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Team I: Crowd and Riot Control Analysis with PAX

TEAM 1 MEMBERS

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INTRODUCTION

The Crowd & Riot Control (CRC) Analysis Team at International Data Farming Workshop 14 used the simulation system "PAX" (Latin for peace) to gain insight into specific aspects of peace support operations (PSO) and crowd & riot control (CRC).

The agent-based model PAX concentrates on modeling peace support operations on a detailed level. PAX was developed by the EADS System Design Center, initiated and funded by the German Bundeswehr Army Training, Doctrine and Army Development Command and assisted by the Operations Research and CD&E Branches of the Bundeswehr Center for Transformation. Both military expertise and empirical findings from psychological research on aggression were used in the construction of PAX.

PAX is able to show dependencies between the soldiers' behavior – including measures of de-escalation – and the escalation of violence, which may occur between soldiers and civilians as well as between different civilian groups. To analyze this in detail, PAX allows the investigation of a broad variety of measures of effectiveness (MOEs), e.g. the level of escalation, the number of civilians and/or soldiers who get injured and/or killed or the average fear within specific civilian groups etc.

The main goals of team 1 at IDFW14 were to:

1. test the new PAX version and review and face validate the upgrades made to the PAX model and tools between IDFW 13 and IDFW 14, especially the implementation of extended possibilities for the setup of scenarios (such as more flexible rule sets for the soldiers and the ability to give detailed cognitive motives to the civilians).
2. develop and test a potentially violent CRC scenario with different civilian groups. Develop and test alternative vignettes using different approaches with respect to the tactics, techniques and procedures (TTP) of the security forces by comparing different user-defined rule sets to the predefined ones.
3. conduct experiments with different designs (both NOLH and gridded).
4. gain insight into other models (participation in plenary sessions).
5. provide information about the simulation model PAX (plenary session briefing on the new version PAX 3.0).

Scenario

The base scenario used during International Data Farming Workshop 14 (IDFW14) addressed a checkpoint operation in a post war country. In this scenario, different – potentially opposing – civilian groups are modeled and the effects of various TTPs of the military forces are simulated and analyzed.

The situation in the checkpoint area is expected to be initially calm, but have the potential for escalation due to opposing groups in the area and the effects of the recent war on the civilian population.

The base case scenario is shown in Figure 1 An urban area is divided into a western and an eastern part by barriers with a directed checkpoint installed and controlled by the PSO force.

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Figure 1: Scenario

In the PAX scenario (see Figure 2), there are two ethnic groups, simply referred to as northern and southern. While the southern group is supposed to be generally more benefited, the northern group suffers more unemployment and feels disadvantaged. The "Northern workers" – identified by a round shape – and the "Southern workers" identified by a hexagon shape both want to cross the checkpoint from west to east, in an attempt to go to work.

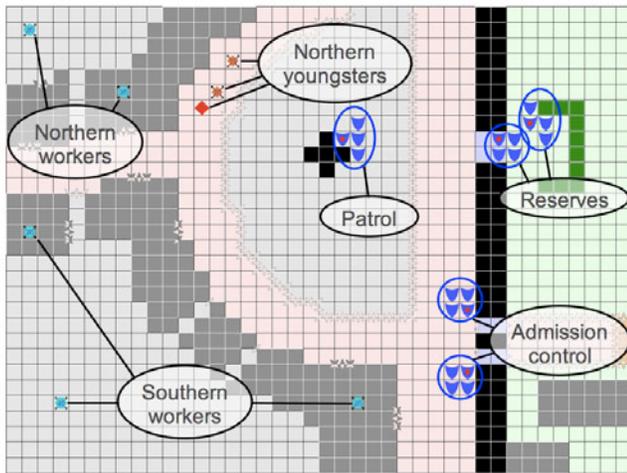


Figure 2: PAX scenario

Besides these two groups, there is a group of "Northern youngsters", ethnically belonging to the northern group, who are rather frustratedly "hanging around" in the area and whose intention is not to cross the checkpoint but rather to disturb the other group and generally to interfere with the military operation.

The military force in the scenario consists of 5 squads: Two reserve squads, one patrol squad and two admission control squads at the checkpoint with the mission of checking for unauthorized persons (in this scenario all civilians of group "Northern youngsters") and weapons carried by checkpoint crossers (which are confiscated if found).

ANALYSIS

The main objective of the CRC Analysis group was to evaluate the possibilities of the new PAX version 3.0. Thus, the new features such as user-definable soldier rule sets as well as user-definable cognitive motives of the civilians were extensively tested and analyzed in order to see how well these features provide flexibility in the scenario setup, allowing for the creation of more realistic and adequate scenarios.

The main focus of the analysis was to examine how the different soldier rule sets, e.g. Rules of Engagement (RoEs), affect the situation in terms of the

- overall escalation of the situation,
- number of casualties on soldiers' side,
- number of casualties on civilians' side and the
- number of workers passing the checkpoint.

Determining important model factors

During the Data Farming (DF) process, PAX parameters of main interest and presumable importance with respect to the model and the scenario under examination were identified. Thus a number of parameters were analyzed in a simulation experiment using the Nearly Orthogonal Latin Hypercube (NOLH) design provided by the Naval Postgraduate School (NPS) Monterey, CA, USA.

The NOLH design used contained 13 parameters which are shown in Table 1. Each design point was calculated using a MultiRun of the simulation model PAX with 30 replications with different random seeds.

