brackets): United Nations Assistance Mission for Iraq (6), UNFICYP (2), UNMIK (1), UNMIL (11), and UNMIS (2). The UNFICYP detector is a Scintrex E3500 model, which claims nanogram limits of detection (specifications available at <http://www.scintrextrace.com/brochures/current/E3500.pdf>, accessed 7 January 2011).
24. The missions currently deploying Carlog (specifically Fleetlog2) with GPS are: UNMIK, United Nations Truce Supervision Organization, United Nations Disengagement Observer Force, UNIFIL, ONUB, UNMIL, MONUC, United Nations Stabilization Mission in Haiti, UN Mission for the Referendum in Western Sahara. The commercial vendor is found at <http://www.e-drivetech.com> (accessed 7 January 2011).
25. Email from Ebrima Ceesay, Officer-in-Charge, Surface Transport Section, DPKO, 21 December 2006.
26. MONUC purchased its Carlog system with 336 units for $173,100, or $514 per unit (MONUC 2007).
27. See Barrett Communications, available at <http://www.barrettcommunications.com.au> (accessed 7 January 2011). Among the models the United Nations currently uses is the Model 950 (125 watt) mobile transceiver.
28. This section draws heavily from an article by Martin et al. (2011).
29. See the MIT Press journal *Innovations*, which seeks "entrepreneurial solutions to global challenges", and articles by Schuler (2008) and Gabriel et al. (2008).
30. Commercial examples of smartphones include the Apple iPhone, RIM Blackberry, Google Nexus One, Palm Pre and the Treo.
31. An example of a company providing on-demand telephonic translation is Telelanguage. It claims to have interpreters trained in over 150 languages, enabling customers to connect to an interpreter within seconds around the clock (<http://www.telelanguage.com>, accessed 7 January 2011).
32. Some examples include TigerText (<http://www.tigertext.com/>, accessed 7 January 2011), Tivi (<http://www.tivi.com/, accessed 7 January 2011>) and Mobile Defense (<https://www.mobiledefense.com/>, accessed 7 January 2011). Information on "The Guardian" is available at Huffington Post (<http://www.huffingtonpost.com/rebecca-novick/technology-of-liberation_b_385294.html>, accessed 7 January 2011) and Netsquared (<http://www.netsquared.org/projects/guardian-secure-private-anonymous-telephone-built-google-android>, accessed 7 January 2011).
33. For an example of overlays, see <http://maps.google.com/> or Google Earth (<http://earth.google.com>).
34. The *Report of the Panel on United Nations Peace Operations* (widely referred to as the Brahimi Report, after its chairman, Lakhdar Brahimi) made the following recommendation: "Peace operations could benefit greatly from more extensive use of geographic information systems (GIS) technology, which quickly integrates operational information with electronic maps of the mission area" (UN Security Council 2000: para. 20(c)).

35. GIS has become so much a part of modern engineering that the engineering branches in several missions have their own GIS sections. The Cartographic Section at UN headquarters also provides services to the Security Council as well as GIS support for DPKO and missions in the field.
36. The United Nations has a GIS Operation Manual, templates for resource planning and budget guidelines and missions have Standard Operating Procedures for GIS units.
37. This would include, for example, the locations of civilian police, military observers, national battalions and UN Volunteers.
38. This list is a summary of the Map Index of the MONUC GIS unit. The Index was supplied to me in November 2006 by email. A full list of types would add the following map types: communications (radio and cell phone network coverage, radio checkpoints); electoral divisions (registration centres and polling stations, election risk analysis, logistics, cast votes for presidential and legislative assembly positions, spoiled ballots, alliance map, collection plan, voter turnout); humanitarian information (internally displaced persons, child protection/orientation, medical facilities); natural resources (eco-regions, hydrography, national parks, riverine maps, mineral and mining operations); public information (radio station coverage, including MONUC's Radio Okapi); transportation (transportation network, aircraft landing sites, helicopter ranges, roads status, arms trafficking and trade roads) and other purposes (locations of quick-impact projects).
39. The "Google Earth" program can be downloaded free from <http://www.google.com/intl/en_uk/earth/index.html> (accessed 7 January 2011).
40. The Darfur map can be found under the heading "United States Holocaust Memorial Museum: Crisis in Darfur" at <http://earth.google.com/intl/en_uk/outreach/cs_darfur.html> (accessed 7 January 2011). For other information, see <http://earth.google.com/outreach/cs_darfur.html> (accessed 7 January 2011).
41. Whereas the US military uses the term "network-centric warfare", the UK and Canadian forces use the term "network-enabled operations". For more on this, see Mitchell (2009).