Assessment of Man-portable Robots for Law Enforcement Agencies

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Abstract **-** This project has involved testing a Packbot Scout within a SWAT-unit[1] for five months. This was done to explore the tactical benefits of the system and to test the robot's technical performance with end users. Another objective was to compare earlier results – obtained by investigating military during training – with results from deployment during true risk. The SWAT-team, equipped with and trained to use the robot, set a standard to bring it with them on regular missions. Using the robot during negotiation proved to be the most beneficial application. Other uses would be for long-term surveillances and deploying non-lethal weapons. Early results indicate that the Stockholm SWAT-unit, consisting of 80 active officers, could deploy the robot at least 20 times a year.

Keywords: *SWAT police, user study, man-portable robot, Packbot*

I. Introduction

Robots are already an established tool for high-risk applications such as EOD[2]. Other applications could benefit from the use of robots, although a number of issues must be considered to enable deployment on a regular basis. The technical design must be adjusted to meet special requirements for other applications, requiring detailed knowledge about the end users and the tasks they face. Relevant niches in which robots can perform successfully need to be identified, and methods for deployment have to be developed. Robot systems need to be versatile, not only serve multiple purposes for one particular user, but also adapt to several different professions. Keeping the assorted end users in the loop during product development, while simultaneously exploring methods for deployment is crucial to achieve successful and rapid implementation.

In previous studies we have investigated man-portable robots for Military Operation in Urban Terrain[3] [1]. These studies were performed during military training maneuvers which in general provided a realistic setting. One aspect, however, was not accurately represented during training – the relation to mortal danger. As a consequence we decided to perform a parallel study involving a user group in actual risk, namely the Stockholm SWAT-unit. SWAT-units do, just as MOUT-soldiers, target people rather than artifacts or substances such as in EOD, CBRN[4], and USAR[5].

The objectives of the project were to:

- Investigate if users at real risk render results that significantly differ from results obtained during training maneuvers.
- Broaden the scope of knowledge regarding the feasibility of robots within another high-risk work group.
- Perform continued user-governed assessment of the Packbot Scout[6] in realistic settings.
- Survey a user group to identify opportunities for continued research.

This paper presents initial findings gained through two sets of interviews and one written mission report[7]. The first set of interviews was performed with the SWAT-unit's chief and a member of their Training and Development team, at the time the robot was handed over for test[8]. The second set of interviews was performed with the two officers selected to operate the robot after having had the opportunity to deploy the robot for five months[9]. The results were verified with the respondents.

This article is organized with related work in section 2, a description of the users in section 3, and a description of the robot in section 4. Section 5 describes how the robot was dealt with during the trial and how it could be deployed in the future. Section 6 discusses the results and suggests future work.

[1] Special Weapons And Tactics.

[2] Explosive Ordnance Disposal, i.e., removal, disarmament, and destruction of explosives.

[3] MOUT

[4] Chemical, Biological, Radiological, and Nuclear detection and decontamination.

[5] Urban Search And Rescue. The goal in USAR is to localize humans confined in destructed buildings. The victims are considered to be static unlike the targets of MOUT or SWAT-missions.

[6] The robot system is described in Section 4.

[7] A one page police report describing a live mission performed with the robot.

[8] This interview was performed with both respondents at the same time and lasted for 1 hour and 40 minutes.

[9] These interviews were performed with one respondent at the time and lasted 45 min each.

II. Related Work

Various studies have previously investigated high-risk workers deploying field robots. The most common application, bomb removal or destruction, has been successively refined since the first attempts in Northern Ireland in the beginning of the 1970's [2]. Today this is a well established robot niche with several mature systems available as demonstrated at the European Land-Robot Trial 2006 [3]. Other areas of robot deployment shared by the police and military are security, surveillance, reconnaissance, and tactical support [4, 5, 6; 7, 8, 9]; these are areas that have received substantial investments, although much of the research is not published in detail [10]. The task of CBRN contamination control seems to be a prominent next step as sensor payloads are maturing for deployment on robots that are already in daily use [7, 11, 12, 13; 14]. Rescue robotics, and especially Urban Search and Rescue, is one of the areas of field robotics currently receiving the most attention in academic research. Countermeasures against, and preparedness for terrorist attacks and earthquakes have invigorated efforts to push robot technology into use [15, 16, 17, 18, 19].

