[Extract from report submitted to US Army CECOM NVESD in 2000.]

Testing

Testing of the equipment developed in this programme took place in minefields in Afghanistan, Angola, Mozambique and Zimbabwe. The tests were of the users' opinion of the equipment and of its ability to withstand AP blasts. The author was not permitted (by Ian Bulpitt, the CTA UN MAPA) to be present for blast tests in Afghanistan and apologises for the poor photographic record of the blast tests. The author was present for the PPE user-trials. PMN (from stores) and POMZ-2M mines were used in the tests in Afghanistan. The use of POMZ-2M mines was in direct breach of the trial TOR.

Many people helped with the field testing. Special thanks to: Herman van der Vorm, John Kirby, Fredrik Pallson, Noel Spencer, Hendrik Ehlers, Filipe Mazuma, Havard Bach and Gier Bjorsvik

User trials of PPE in Afghanistan

With the co-operation of MAPA Afghanistan, a series of user trials followed by blast testing of the AVS PPE took place in the Autumn of 1999. The MAPA technical advisor, Fredrik Pallson liaised with Andy Smith and produced the Terms of Reference for the trial. The TOR is reproduced in Appendix A to this report. A full report of the trial is in Appendix C.

The picture on the right show the deminers when first issued with the PPE and trying the visors to find out how well they could see through them.

The picture below shows META getting feedback from a deminer.

The user trial involved deminers from Afghan Technical Consultants (ATC) and the Mine Dog Group (MDG) wearing the equipment while working for a period of several weeks. The equipment was introduced to the men in Kabul and the usage monitored by MCPA and AVS.

The picture on the right shows an ATC deminer excavating with the standard issue short bayonet that remains the MAPA "prodder of choice". The apron provides good frontal coverage when kneeling.

The picture on the right shows an MDG deminer using a pick-axe to investigate an area where a dog had signalled. The pick has a long slim handle and a relatively small metal head. This deminer found swinging the pick-axe difficult with the straight armour sides (they were revised as a result of several comments).

Some Afghans squat (above left), others kneel and crouch forward (above right). The apron is versatile enough to allow all the users to wear it in the way they like.

There was no resistance to wearing the apron. Indeed, there was an eagerness to wear it that may have been because no one expected the user to lie down to excavate with it on.

MAPA SOPs dictate that deminers should excavate while lying down – and even use a pick-axe in that position (both if which are impossible, of course).

The picture on the left shows a squatting deminer wearing one of the very few frag-jackets available while he excavates. The jacket does not extend between his legs. In a blast his thighs, genitals and lower body are very vulnerable.

The user trial was considered a success, with valuable critical feedback gained. The MAPA conclusion was that the:

> *equipment was very well received and liked by the deminers but a few simple alterations are required to enhance the comfort and safety of both the apron and visor fixing"*.

As a result, three changes were made to the design of the PPE ensemble.

1. The sides of the Mk3 apron were redesigned to allow easier arm movement.
2. The polycarbonate "wings" of the head-frame were made less flexible by using 5 mm polycarbonate.
3. The size of the bag was increased to allow easier packing and unpacking of the equipment.

Blast testing PPE in Afghanistan

When the time for blast testing arose, MAPA management put the supervision of the blast trials under a Technical Advisor who had not been involved in the planning. Political delays (principally caused by CTA MAPA resentment of criticisms publicly made of the old 3 mm visors currently issued) meant that the author was refused access to the blast trial. The Technical Advisor's report of the blast trial of eighteen PPE sets is reproduced in full at Appendix A (MAPA retained the other PPE sets for its own purposes)[1]. While the results of the trial were satisfactory, several of the conditions stipulated in the agreed terms of reference were not met and these limit the reproducibility of the tests. Chief among these was the failure to weigh the explosive charges used or to photograph the mine with its charge prior to detonation.

The picture on the right is the only photograph showing the way that the equipment was set-up prior to the test.

The picture below shows a typical result.

The size of the blast varied dramatically and in many cases there was evidence that the detonating charge did not fully combust (although it probably did in the example shown above).

Conclusion

The blast testing was considered a success by MAPA who said that the PPE:

> "demonstrated its effectiveness against the most common and the largest of the blast mines found in Afghanistan, the PMN and the PMN2…. The equipment [also] proved effective against the POMZ mines."

Consequences

When I examined the PPE in Pakistan in January 2000, I found several minor failings that led to further design refinements. The results of the "autopsy" I carried out on the PPE are in Appendix B of this report. The design refinements that followed were:

1. An improved method of attaching the armour collar.
2. Improved QC during manufacture to ensure that the Kevlar extended to the full extremities of the outer cover.
3. The use of a different washable cover to reduce superficial blast damage.

Without devaluing our debt to MAPA, it was decided that a professional presence at any future blast testing of any equipment was highly desirable. The production of detailed TOR prior to the test had not guaranteed the conduct of the trial in this instance.

[See also Annexes A, B, C.]

[1] Two other PPE sets were blast tested – in Angola and Mozambique.

Blast testing PPE in Angola

In March 2000 a single unit of SD manufactured Mk3 PPE was tested in Southern Angola with the demining NGO MgM. MGM deminers and its director Hendrik Ehlers were present, along with several members of the local security forces.

The purpose of this trial was to:

- Meet the requirement to have blast tested 20 units of PPE.
- Test the efficacy of the design refinement to the apron collar.
- Confirm the improved blast resistance of the cover material.

The test

This test was against a MAI-75 bakelite AP blast mine casing refilled with 200g of PE and detonated with safety fuse. The PPE was supported on a lightweight metal frame. The centre of the mine was 30cm from the base of the apron which was positioned as if being worn by a kneeling deminer. The mine was positioned just below the ground surface, then covered with spoil (the picture shows the mine prior to the covering being applied). The soil was a baked and fibrous earth in which it was impossible to prod beyond 5cm (no soil hardness tester was available).

In the blast the lightweight metal frame came apart and the top half was thrown backwards with the apron eight meters. The visor landed very close to its original position.

The detonation was recorded on video using a protected camera four meters from the blast site.

Post blast condition of the PPE

The visor and its head-frame and fixing were intact. The visor face had been marked by small fragments all over except on the bottom 5cm which the collar had protected. When the scratch-guard was removed, the visor surface beneath it was clear and unmarked.

The apron cover had one small rip alongside the collar with no damage to the aramid inner cover. There were 15 small black fragments marks on the outer face of the collar, none of which had penetrated the washable cover.

Conclusion

The PPE set performed as designed. The apron collar remained firmly in place and the cover material resisted superficial blast damage very well. In future testing, the use of a soil-hardness gauge may help ensure that conditions can be reproduced and testing anomalies avoided.