Human-robot interaction outside the scope of high-risk field workers has been targeted for research as well. An early example is the integration of the SURBOT [20] for mobile surveillance in a nuclear power plant. More recent examples consist of testing of the robot seal Paro amongst elderly [21], the fetch-and-carry robot CERO by a partially impaired person [22], and a number of long-term tests of tour guide robots such as the RoboX9 at Expo02 [23]. By now space applications have been tested substantially through NASA's deployment of rovers on Mars [24].

Robot deployment within SWAT-missions specifically[10] is performed and occasionally reported in news-media [25, 26, 27]. Most of these cases seem to be ad hoc solutions in which EOD-robots are used for other applications. Although the academic community has published little on robotics for SWAT-tasks [28, 29, 30], there are commercial products aimed at the application [12, 14, 31, 32].

III. User Description

A. Organization, demography, and training

Sweden has three main SWAT-units: Malmö, Göteborg, and Stockholm, who attempt to keep methodology and gear aligned since they occasionally perform joint missions. The Stockholm unit, 85 members strong and the largest of the three, is organized into eight SWAT-teams, each consisting of 8-9 officers. Each team works four shifts per week. The number of teams on service varies with the expected amount of crime, with at least one team on duty at any given time[11]. During daytime it is common to have one team on alert, and another scheduled for training acting as backup. Although the teams have an appointed leader, most decisions are made jointly; only under time-pressure is hierarchal leadership enforced. The Stockholm SWAT-unit has four mission commanders who handle crime-site command and communication with the police chief. There are 22 negotiators associated with the SWAT-unit. Most of them are stationed elsewhere but are on call. Due to physical demands, the members of the SWAT-teams are currently all male[12]. The negotiators on the other hand, always work in a pair of one male and one female, for tactical advantage purposes. It is moreover attempted to have a diverse ethnical background amongst the negotiators.

The average age within the SWAT-team is 36 years. Average time spent with the unit is 8-9 years. A minimum of five years of police service is required before being considered for the 3-month special SWAT-training[13]. 20% of the working hours are spent on training, which to a large extent is handled within the teams. To be able to act swiftly and in a synchronized manner, the SWAT-teams use predefined and well practiced concepts based on reference scenarios[14]. Despite all teams receiving the same basic training and having the same gear, they occasionally develop their own behavior depending on experiences encountered; individualization is discouraged by management in the interest of interoperability. In the past all SWAT-team members were encouraged to be able to handle all techniques and equipment. Recent increases in technical complexity have required the team members to assume specialized roles. Keeping the competence for different technical aids high is considered a problem; new gear is not always properly evaluated.

B. Tasks

In contrast to many other police units, whose objective is to prevent crime, the SWAT-teams are mainly reactive; although they are occasionally deployed proactively to demonstrate suspicion and readiness to strike. Their main objective is to target dangerous situations. Common tasks include resolving hostage situations, arresting potentially aggressive suspects, and taking suicidal or violent mentally deranged persons into custody. In other cases they are called upon to perform rapid arrests or searches to prevent suspects from disposing of evidence. The SWAT-teams may also be used for riot control or routine missions such as high-risk escorts or searching for missing persons.

Missions are initiated either by alarm of an ongoing crime, or by the request of assistance by another unit (response respectively planned missions). Responding to an ongoing crime is more frequent. Apartments or homes are the most

[10] EOD-robots excluded.

[11] SWAT-units are organised in shifts to provide permanent service over time. Military units are to more extent deployed the entire unit at once with periods of recuperation in-between.

[12] A program to equalize the gender distribution is ongoing.

[13] The police officers are older, have more experience, and are allowed to have an opinion in larger extent than the soldiers [1].

[14] This, although, the SWAT-police considers them self to be less oriented towards training and relying fixed behaviours than the military. Larger space is left to individual solution from one case to another.

frequently targeted environments, but *open-air* missions occur as well. The SWAT-units are equipped and trained to perform their duties wearing gas masks. Targeting suspects in possibly toxic environments occurs 2-4 times per year[15]. The Stockholm SWAT-unit on average performs close to one high-risk mission per day. 600 missions were performed during 2006. Of these, half were classified as high-risk missions. The most common tasks include dealing with severe criminals or organized crime.

C. Typical scenario

In advance of planned missions, the requested units usually survey the strike scene in detail[16]. This includes gathering evidence, getting to know the suspects, their armament, their vehicles, and the layout of the strike area. If the suspects reside at different addresses, the arrests are often synchronized. Planned missions usually occur before or after the crimes are committed, in order to minimize risks to third parties.

During crime response missions, the first objective is to locate and confine the suspects to prevent escape or hostage taking. Subsequently, the mission commander, the SWAT-team commander, and negotiators decide how to address the situation. A defensive approach, which entails that the suspect surrenders according to conditions stated by the police, is preferred. Negotiation makes up a large portion of this situation and can be a tedious process[17]. Long negotiations challenge the SWAT-teams' ability to maintain a high level of readiness. Missions lasting longer than 6-9 hours require a relief unit.

Offensive actions are based on forceful confrontation with the purpose to shock and overwhelm the suspects. Distractions such as teargas, pepper spray, or shock grenades might be used. The use of distractions or deliberate weapons fire (for other than self defense purposes) has to be sanctioned by the police chief.

The Swedish police are increasing efforts towards non-violent solutions through negotiation[18]. Decreasing human violence is regarded far more important than avoiding material damage. Breaching doors is the most common destruction during SWAT-missions.

D. Limitations

When asked about the main limiting factor, the robot operators responded that the restrictions imposed by the commanders[19] were the most constraining to their performance. Despite proper competence, knowledge, and tools to act, the SWAT-teams feel they are held back from solving cases.

Personal risk was not reported to be a very limiting factor; mission commanders usually take preventive measures to avoid risks to third parties or the suspects, long before the SWAT-officers regard themselves endangered[20]. The most life threatening moments were considered to occur during emergency vehicle transports or vehicular pursuits. The SWAT officers argued that their being aware prepares them for dangers, whereas the police in general to greater extent encounter high risks by surprise. They also reported that they are often able to demonstrate enough superiority to cause the suspects to surrender without resistance.

IV. The Robot System

A. The Robot

The iRobot PackBot Scout is a man-portable robot tele-operated using a video link (Fig. 1). The track propulsion system includes articulated tracked arms (flippers) which can be rotated 360 degrees. The flippers enable significant off-road abilities considering the small dimensions of the robot; in addition they enable recovery from roll-over. The top speed of the robot is 3.7 m/s and the Ni-Cd batteries enable an operating time of about three hours. The PackBot is equipped with fish-eye daylight video camera, IR-camera[21], IR-illuminator, GPS receiver, electronic compass, and absolute orientation sensors (measuring roll and pitch).

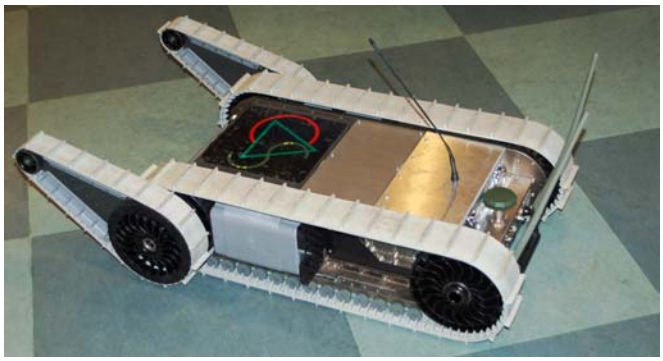

Figure 1. The Packbot Scout with the distraction siren (centered on top of the robot).