ROFI armour

At MgM's suggestion, a unit of the Norwegian made ROFI armour that MgM currently uses was subjected to the same test against a MAI-75 bakelite AP blast mine casing refilled with 200g of PE and detonated with safety fuse. The ROFI PPE and an earlier AVS visor with a hard plastic head-frame (also supplied by MgM) was supported on the same lightweight metal frame as in the previous test. The centre of the mine was 30cm from the base of the PPE which was positioned as if being worn by a kneeling deminer.

The mine was positioned just below the ground surface, then covered with spoil (the picture shows the mine prior to the covering being applied). The soil was a baked and fibrous earth in which it was impossible to prod beyond 5cm (no soil hardness tester was available).

In the blast the lightweight metal frame separated and the top half was thrown backwards with the armour just over eight meters. The visor landed in front of the crater made by the detonation.

The detonation was recorded on video using a protected camera four meters from the blast site.

Post blast condition of the ROFI PPE

The visor and its head-frame and fixing were intact. The visor face had been marked by small fragments over its entire surface.

The cotton cover of the armour had been torn by the blast. Sixteen small fragments had burnt into the collar (which was behind the visor at the front of the wearer's neck – so had gone beneath the visor). The lower part of the armour had been torn away from the upper over two thirds of its length, allowing blast to pass through to the wearer's stomach. One of the small thigh flaps was held by a single stitch after the blast, the stitching holding the other had been torn away over half of its length.

Conclusion

The armour consisted of discrete Kevlar panels held together by their cotton covers. This allows flexibility, but means that the armour is only as strong as the stitches holding cotton cover to cotton cover. The position of the collar inside the visor allowed fragments to get beneath it. The design of the attachment of the lower parts of the armour to the upper allowed the blast to tear it apart.

In my opinion the visor performed as designed but the armour failed to perform appropriately for blast mine protection issued to deminers who kneel/squat to work. This opinion was shared by the deminers and MgM management.

[This result was made known to ROFI who immediately, and commendably, refined their armour design.]

Blast testing PPE in Mozambique

In March a single unit of AVS PPE was tested in Tete Province, North West Mozambique with the demining NGO Norwegian People's Aid. The purpose of the test was to:

- Meet the requirement to have blast tested 20 units of PPE.
- Test the efficacy of the design refinement to the apron collar.
- Confirm that the earlier cover material did not perform as well as its replacement.
- Determine whether having the neck-flap unsecured made a difference to its performance.

This test was against a PMD-6 wooden "shoe-box" AP blast mine casing with its original 200g TNT charge. The charge has a pre-cast hole for a detonator and was fired using safety fuse. The PPE was supported on a heavy metal frame weighted with a sandbag intended to simulate the position of a kneeling deminer. The neck-flap of the apron had no Velcro to hold it closed.

The apron was positioned with the centre of the mine 25cm from its base. The centre of the visor face was 74cm from the surface of the TNT. The mine was laid just below the surface in soft sandy soil.

In the blast the support frame tipped over backward with the apron. The visor landed alongside the blast crater.

The detonation was recorded on video using a protected camera four meters from the blast site.

Post blast condition of the PPE

The visor and its head-frame and fixing were intact. The visor face had been marked by fragments except on the bottom 5cm which the collar had protected. When the scratch-guard was removed, the visor surface beneath was clear and unmarked.

The washable apron cover was severely damaged by the sandy soil (some of which was contained within it). The surface layer of aramid inside was torn in one place. There was no damage to the Kevlar beneath. There were multiple fragment marks on the outer face of the collar, none of which had penetrated the first layer of aramid beneath the washable cover. The unfastened neck-flap was torn off.

Conclusion

The PPE set performed as designed. It does appear to be important to close the neck-flap, as designed. The cover material was shown to be less resistant to blast damage than the material it replaced. The apron collar remained firmly in place. The cover was replaced with a Cordura material.

TERMS OF REFERENCE

EVALUATION BLAST APRONS
AVS Mk3 PPE (Personal Protective Equipment)

July 1999

Introduction

There exists a need within the Afghan demining organisations for an upgrade of existing PPE which has seen long service and the standard of which has been superseded by the widespread adoption of new standards and demining practice.

US Army CECOM NVESD, as part of the US R&D effort in support of humanitarian demining, has supported the development of simple body armour/visor sets for use in humanitarian demining. These sets have been designed by AVS Consultants UK (AVS) and are made in Zimbabwe in a workshop established by SD for the purpose. Staff from a nearby commercial enterprise has been trained in production and that company (Security Devices Pvt) will continue commercial production of products when "signed-off" by AVS and accepted by NVESD.

The AVS Mk3 PPE have been developed from the AVS Mk 1 armour apron and visor sets that are in use in Zimbabwe, Mozambique, Bosnia Herzegovina, Kosovo, Angola, Namibia and the Yemen. That equipment has performed as designed in more than a dozen real blast mine incidents involving deminers and over 40 simulated tests against a range of blast mines (PMN, PMN-2, R2M2, MAI-75, POMZ and AUPS).

Aim

The primary purpose of the trial is to access the acceptability of the equipment to the deminers who would wear it. A secondary purpose is to demonstrate its effectiveness against the most common blast-mine threat in Afghanistan – the PMN. A third purpose is to assess its effectiveness against the smallest common fragmentation mine in the theatre – the POMZ.

Execution

General Outline Trials of the aprons and visors are to be conducted by META staff under the direction of the MACA Technical Advisor in Afghanistan under normal field conditions. Two NGOs will assist in carrying out the field-testing.

Conduct of the trial

The trial will be carried out in two phases as follows

Phase I – User Trial – As stated above the trial will be conducted in Afghanistan. With two different teams from two different NGOs. The 20 PPE will be divided in two sets of 10 PPE and then these sets issued/distributed to each team. The deminers are to use the equipment every day in the same manner as per SOP/TTN protective clothing. AVS technical representative will introduce the armour, the way it is designed to be used and its maintenance to the designated deminers.

Phase II – Blast Trials – Against live mines at the CDS in Kabul. ATC The mines that are going to be used are PMN and POMZ.
Of the 20 sets supplied, 17 will be tested against PMN and 3 against POMZ fragmentation mines. The mines will be initiated by a small charge, so adding to the overall HE content and making each blast represent a "super-charged" worst case scenario. The weight of the additional seismic charge will be recorded, and the relative positions of the mines and test- pieces photographed.
The PPE will be presented in to the blast in a manner that simulates a kneeling/squatting deminer with the lower edge of the visor 60-cm from the mine and at an angle of 35 degrees from vertically over it. All the tests will be as far as possible in the same conditions.