[15] The Swedish Emergency Management Agency is funding acquisition of sealed CBRN-vehicles to provide the police with the capability to operate in hazardous environments; robots could play a role in within this.

[16] This was also reported by Jones et al. [28]. The military will, in comparison, most likely be less informed [1].

[17] On one occasion a negotiation lasted for 44 hours.

[18] The ambition to achieve non-violent solutions was pointed out to vary greatly between countries. In particular, Australia and United Kingdom were mentioned to favour negotiation before violence.

[19] Police chief as well as the mission commander.

[20] This on the contrary to EOD-technicians or MOUT-soldiers who report risks to be a crucial limitation [34].

[21] Infra Red, in the close to visible spectrum.

Figure 2. The operator control unit.

The operator control unit consists of an Amrel Rocky Patriot rugged laptop fitted with a joystick[22] allowing for three degrees of freedom, and a keypad for toggling functions on/off (Fig. 2). Communication between the robot and the user interface is achieved using double IEEE 802.11b radio links.

A carrying system was added to both the robot and the operator control unit to enable hands-free portability. Other field adaptations included fitting the joystick, keypad, and cable connectors with protective covers. A small whiteboard was attached to the laptop with Velcro so that it could be easily removed and used by the operator to sketch the explored region. Extra batteries and chargers, both for wall-socket and vehicle charging were provided, as well as protective cases for transport and storage.

B. The Payload

During the project the robot was equipped with a distraction siren (Fig. 1). The siren is originally an alarm siren for intruder deterrence, developed and manufactured in Stockholm by Inferno[23]. The patented siren generates a high-pitch noise which is intolerable to the naked ear. Four different frequencies are modulated to cognitively overload the auditory organ while not causing hearing impairment (123-127 db(A)). Wearing hearing protection or plugging ones ears blocks the effect.

V. Robot Deployment

A. Deployment during trials

The joint study was initiated in mid-December 2006[24] when researchers met with representatives from the Development and Training group of the unit. The meeting addressed working out guidelines and legislation issues for the trials. The police also gave a general overview about their work. It was decided to perform the testing with one of the eight SWAT-teams until May 2007. The appointed team was trained in the basics of robot operation a few days later.[25] It was left up to them to use the robot as they considered appropriate, during training and real missions. The one-day training session included a brief description of how the military had been using the system in urban intervention [1]. Two team members were appointed robot operators for the duration of the trials. It was declared that real mission deployments were of interest to the study, while it was not of great concern whether the robot was damaged. The distraction siren was added to the robot system by March 2007[26]. The interviews with the operators were performed at the beginning of May 2007[27].

After handover, the two operators continued to train with the robot about once per week. In addition, they gave the other team members the opportunity to familiarize with the robot's performance and try operating it. Training – performed both outdoors and indoors – included passing obstacles and operating under different lighting conditions. The most frequently trained task was mapping of previously unknown premises and locating suspects. During three training sessions, the operators first explored a premise before executing a strike mission into the investigated area and finally evaluating the benefit of previous knowledge.

The distraction-siren payload was evaluated in a mock hostage situation during which one officer acted hostage taker and one officer acted hostage; both were previously unacquainted with the distraction-siren. The test showed that the noise, although extremely annoying, does not completely disrupt willpower (Figure 3).

Figure 3. Tactical test of the distraction-siren. From left to right: the officer acting as criminal; the officer acting as hostage; the two SWAT-officers attacking. The hostage taker was instructed to shoot at the police, which he succeeded in despite the siren. The hostage immediately plugged his ears with his fingers. The electronically filtered hearing protection used by the police protected them from the noise.

[22] Sideways, forward/backward, and twisting the knob (to control the flippers).
[23] www.inferno.se
[24] 14 December 2006
[25] 19 December 2006
[26] 18 March 2007
[27] 8 May 2007. The trials are continuing.