The blast will be filmed from a safe distance.
For the fragmentation test the PPE will be upright at 1,5 m from the POMZ in a manner that simulates a standing deminer directly facing the mine.

Phase III – Evaluation and Report – Monitoring reports from Phase I and II will be utilised for the evaluation.

Tasking

♦ MACA HQ Technical Advisor
OPI of Trial
- Co-ordinate with META staff in monitoring and logistic staff in administrating the trial
- Write trial report.

- META
- Design monitoring sheets
- Provide a monitoring plan for MACA Technical Advisor for approval.
- Brief selected teams for the trial.
- Work together with AVS technical representative, Matthew Chambers.
- Execute approved monitoring plan
- Visit each team at least twice during the two week user trial. Written assessments are to be send to MACA Technical Advisor, after each visit.
- Assist in report writing

- ATC and MDC
- Provide one team each, close to Kabul to carry out the trial
- Draw from UNOCHA logistics 10 PPE

- AVS
- Arrange for accompanied delivery of 20 PPE sets to Islamabad on September 16th 1999.
- Provide one technical representative to work in conjunction with META and train the deminers to use the equipment
- Assist in report writing.

Coordination Instructions

Timings

Phase I – W ill be conducted by teams selected between 20 September to the 4 October

Phase II – Blast and Fragmentation tests will be carried out between 5 and 10 October.

Phase III – Written report will be finalised by the end of October 1999.

Damage evaluation

The MACA Technical Advisor and AVS Technical representative will evaluate the damage to the PPE with a view to estimating any injury, and the result of each blast will be recorded photographically. The MAPA Technical Advisor will write an opinion of the utility of the armour against the threats tested and that will be included in the Trial report.

Trial report

AVS Technical Representative is required to produce a report on the trial for US Army CECOM NVESD. The MACA Technical Advisor will collaborate on this report and a jointly authored report on the outcome of the trial will be prepared. If opinions vary significantly, that fact will be stressed in the

final report. Video footage and a photographic record will also be prepared and a copy supplied to MACA by AVS Consultants.

Attachment A

Photographs of the PPE are shown on the following page. Visor and blast apron both fit into a single padded over-the-shoulder bag for easy transport to the working area.

The apron

The AVS Mark 3 Demining Blast Apron represents a departure from traditional, close-fitting designs of body armour. Rather than requiring straps that pulls the armour to the body, the AVS Apron hangs comfortably from the shoulders to form a protective "wall" between the deminer and the threat.

In many theatres, deminers have occasion to put on and remove protective equipment many times during a working day. The AVS Apron has no straps, enabling it to be put on and off in a few seconds. Demining often takes place in countries with a hot climate, making conventional military armour very uncomfortable to wear all day. The AVS Apron has been designed to allow air to circulate between the apron and the body, helping the wearer to remain cool.

The apron collar is positioned so that it overlaps with a standard 5mm polycarbonate AVS visor, avoiding the problem of blast ingress between the items. This system, together with a flap that protects the throat, offers full blast protection to the head, neck, torso, abdomen and groin. It also offers 450m/s fragmentation protection to the body areas and more than 250m/s protection to the face and head.

Other armour features include an ID pocket, nametag, wipe-clean cover and padded neck. For deminers that work upright, such as dog handlers, an additional piece that hangs down to the ankles is available. Other products include a genital protector and knee-pads. For groups that issue personal radio communications in the field, an optional radio-loop is available on the left shoulder allowing the radio to be clipped in place and used without detatching it.

Visor

The AVS visor is made by heat-forming 5mm polycarbonate and each one is numbered for identification and replacement purposes (polycarbonate degrades in sunlight so frequently exposed visors should be replaced annually).

The unique headframe is made using ballistic aramid for durability, and covered with waterproof nylon. The fixings are made from heat-formed polycarbonate, which provides durability and the flexibilty to adjust to any head size. Inside the headband is a removable padded strip made from towelling, which serves as a washable sweatband and adds to the wearer's comfort. The straps are fastened with velcro and so are readily adjustable.

Scratch-guards can be easily fitted to the visor, so prolonging its life. They are designed to stand off from the surface of the visor, with gaps on all sides so particles do not become trapped between the visor and the guard. The guard is made from 0.75mm polycarbonate, so effectively increasing the level of protection over an unguarded visor.

When the guard gets scratched it can be readily replaced at very low cost compared to visor replacement.

Bag

The all-in-one bag has been designed to enable all PPE to be carried as one unit and to give a reasonable level of protection during transit.

The bag is cylindrical, has a toggle drawstring for closing the top and a shoulder strap for portability. It is made from ballistic aramid for durability, has a waterproof nylon outer and is padded. Within the bag there is a flap that is used to stop the apron rubbing against the inside face of the visor.

Apron

Dimensions: 48 x 90cm

Kevlar/aramid/polycarbonate
Weight: 2.34kg
STANAG V50: 450m/s +

Visor, headframe and scratchguard

Dimensions: 30 x 23cm
Weight: 0.96kg combined
Face 5mm untreated polycarbonate
STANAG V50: 250m/s (250-280)

All-in-one bag

Dimensions: 25cm diameter x 60cm high
Weight: 0.59kg

Total weight of PPE set: 3.89kg

[This was the entire reporting provided under the CTA's direction, and was typical of the MAPA at that time. It is made up almost entirely of text provided by AVS.]

Appendix B:

PPE "autopsy" Afghanistan

In January 2000, AVS travelled to the MAPA UNOCHA offices in Islamabad where he had arranged that the armour blast tested by MAPA after field trials would be stored. The individual who had conducted the trial (Noel Spencer) and the head of MAPA (Ian Bullpitt) were both on leave. His deputy (Dan Kelly) was present and was interviewed. The MAPA Technical Advisor (Fredrik Palsson) was also present during part of the study.
The armour aprons were examined by making a photographic and video record of the condition of each apron, then cutting off the front cover and collecting any fragments inside. The outer layer of aramid was then removed and any damage noted. If the kevlar beneath had been damaged by fragments, the kevlar was cut into in order to determine the depth of the damage and to recover the fragment responsible when it was still present.
The visors and scratch-guards were examined by making a photographic and video record of the condition of each, then removing the scratch-guard and recording the damage to the visor face. Damage to the head-frames and their “wings” was also recorded. See the CD video titled “The affects of blast trials on AVS Mk3 PPE in Afghanistan”.

PPE set 1

The set was marked on the bag as having been tested against a PMN and trialled by A. Hafeez of MDG 2. A few fragments of the explosive device used penetrated the outer cover and were recovered. These were small pieces of red bakelite. The outside of the armour cover was marked but there were no penetrations. When the cover and outer layer of aramid was removed there was no damage to the kevlar or its stitching inside the apron.
The visor was heavily "sooted" with a thick black sticky deposit which scratched off without leaving any marks on the polycarbonate beneath. The scratch-guard was heavily "sooted" but intact. The area beneath the scratch-guard was unmarked and clear. The head-frame and "wings" to the visor face were undamaged.
Conclusion
The test did not compromise the integrity of the PPE set.
From the low level of damage to the apron, it appears that the armour may have faced an inadequate detonation. The residue on the visor was incompletely burned explosive, but not apparently the TNT in the mine. I presume that the destructive charge of industrial grade plastic explosive (not specified by the tester) failed to detonate properly and the mine itself deflagrated without the full initiation of its main charge. However, the small size of fragments recovered is not usually associated with deflagration and may indicate that the mine detonation was satisfactory and the “sooting” from incomplete burning of the detonating charge was no more than a secondary feature.
A less heavy black "soot" has occurred in incidents and is sometimes recorded as "burns" to the victim. It can be driven into the flesh and cause a discoloured "carbide tattoo", but is not technically a burn. A scattering of carbide tattoos on a victim's unprotected face is sometimes evident when they are interviewed long after the event (witness Paul Jefferson, perhaps the best known such victim).

PPE set 2

The set was marked on the bag as having been tested against a POMZ and trialled by Ayatullah of ATC. The outside of the armour cover was holed but not ripped. A fragment was heat welded to the thin polycarbonate covering the name-plate pocket on the front of the armour. The collar and neck guard were in place. There were 43 obvious holes in the outer fabric of the apron. From the rear of the apron, four total penetrations were visible. The outer stitching was all intact. When the outer cover was removed the holes could be counted from the inside where the scarring of the material was much clearer. There were 130 penetrations of the cover, many by tiny fragments the size of grains of fine sand. Many of these fragments were found inside the cover and below the first layer of aramid. Damage to the stitching inside the apron was limited to the immediate areas of fragment strikes. Several large strikes were found heat-welded to the kevlar.

The visor was relatively undamaged with no “sooting” and light fragmentation with no penetrations. Three fragments struck the visor, along with some dust. The scratch-guard was intact, not penetrated and marked with light sand. The head-frame and visor "wings" were undamaged.

Conclusion

The integrity of the PPE set was compromised by the fragmentation mine used.

Four fragments fully penetrated the armour and so are presumed to have been travelling in excess of the 450m/s STANAG rating that the protection is known to offer. Given that the fragments were an irregular shape and flying without the spin applied by a rifled barrel, it is very likely that they were moving at speeds well in excess of 450m/s in order to penetrate (irregular fragments are known to be far easier to stop than those used in a STANAG 2920 test). 126 fragments were stopped. Just over 3% of the fragments that struck the apron penetrated it. None of the fragments that struck the visor penetrated, from which one must infer that none of the fast moving fragments struck the visor.

PPE Set 3

The set was marked on the bag as having been tested against a PMN and trialled by Agha Gul. The outside of the armour cover was holed in a spray across the middle and on the outer side of the collar but there were no penetrations deeper than the cover and outer layer of aramid. The middle of the apron was sprayed with a yellow stain believed to be incompletely detonated TNT. The collar had been struck by many bakelite fragments, larger than those found in the apron front but the largest was no more than 5mm by 2mm. When the front cover was removed there was no damage to the stitching inside the apron. A large number of fine fragments were found inside the outer cover. Some were bakelite but others appeared to be stone.

The visor was heavily "sooted" with a thick black sticky deposit which scratched off with a fingernail without leaving any marks on the polycarbonate beneath. There were more than 20 fragment strikes towards the top of the visor and on the top area of the scratch guard. The scratch guard was cracked. One strike had caused a raised area on the inside of the visor but there were no penetrations. The area beneath the scratch-guard was unmarked and clear. The head-frame and "wings" to the visor face were undamaged.

Conclusion

The test did not compromise the integrity of the PPE set.

Fragments of red bakelite were recovered from beneath the outer cover, so positively identifying the mine type as a PMN or an MS3. It appears that the armour faced a detonation where the explosive charge of industrial grade PE (not specified by the tester) failed to detonate properly although the mine itself may have (the yellow TNT stain on the apron introduces doubt). The residue on the visor was incompletely burned explosive, but not apparently the TNT in the mine. I presume that the destructive charge of industrial grade plastic explosive (not specified by the tester) failed to detonate properly. There was evidence that the device itself did detonate properly, as is further indicated by the large fragment strikes to the apron, collar and visor.

PPE set 4

The set was marked on the bag as having been tested against a PMN and trialled by Jalil. The outside of the armour cover was torn away from 15cm to 30cm high in a ragged triangle. There were also strikes radiating up and to the left. The collar was almost entirely torn off and the neck-plate beyond was entirely loose. The entire cover was ingrained with stone dust.

When the front cover was removed there was damage to the stitching inside the apron but the kevlar was not damaged except in one place fifteen centimeters from the bottom. In that place the damage was only to the surface layer of kevlar. A large number of stone fragments were found inside the outer cover.

The visor had been sprayed by fragments that holes and borke the scratch-guard. When the scratch-guard was removed, there was much less damage to the area beneath than the heavily marked area above the guard.

The visor face was heavily "sooted" with a thick black sticky deposit which scratched off with a fingernail without leaving any marks on the polycarbonate beneath. There were more than 100 fragment strikes on the visor, concentrated towards the top. The visor head-frame was undamaged but one "wing" to the visor face was broken (apparently by the support frame landing on the apron after the detonation.

Conclusion

The test did not compromise the integrity of the PPE set.

No mine fragments were found inside the apron. There was stone dust outside and stone fragments inside. The number of fragment strikes on the visor and apron front was unusually high and their penetrating force unusually low. It seems likely that an excessive charge was detonated in front of this apron which may or may not have included a mine. Almost certainly the surface laid charge was covered with stones prior to detonation (otherwise the stone fragments and dust is inexplicable when the charge was surface laid).
Unfortunately, the tester kept no record of the charges used and made a blanket claim of 30g PE used as a detonating charge for all blasts when asked. This is thought to be unrealistically small given that large detonators were used and close contact with relatively large mines was required. The tester reported that the PPE and its support frame (a heavy steel article) was blown back 15 meters by the detonation. Nothing similar to the damage or the blow-back has occurred in more than 20 tests of similar PPE against PMN mines (or in the DDIV of real deminer victims), from which I infer that this charge was not a simple PMN mine but an extreme alternative - possibly deployed because of difficulty in getting complete detonations in previous attempts.