Once the team had familiarized themselves with the robot, they decided to include it on missions involving five or more police officers. This was the case for about half of all missions performed. On missions with fewer than five participants, the team in general considered that no one could be spared to operate the robot. In addition, the jeep used for transport of a small number of people did not have much extra space; accommodating the robot was not a problem for large teams since they had access to a van. Since only one SWAT-team was trained to bring the robot, and did so on half of their missions, the robot was available approximately 10% of the total time.

The robot was deployed in one real mission during the five-month trial[28]; it was used to investigate a suspect bomb in a staircase outside an apartment[29]. The robot enabled the police to keep the suspicious object, as well as the surroundings, under surveillance with standoff. Once the bomb squad arrived, the robot was used to gain initial information about the object and the surroundings. While the object was targeted by a bomb-technician wearing a bomb suit, the robot was used by the others to monitor progress.

The robot was also considered for exploration of a smoke-filled shop which was not on fire. After the team broke the door of the shop, they intended to use the robot to search for victims, but the fire brigade arrived and took over before the mission was initiated.

The operators reported that it is usually possible to find a safe spot for the operator[30]. Handling the robot was not found too challenging for field operation, though the control unit lacks key-backlight which is required in darkness. The operators considered the video feedback to be fairly adequate. However, they thought an improvement in resolution would be beneficial, as well as the ability to pan/tilt the camera, since having to elevate the front of the robot with the flippers to view upwards (Fig. 4) proved time consuming. A backwards facing camera was suggested to make backing out of narrow spaces more convenient. A zoom function was further suggested to enable closer inspection[31].

The range of the radio link was considered sufficient to cover apartments, which is the type of premise targeted the most. Operations were usually performed from a staircase or neighboring apartment. Ruggedness and reliability were satisfying as well, although the users claimed the operator control unit and the robot sometimes failed to synchronize[32].

Spiral staircases were the only obstacles said to pose a problem. This problem became evident during the live mission targeting the suspected bomb. The police vehicles can generally approach the mission area fairly close making the distance the robot has to be carried not being very far. The robot was considered heavy though not a major obstacle[33]. The size became a problem only during vehicle transportation.

The users immediately noticed the absence of two-way audio, which would make voice communication possible with suspects and victims. Missions including negotiations might, as mentioned, span for an extended period of time. Battery replacement and the possibility to charge batteries, both from wall sockets and vehicles, are needed. The operators additionally suggested the ability to charge the batteries while mounted in the robot, instead of first having to remove them.

The distraction siren was considered to be of significant interests as it is less violent compared to shock grenades or chemical agents, and therefore might be less restricted for use. Suspects' and victims' reaction to the robot is an open issue; the robot might appear frightening, increase aggressiveness, or be ignored. The trials did not give any opportunity to investigate this issue, which can hardly be examined with validity during training.

B. Considerations on future deployment

Apart from the mission actually performed (inspection), the respondents indicated a number of possible applications. The most prominent task suggested was to use the robot as a tool during negotiation[34]. In the first phase it could be used to establish communication with the suspect either by bringing in a cell phone/radio or establishing a two-way audio link on the robot[35]. During negotiation, the robot could be used to transport items to and from the suspect (the counter-parts often demand food, cigarettes etc.). The robot could furthermore be used for retrieving weapons in case of surrender.

Using the robot for the mentioned applications would provide the opportunity to observe the suspects' aggressiveness, rationality, armament, the premise, and possible hostages. If negotiating with suicidal individuals, the robot might be used to monitor their mental state. As demonstrated in the live mission, the robot can also be used for visual inspection of objects[36]. A robot equipped with non-lethal weapons could be used for distraction if negotiations fail. Adding non-lethal weapons such as tear gas to the robot, however, poses a risk, as the weapons could come into the offenders' possession. It was suggested that the robot should

[28] 18 February 2007

[29] The suspected bomb was located outside an apartment used for persons being under protection.

[30] The enemy's location will be less know during MOUT which requires the operator to be protected by other soldiers [1].

[31] Backwards facing camera and zoom are features available on the URBOT [7].