PPE set 5

The set was marked on the bag as having been tested against a PMN and trialled by Hafizullah of MDG. The outside of the armour cover was shredded from midway between the collar and the base and the bottom seam obliterated. The outer cover was missing for the bottom 25cm and the inside aramid layer badly holed for the lowest 15cm. A spray of dense fragments hit the apron from the bottom left rising towards the right across the front. Other lines of fragment radiated upwards. The kevlar core of the armour was "bruised" but there were no penetrations. The collar and neck plate were in place and lightly damaged. The remainder of the cover was ingrained with stone dust.
The visor was sprayed with light "sand" damage with no “sooting”. The scratch-guard was cracked but not badly marked. The head-frame and "wings" were undamaged.
When the front cover was removed there was damage to the stitching inside the apron but the kevlar was not penetrated. A large number of stone fragments were found inside the outer cover.
Conclusion
The test did not compromise the integrity of the PPE set.
No mine fragments were found inside the apron and there was stone dust both inside and outside. The impacts were all low on the apron, indicating a surface laid device. The absence of any fragments of mine casing and the unusually high number of fragment strikes in a concentrated area and their unusually low penetrating force imply that a mine may not have been used. It seems likely that a charge was detonated in front of this apron which may or may not have included a mine. Almost certainly the surface laid charge was covered with stones prior to detonation. In the absence of a detailed explanation from the tester, I infer that this charge was not a PMN mine but an alternative possibly deployed because of difficulty in getting complete detonations in previous attempts.

PPE set 6

The set was marked on the bag as having been tested against a PMN and trialled by Abdul Quayoom Zarzay. The armour was marked by what appeared to be a red mud spray and fragments concentrated towards the top right and striking the collar heavily. The collar and neck-plate were in place and the stitching undamaged. When the cover was removed, there was no damage to the kevlar inside. The visor was lightly marked with grey sand. The scratch-guard was similarly marked but broken with much of it missing (apparently removed later than the test).
Conclusion
The test did not compromise the integrity of the PPE set.
No fragments were found inside the apron so there was no evidence of the device used. The pattern of damage and its intensity was similar to that experienced in previous PMN tests, although lighter than some. The absence of the scratch-guard cannot be readily explained. I believe it may have been torn before the test because the visor face below was sprayed with grey sand.

PPE set 7

The set was marked on the bag as having been tested against a PMN and trialled by M.D.Zahit of MDG 2. The outside of the apron was marked with grey stone dust. The cover over the lower half of the apron was shredded by lateral spray lines of fragments rising from the bottom right where the bottom seam was obliterated. The collar had been marked by light fragmentation and showed some black staining. It was torn away over most of its length but the neck-plate was in place and undamaged. The

visor was lightly marked by grey dust. The scratch-guard was loose in the bag and lightly damaged with grey sand. The visor head-frame and "wings" were undamaged.
When the front cover of the apron was removed lateral sprays of brown and grey fragmentation were visible against the kevlar. Stone and an unidentified brown dust, but no actual fragments, were found. The kevlar "core" of the apron was stained but the top layer had not been penetrated.

Conclusion

The test did not compromise the integrity of the PPE set.
No fragments were found inside the apron so there was no evidence of the device used. The pattern of damage and its intensity close to the bottom of the apron imply a surface laid device that may not have included a mine and which was probably augmented with stone.

PPE Set 8

The set was marked on the bag as having been tested against a PMN. The number 1269 was written on the visor. The apron cover was severely marked with the outer cover shredded in a band across the middle of it. A lighter band of fragments struck higher and damaged the collar cover. The central stitching on the collar was torn and its cover was torn away at one end. The stitching around the neck hole and on the neck-plate was damaged.
Several fragments of red bakelite were found inside the collar. When the apron cover was removed, other small red bakelite fragments were recovered. The inner layer of aramid was shredded across the central band coinciding with the outer cover and the kevlar behind was marked but not penetrated beyond a single layer. Small fragments of bakelite were found along with black unidentified fragments.
The visor was "sooted" with a paler deposit than in others in this test series with a dark brown tinge. It scratched away with a fingernail leaving clear polycarbonate behind. The scratch-guard was intact and in place although a line of fragments had struck it in the middle rising to the left. Several of these penetrated the scratch-guard and marked the visor beyond, but not deeply. The visor behind the scratch-guard was largely clear and the damage was light with dents not deeper than 1.5mm and no distorted of the inner face of the visor (no bumps).

Conclusion

The test indicated that the protective materials were strong enough but that the stitching holding the collar in place was not strong enough.
The fragments found inside the apron and collar were of red bakelite, indicating that the mine used was either a PMN or an MS3. The apron was not struck at the bottom, indicating that the device was probably laid "in" rather than on the ground. If it was "in" the ground, its top was probably flush with the surface, so explaining the relatively low damage on the apron (relatively low compared to tests with mines buried with their top at 10cm.

PPE Set 9

The set was marked on the bag as having been tested against a PMN-2.
The apron was sprayed with fragments from the base to the collar. The collar was torn off. The pocket stitching was also torn partly away. The neck-plate stitching was damaged but it was in place and the neck-hole stitching was undamaged. The visor scratch-guard was broken away and not in the bag. Six minor fragments had marked the visor above the scratch-guard but the visor was largely clear. Its inner face had not been distorted (bumps) by any strikes. The head-frame and "wings" were undamaged.
When the apron cover was removed it was found that the aramid inner cover was holed in many places along with the outer cover. The kevlar inside was not penetrated beyond three layers in any place. On the bottom seam of the apron the kevlar did not extend to the bottom. At 10mm from the bottom, a single fragment had passed through two layers of armour cover and two layers of aramid.
When the apron was examined two pieces of aluminium similar to that used to secure the rubber top of a PMN were found, along with pieces of red bakelite and rubber. There were no stone fragments. The aluminium strips had penetrated to two layers but "wormed" as they did so and the penetration in the second layer was 4mm from the penetration in the first layer.

Conclusion

The test indicated that the protective materials were strong enough but that the stitching holding the collar in place was not strong enough and the quality control method had failed to ensure that the kevlar core extended to the very bottom of the apron. The manufacture of the apron was flawed.
The mine used in this test was a PMN, not a PMN-2. The damage to the bottom of the apron indicated that the device was surface laid. There was no evidence of it having been reinforced with stone.

PPE Set 10

The set was marked on the bag as having been tested against a PMN and trialled by Ab Aayerom Zazay of ATC. The name Abdul Jalil was on the identity card in the apron pocket.
The apron was streaked with stone dust with all the fragment damage concentrated in the centre below the collar. The stitching securing the collar was broken in the middle. There were three fragment strikes on the right shoulder of the apron (the only case of this in this test series). The neck-flap was in place.
The visor scratch-guard was holed by very heavy fragmentation and the damage to the visor was severe with more than 20 dents 3mm deep and corresponding distortion on the inner face of the visor. One strike 10mm from the top had left a ragged 3.5mm diameter cavity (apparently the fragment burned up) and a pin-hole through the visor. The angle of the strike was such that any fragment that had penetrated would have passed over the wearer's head, but it did not appear that any fragment had passed through.
When the apron cover and inner layer of aramid was removed no fragments of mine casing were found. There was no damage to the kevlar core or its stitching, and a quantity of sand and stone-dust was found.

Conclusion

The test demonstrated that the material used in the apron was capable of withstanding the charge but that the integrity of the visor may have been compromised. The stitching securing the collar was shown to be inadequate.
The absence of mine-casing fragments inside the apron and the severity of fragment damage to the visor implies that a mine was not used in this test. The presence of stone particles and dust inside the apron leads me to believe that the test involved an explosive charge covered in stones. The area of the apron and visor struck lead me to infer that the charge was laid in a small hollow in the ground and stones were piled on top of it.
The storage of the PPE for examination was inadequate, with labelling incorrect.

PPE Set 11

The set was marked on the bag as having been tested against a PMN and trialled by A. Gagul(?). The name M. Nazif of MDG-2 was on the card in the pocket of the apron.
The cover of the apron was torn and holed in a small area low down and to the right. Above this there were apparently wet splashes of TNT yellow . The apron collar and neck-plate were in place. The visor scratch-guard had been sprayed by large but slow moving fragments. It was broken on one side. The visor beneath the scratch-guard was almost unmarked. The area above the scratch-guard had been struck by nine small fragments. The visor head-frame and "wings" were undamaged.
When the cover of the apron was removed fourteen large bakelite fragments were found. Two of these still retained a smooth contoured face that was once the surface of the mine.

Conclusion

The test demonstrated that the material used in the PPE was capable of withstanding the charge.
The TNT stains and relatively large fragments illustrate that the detonation of this device was incomplete. The fragment type indicate that the device used was a PMN or an MS3 blast mine.

PPE Set 12

The set was marked on the bag as having been tested against a PMN-2 and trialled by M. Sharif.
The cover of the apron was shredded over half its height from the ground and the bottom edge was frayed. The collar stitching was broken and its cover shredded on the right side. The neck-flap was in place although a few stitches were broken in the area around the neck-hole. The name-tag pocket on the outside of the apron had been torn away.
When the armour cover was removed four small pieces of distorted green plastic were found embedded in the kevlar to a depth of 3 layers. Other extensive areas of discolouration showed apparent burns but without penetration.
The visor was found in pieces in the equipment bag. The tester reported that the support frame and the armour had been blown back by the charge for a distance of 15m and the heavy steel frame had landed on the visor, breaking it. The scratch-guard was missing. One wing of the head-frame was broken. By piecing the visor together it became apparent that it had been struck heavily towards the top by multiple fragments but that the scratch-guard was in place because the marking stopped abruptly. The visor had been cracked laterally with radiating fracture lines propagating upward and downward in a manner that seemed to confirm that it had been struck by a long, heavy weight. A close examination of its fracture lines showed no sign of blast debris along the fractures, so confirming that the breakage occurred after the blast event. The visor pieces were flattened to ensure that they were not brittle and they sprang back as normal.

Conclusion
Accepting the tester's explanation of the unusual visor damage, the test demonstrated that the material used in the PPE was capable of withstanding the charge. The stitching attaching the collar to the apron body was inadequate.

PPE Set 13

The set was marked on the bag as having been tested against a PMN-2.
The cover of the apron had been severely torn and damaged to half its height extending from the bottom line upward. The name-tag pocket was heavily damaged and the lip of the collar had been struck by fragments. The apron collar and the neck flap were in place with undamaged stitching. The visor scratch-guard was missing and the damage to the visor face implied that it was not in place at the time of detonation. The visor had been burnt into by 15 heavy strikes that had left black pits with no fragment remaining. The visor head-frame and wings were undamaged. The back of the apron was marked with a line of rust and a tear to the cover where the apron had struck the support frame.
When the apron cover was removed the kevlar was found to be heavily marked with black stains some of which centred on surface damage to the kevlar. In three places the "fragments" had burnt in. The deepest left a black stain to twelve layers deep (penetration to nine). The stained kevlar was retained for testing to try to determine the nature of the “fragment” which was believed to have been burning PE.
Conclusion
The test demonstrated that the material used in the PPE was capable of withstanding the charge.
It is unfortunate that the poor record keeping of the Tester make it uncertain quite what the charge was. It is possible that the pliant plastic of PMN-2 casing would continue to burn after impact, but it has not burned up completely in earlier tests. The nature of the kevlar damage was unique (to all my tests) and the ability of fragments to burn up completely while embedded without oxygen is puzzling unless they were parts of the PE charge itself. It was hoped that forensic examination would answer this puzzle and the sample is now in the Zimbabwean forensic laboratory. Unfortunately, it seems likely that we will be obliged to wait for political stability in that country before we get a result.

PPE Set 14

The set was marked on the bag as having been tested against a PMN-2.
The cover of the apron was severely damaged at the base rising to 20cm high. The collar and neck-flap were in place. A few fragments had struck the upper part of the apron and the underside of the collar.
When the apron cover was removed, a spray of grey/blue discolouration was apparent. The deepest damage to the kevlar was found to extend to two layers deep. Two twists of thin aluminium strip were recovered from beneath the top layer of kevlar.
The visor scratch-guard was holed and broken by fragment strikes that had left pits and corresponding inner dents in several places. The damage to the visor face was appreciably greater above the extent of the scratch-guard.
Conclusion
The test demonstrated that the material used in the PPE was capable of withstanding the charge.
There were no identifiable fragments inside the apron cover to positively identify the device used. However, the thin aluminium strip recovered closely resembled that used in the band holding the rubber top to a PMN (and was found with red bakelite in another test in this series). This implies that the mine may have been a PMN, but the absence of bakelite makes that uncertain.

PPE Set 15

The set was marked on the bag as having been tested against a PMN.
The cover of the apron was covered in grey stone dust and had been struck by two discrete areas of light fragmentation on both sides, and by a third cluster on the underside of the collar. The stitching in the middle of the collar had been torn away and the neck-flap stitching was broken.
The visor was heavily discoloured with an oily black deposit which scratched off with the fingernail without marking the polycarbonate. There were several light fragment marks above the area covered by the scratch-guard. The visor head frame and "wings" were undamaged.
When the apron cover was removed, the damage was found to extend beyond the inner cover of aramid in a few places. Damage to the kevlar did not extend beyond one layer - but no fragments were found. The cover contained only stone dust and sand.
Conclusion
The test demonstrated that the material used in the PPE was capable of withstanding the charge.