[32] This error might have been caused by the fact that the OCU does not work properly after having been put in, and taken out of, the laptop's standby-mode. The standby-mode is activated by hitting the on-button while the ESC-key is used to turn off the lap-top. Making the mistake to attempt a reboot using the on-button might have been the cause of the robot comms lost error.

[33] Military missions might, on the contrary, include covering significant distances on foot which makes weight more important. MOUT trails proved the weight of the Packbot to be right on the limit to what can be accepted for a man portable system [1]. Something that is verified by work with the URBOT that weights 30 kg [30].

[34] This was also an application pointed to be of interest in MOUT [1].

[35] Features that have been taken into consideration by Robotic FX [14].

[36] This has also been suggested by the military and would benefit of a snap-shot and zoom function in the user interface [1].

have a self-defense system, such as the ability to administer electrical shocks.

Another suggestion was to use the robot for long term surveillance of a door or a passage to relieve police officers[37]. The robot could also enable the police to manifest their presence without exposing personnel to risks. Additionally, the robot could be used for missions in hazardous environments if equipped with appropriate sensors. The operators stated that the robot mainly would be used for defensive purposes on missions, i.e., to locate suspects and initiate negotiations, rather than to target them. The robot was not considered to be suitable for offensive deployment as it does not have the ability to act against the counterparts and as it is too slow. To circulate and map an area holding the suspect did not seem to be a likely application[38]. It was pointed out that outdoor operations could come into question, although this was not tested to any large extent. Considering the restrictions for using violence, the operators did not regard equipping the robot with lethal capabilities to be of any interest[39].

The main benefits robots could bring to SWAT-deployment were as an enabler of a number of new features during negotiation, and also some new tactical advantages in case the mission had to be solved offensively. The users did not consider the system to have a major influence on their personal risk[40]. The police did not consider the robot to have imposed any major disadvantages. The only negative issue mentioned was that a robot system would entail yet another high-tech utility requiring maintenance, training, transport, etc. It was not believed that the option of a robot would make the police officers decline to perform risky duties themselves[41]. In addition, it was mentioned that the doer-mentality and high ambition to achieve immediate results might prevent the SWAT-police from deploying the robot[42].

C. Acquisition

The operators were asked to estimate how often the robot would be deployed if the suggested improvements were included. They felt that their team had encountered unusually few opportunities to deploy the robot during the evaluation period, but one of the operators estimated that the robot could be part of every fifth high risk mission of the Stockholm SWAT-unit (about once per week).

One of the two operators distinctively argued that the tested system should be acquired once two-way audio and key-backlight had been incorporated. The other operator was more ambiguous. Although he stated that the robot could be valuable, he argued that acquisition depends on cost and stated the price limit to be about 29,000 USD. The other operator projected the price limit to about 43,000-57,000 USD[43].

Neither of the operators could suggest any alternative equipment they currently lack, that would be preferred over the robot. On the other hand, they did indicate occasional shortage of personnel to be a limiting and risk-increasing factor. When asked to compare the benefits of the robot to night vision goggles, both operators argued night vision goggles to be more useful[44].

Both respondents agreed that one robot would fulfill the tactical needs of the entire unit. Having a second system for training and for backup would be convenient. It is currently being evaluated if the unit should be equipped with a designated vehicle for the new technical equipment; it was suggested that the robot should be stationed in the tech-vehicle. Estimating how many robots would be destroyed during a year proved difficult as the suspects' reactions to robot encounter had still not been experienced. One operator argued that it probably would not be very many while the other chose not to speculate.

VI. Discussion And Future Work

Performing tests in a real setting is of benefit to accuracy, but can also convey practical difficulties; especially when targeting high-risk applications. It has, in this study, not been possible to gain data from several parallel methods to verify validity through triangulation[45]. As indirect observations were the only source of information, it would have been particularly beneficial to have a large data set, i.e., many operators with extensive experience; unfortunately, this was not possible either. Only two respondents were available and their experience was, despite the rather long trial period, limited. In addition, there is an obvious risk of bias between the respondents since they work in the same team.