The absence of any fragments except stone and sand inside the apron make it hard to determine what charge was used. The heavy discolouration on the visor implies that the PE charge used may not have fully detonated.

PPE Set 16

The set was marked on the bag as having been tested against a POMZ.
The apron cover showed a number of fragment strikes around the lower right hand side. The collar and neck-flap were in place. The visor and scratch-guard were in good condition. The visor head-frame and "wings" were undamaged. The visor had been struck by three small fragments, one of which was embedded in the polycarbonate. There were no penetrations.
When the apron cover was removed it was possible to count the holes through it more easily. Many were tiny, and 67 were seen to have penetrated the first layer of aramid. A further 8 fragments struck the collar and penetrated the first layer of aramid. Two fragments had fully penetrated the apron, both in its lower half.

Conclusion

The test demonstrated that the material used in the PPE was not capable of withstanding all of the fragments emitted by a POMZ detonation at 1.5m. This was expected. That the PPE withstood all but 2 of 75 fragments was unexpected. The good performance of the visor may indicate the superior qualities of polycarbonate when faced with this threat, but seems more likely to represent “luck”.

Annex C:
AVS PPE User trials in Afghanistan

Introduction

Twenty AVS Mark 3 Apron and Visor sets were taken to Afghanistan and issued to deminers from two NGOs. The object of this phase of the trial was to determine the deminers' attitude to the equipment. When the PPE was issued to two of the Afghan demining NGOs, the deminers were instructed in its use and maintenance by AVS and META staff. The deminers then used the PPE in their normal work for a period of two weeks (while monitored – perhaps several weeks more unmonitored). Both trial teams were monitored periodically by AVS and META representatives and each deminer was interviewed towards the end of the trial period.

1 Demining in Afghanistan

Manual demining in Afghanistan is conducted using two-man teams with a one-man drill. Deminers operate in pairs taking turns to work a 30 minute shift. The deminers work from Saturday to Thursday, starting at approximately 06:00 and finishing at 12:00.

The working deminer executes the whole clearance process himself - sweeping with a detector, marking signals, excavating with a pick and a bayonet and removing the find. The resting deminer monitors his partner from a safe distance. There was no significant vegetation at either of the two trial sites. It was observed that, of time in the clearance lane, the deminer will typically spend about 15% upright with a detector, 80% kneeling for excavation and 5% leaning forwards to mark a signal or retrieve a fragment. When uncovering a mine the excavating percentage is further increased.

Deminers have been trained to work in the prone position but were allowed to work in the kneeling position when circumstances dictated. "Circumstances" were loosely interpreted to include insufficient space, stony ground, insects etc. For the purposes of this trial the subjects were instructed to work in the kneeling position, but it was observed that most of their colleagues were also kneeling or squatting without wearing appropriate frontal protection.

2 User group 1

The trial site was a village situated on top of a low pass on a secondary road 40km to the North of Kabul. The area had been both a strategic location and a battle area. The main threats were defined as primarily anti-tank mines and UXO but a small number of anti-personnel mines had also been found. Prior to clearance a truck carrying construction materials initiated an anti-tank mine and several lives were lost.

The participating team, Mine Dog Group (MDG) Team 2, were clearing two defined areas around Charoka Village in Midan Wardak District, The areas were a flat area within the village and a flat section of dirt track leading away from the village. Work in the village started on 11th August 1999 and was expected to continue until approximately 5th October 1999. In the period to the last inspection of the trial subjects, the team had discovered 8 AT mines, 4 AP mines, 6 UXO and 7,795 metal fragments. All mines and UXO were excavated, as were an estimated 50-60% of the fragments. The surveyed area to be cleared measured 90,000m^2, of which 95% had been cleared by 2nd October 1999.

The team consisted of 12 deminers, 4 dogs and handlers, 1 medic, 2 section leaders and 1 site manager. Six apron and visor sets were issued to deminers and the team used them from 21st September to 4th October 1999.

The ground was, for Afghanistan, generally soft with a stone to soil ratio of about 30:70, allowing the subjects to work with a bayonet alone. However there were numerous areas where the ground had been compacted through use, requiring the use of a pick to start the excavation. The weather was generally fine for the duration of the trial but work was stopped for one day while it rained, considerably softening the ground for the next day's work. Ambient temperature ranged from 20°C on the early morning to 30°C at mid-day.

The deminers were trained and observed on 21st September, monitored on 25th September and 2nd October and interviewed on 2nd October 1999.

3 User group 2

The second trial site was an area of Kabul known as the Karta hills overlooking a now largely deserted suburb to the South of the city. At the top of the hill were several gun emplacements that had been protected by AP mines and the area had been a battlefield on a number of occasions.

The second user group, Afghan Technical Consultants (ATC) team 12, were clearing a large area, consisting of parts of a broad summit and the sides of a hill. The operation started on 24th August 1999 and was due to continue until the end of October 1999. By 4th October 1999 the team had discovered 0 AT mines, 4 AP mines, 0 UXO and 29,820 metal fragments. All mines were excavated, as were an estimated 30-40% of the fragments. The total area of the clearance site was 28,141m2, of which 53% had been completed by 23rd September 1999.

The team consisted of 24 deminers, 1 medic, 4 section leaders and 1 site manager. 12 apron and visor sets were issued to deminers and the team used them from 21st September to 4th October 1999.

The ground was very hard with a stone to soil ratio of approximately 50:50, requiring the use of both picks and bayonets to investigate a signal. The weather was generally fine for the duration of the trial but work was stopped for one day while it rained, considerably softening the ground for the next day's work. Ambient temperature ranged form 20°C on the early morning to 30°C at mid-day.

The subjects were trained and observed on 21st September, monitored on 23rd and 30th September and interviewed on 30th September 1999.

4 Deminer interviews

18 separate interviews were conducted at the trial sites by an AVS representative, aided by a META representative, and by ETA representative working on his own. The deminers were called from the field in pairs and asked questions from a list prepared jointly by AVS and META. For the purposes of this report the results from the two groups have been combined. It should be noted that the subjects had obviously discussed many aspects of the PPE during their free time and a high degree of consensus was evident from their individual responses.

4.1 Interview results

The questions, answers, degree of consensus where appropriate and monitors comments are reproduced below.

1) *Is the armour-apron comfortable?* – 100% ticked 'yes'.
   Is it comfortable to wear for long periods? – 100% ticked 'yes'.
   Is the armour-apron easy to keep between the working area and your body? – 100% ticked 'yes'.

Other comments on the armour-apron? – *The subjects were unanimous in pointing out that it was comfortable to wear, being considerably lighter and cooler than the military frag vest they sometimes use.*

However, 27% identified some slight rubbing at the back of the neck. This seemed to indicate that the apron could move during the course of aggressive excavating and gradually slip from its position on the shoulders to rest on the back of the neck. It should be noted that no physical evidence of this was seen

2) *Is the head-frame comfortable to wear for long periods*? – 100% ticked 'yes'.
   Is the visor still easy to see through? - 100% ticked 'yes' .
   Is the new visor easier to wear than the previous helmet and visor? – 100% ticked 'yes'.

Other comments on the visor and head-frame? – The subjects were universally satisfied with the level of comfort afforded to them. It should be noted that they were used to using a helmet and visor that was considerably heavier.

3) *Is the PPE easy to look after?* – 100% ticked 'yes' but 67% complained that the presence of the scratch-guard made cleaning the visor difficult (it should be noted that rinsing the whole unit is often not an option due to the scarcity of water in Afghanistan). The monitors perceived that the subjects were generally not prepared to go through the process of removing the scratch-guard to clean the unit (the nylock nuts make this an arduous exercise).
How long does it take to look after each day? – 100% cited times ranging from 2-5 minutes.
How easy is the PPE to pack and unpack?- 100% replied 'easy' or 'very easy'. 17% noted that the bag could be a little wider to allow the visor to be inserted more easily
Is the PPE easy to carry – 100% ticked 'yes'.

4) *Do you think you can work efficiently wearing the PPE?* – 100% replied 'yes'. However it should be noted that there was universal disatisfaction with the fact that the apron inhibits movement of the upper arm, described in 7) below.

Do you think you can work faster or slower wearing the PPE – *100% replied that they could work faster than when working in the prone position, with several of the subjects venturing estimates that ranged from 20% to 50% faster. When pressed, some of the subjects maintained that the rate of clearance was the same as when they were allowed to squat/kneel in other situations.*

5) *Have you had any problems with the PPE? What are they?* – 100% replied 'yes', giving their reasons as described under 7) and 8) below

6) Has any part of the PPE broken or been damaged? Which parts – 100% replied 'no'. However, the monitors discovered that the sides of the visor and scratch-guard were becoming scratched on their inside surfaces. It was observed that when a scratch-guard is left permanently fixed to the visor it tends to knock against the visor, particularly during transit.

7) Is the apron limiting your body/arm movement? If yes, specify how.
   a. *during prodding/excavating* – 100% replied 'yes', noting that the apron did not allow their upper arms to move freely whilst working directly in front. The monitors saw that the apron is a uniform breadth and this meant that one's upper arms were having to push the edges back in order to reach areas in front. Some subjects also pointed about that this problem was mare acute when trying to use a pick, which they thought was because it was a two-handed operation.
   b. *During detection/walking* – 100% replied 'no'.
   c. *Placing marks* – 100% said 'no'.
   d. *Other, specify* – no other instances were cited.

8) Does the visor affect your vision/sight (does it disturb your vision)? If yes, specify how.

a. *During walking/detection* – 17% maintained that when looking down at the ground it appeared foreshortened.

The monitors concluded that having to look through both the visor and the bottom edge of the scratch-guard was causing distortion.

b. *During prodding/excavation* - 72% of the subjects expressed a dissatisfaction with the extent to which the visor 'wobbled' during a vigorous activity such as excavation, with 23% of that number adding that this caused them to worry about it hitting them in the face during a blast.

The monitors perceived that the polycarbonate "wings" that secure the headband to the visor were insufficiently rigid to prevent horizontal movement, ie. 'wobbling'

c. Other – No other examples were cited

9) *Is the apron providing you enough protection/cover. If not, what parts do you think are not protected* – 100% maintained that they were being provided with enough protection for the head, neck, torso, abdomen and genitals. However 61% felt there was insufficient protection for the thighs as one kneels down. It was observed by the monitors that the width of the apron could leave the sides of one or both thighs exposed.

10) *Do you suggest any changes in the design? If yes, what changes* – 100% suggested changing the shape of the top part of the apron to address the problem of restriction to the upper arms. 28% suggested that the apron be available in different sizes to suit taller and wider people.

There were also suggestions for some form of sun protection to be built into the visor head-frame, protection for the exposed arms, and it was suggested that the sweatband in the head-frame should go all the way around.

5 Monitor observations

In addition to the points noted above, the following miscellaneous observations were made:

1) The deminers invariably used the bottom edge of the apron to kneel on. In view of the large number of stones strewn across the surface in Afghanistan, this is perfectly understandable. It is, however, dangerous because the deminer runs a greater risk of falling forwards as he stands.
2) Deminers ars all issued with a hat of some sort, and towards the end of the trial several people were wearing them underneath the head-frame for sun protection.
3) Towards the end of the two week period the armour displayed signs that it was moulding itself according to the shape of the wearer and the nature of his actions. As a result the bottom of the armour was curled to fit under the knees, the main body was curving around the torso and the edges were curving outwards to accommodate the movement of the forearms.
4) The deminers seemed to understand the scratch-prone nature of polycarbonate and used the flap inside the bag accordingly. An inspection of visors found only one that was scratched on the inside. Although visors tended to spend the whole working day outside the bag, the monitors found no evidence of them being placed on the ground carelessly.
5) Deminers instinctively took to the design concept of a protective 'wall'. The monitors saw that they were adjusting the position of the apron according to their changes in posture, and they almost invariably kept their free arm behind the apron.
6) No evidence of discomfort was seen when watching the subjects at work. After finishing their shift they did not appear to be overheating and did not seem to be in a hurry to take it off. Their general comments invariably included praise for it's lightness and the fact that it was loose fitting and open at the back, so making it cool to wear.

7) In comparison with the helmet and frag vest that the subjects are accustomed to wearing, the apron appears to offer more complete protection. When lying prone the deminers wear only a helmet and visor, which leaves their shoulders and parts of the neck exposed. When working in a kneeling position the deminers will don the frag vest when it is available, but this still leaves their groin and thighs exposed. It should be noted that the supply of frag vests are limited to 2 per team, leading to the situation of deminers working in the kneeling position with no more than the helmet and visor for protection.

6 Conclusion

The User Trial confirmed that the concept for body armour of a loose-fitting ‘wall’, rather than the traditional tight-fitting jacket, is one that deminers will readily accept. In hot countries, and in situations where the deminer will put on and remove his armour many times in the course of a working day, the logic of a light and strapless apron appeals greatly. The open head-frame and full visor was readily accepted because of its light and cool properties.