One of the reasons for selecting the SWAT-teams was to study a user under real risk. But, according to the two robot operators, they did not consider themselves to be highly endangered. From that aspect the setting might be considered inadequate to meet the objective, even though the risk-defying attitude might be the result of SWAT culture.

Despite limitations in data collection and misalignment with one of the objectives, we consider the results to provide a general overview and a starting point for continued studies. Apart from continuing and widening the ongoing trials, we believe that a theoretical analysis of the police-report records would provide statistical data useful for estimating the robot's value. Moreover, we consider the socio-technical and

[37] This would require a motion detection system as observing a video screen is a task that can not be performed with reliability over time [1].

[38] Contrary to MOUT where combat reconnaissance was pointed out to be one of the primary applications of the Packbot [1].

[39] Weaponization was considered highly interesting in MOUT [1].

[40] Reduced risks are the prime benefit for robots in EOD and MOUT. In MOUT are robots, in addition, believed to reduce weapons deployment [1].

[41] The military entertained apprehension that the robot would delay advance, revile presence, and might make the soldiers less willing to take risks [1].

[42] Behaviour commonly observed during the MOUT-trials [1].

[43] 200,000 SEK respectively 300,000-400,000 SEK. These amounts correspond fairly well with the tolerable price limit of 20,000-30,000 USD, reported by Ciccimaro et al. [30].

[44] Military considered the robot to be as valuable as night vision goggles during MOUT [1].

[45] For example through comparison of results from observations, interviews, and numerical data from experiments [33].

psychological aspects of robot-person interaction to be of particular interests.

Many of the presented findings align well with results from previous studies of both the police and military. For example, using the robot as a mean for communication is suggested by both groups. Considering the robot not to be suited for the most offensive and time-constrained tasks is another resemblance [1]. This and previous work on SWAT-teams result in similar estimations of tolerable price, and the anticipated mental, as well as physical, demands that can be placed on the robot operator [30]. There are striking differences as well[46]. While the MOUT-users demand longer radio range and improved visual feedback, the police officers are generally satisfied with the robot's performance. Military users show a significant interest in weaponization, while the SWAT-officers do not regard lethal abilities as a realistic application. Reduced risk and decreased weapon deployment are considered to be the primary benefits in MOUT. In SWAT, the system is seen as having the most potential as a tool for negotiation and surveillance over time.

VII. Conclusions

The question of whether robots should be acquired for SWAT-units calls for a comparison between frequency and importance of benefits, and the costs of implementation. Bringing the robot as an excuse to communicate or deliver items, and at the same time observe the surroundings, the suspects, and hostages was stated as a primary benefit. Once in place the robot could be used to deploy distractions during arrests. Long-time surveillance was considered as a suitable application as well. Unlike in MOUT and EOD, risk reduction was not considered as a main benefit of the robot. Nor was it of interest to give the robot lethal abilities such as suggested for MOUT. The investigated users were in general satisfied with the performance of the robot. Two-way audio, increased field of view, motion detection, and the possibility to store images for later viewing are desired improvements.

The interplay between the robot and those encountering it stands out as the most significant open issue. Limited experience of actual deployment and only two respondents with experience of the system are the primary limitations of the study. This prevented a reliable estimation of deployment frequency; however, if regarding the one mission performed during the five months test period as representative, the system would be deployed about 20 times per year. It was estimated that one robot would fulfill the tactical needs of the Stockholm unit. Acquisition is the primary cost connected to the introduction of systems like the Packbot. Costs for training, basic maintenance, and tactical development can be handled through available recourses with a slight expansion. The users estimated a tolerable price limit to be somewhere around 30,000-50,000 USD.

[46] The level of acceptance vs. criticism to new gear might be influenced by cultural differences within the two organizations. The police has traditionally not had the recourses to finance custom development, but, been obliged to use COTS. The military, on the other hand, has a history of technical development according to their exact specifications.

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