Parameter farmed over	Min	Max
Reserves:Threshold for intervention	0	200
All soldiers:Threshold calling for reinforcement	0	100
Northern youngsters: Dog factor	0.75	1.33
Northern youngsters: norms for anti-aggression	0	40
Northern youngsters: Readiness for aggression	50	90
Northern youngsters: personality constant anger	0	100
Northern youngsters: Personality constant fear	50	100
Northern youngsters:Willingness for cooperation	0	50
Northern workers: Norms for anti-aggression	0	40
Southern workers: Norms for anti-aggression	0	40
All workers: Dog factor	0.75	1.33
All workers: Personality constant anger	0	100
All workers: Personality constant fear	0	100

Table 1: Parameters varied in NOLH design study

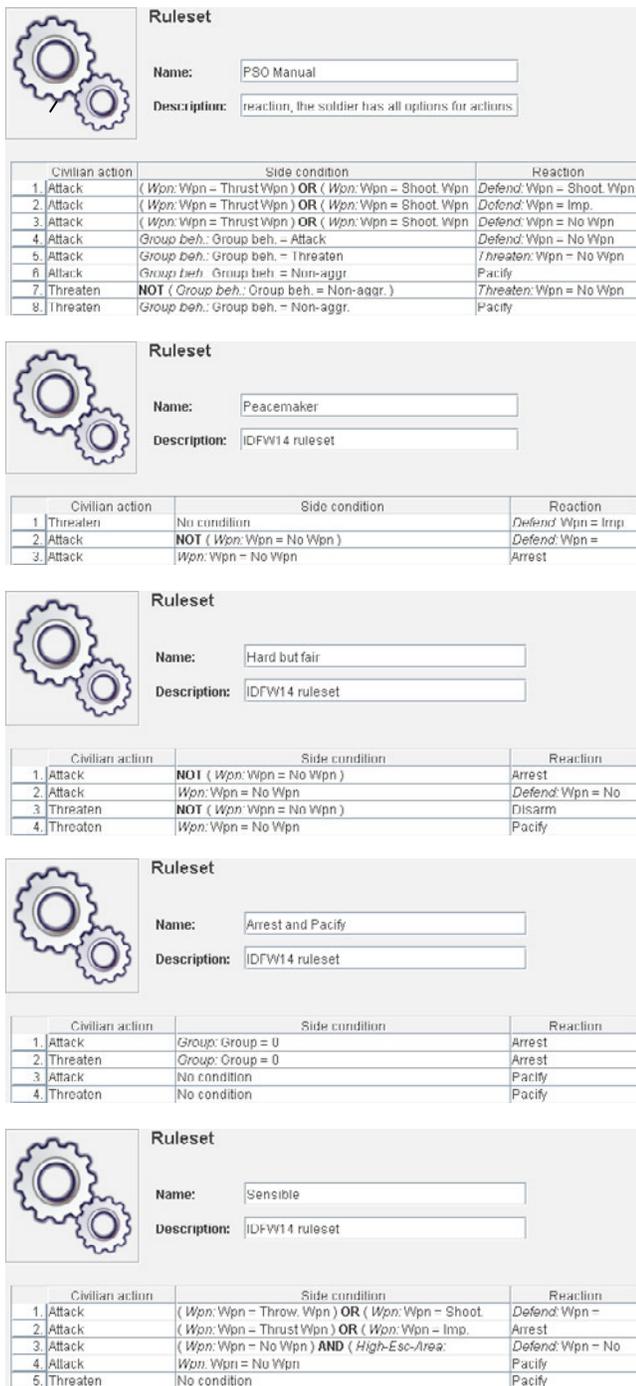


Figure 3: Rule sets examined

When analyzing the data with the help of commercial off the shelf (COTS) statistical software, it became clear that the parameter that had the most significant impact on numerous MOEs was the parameter responsible for the change of the anger levels of the Northern Youngsters group (PAX

parameter "PC_Anger"). The effect of this parameter was most clearly seen in the aggregated escalation of civilians during the simulation.

Examining different Rules of Engagement

Therefore, it was decided to set up a gridded design experiment varying this "PC_Anger" parameter¹ together with a controllable parameter, the "threshold for intervention" of the reserves.

In addition, corresponding with the team goal of assessing the effect of different RoEs, five vignettes were set up each with a different set of RoEs for the soldiers. Each member of the group had the chance to set up a rule set for the Rules of Engagement (RoEs) of the security forces. Therefore the new rule set editor of the new PAX version 3.0 was successfully tested as a side effect of this experiment.

The four rule sets which were each built by one member of the group, respectively, could thus be compared to the "PSO Manual" rule set which was built into previous versions of PAX and is now still shipped with PAX as a predefined rule set. The "PSO Manual" rule set represents a moderate reaction to civilian actions trying to create a balance between an immediate sharp reaction and a complete laissez-faire attitude. Figure 3 shows the rules of the "PSO Manual" rule set and of the different rule sets created by the team members.

It can be seen, for example, that compared to the "PSO Manual" rule set, the "Peacemaker" appears simpler, using a smaller number of rules and selecting more drastic reactions in order to keep the situation under control right from the start, prevent escalation and protect the soldiers.

All in all the gridded study consisted of 3600 single PAX runs performed on a 128 node cluster in Friedrichshafen / Germany. This set of runs had the following characteristics:

- Parameters varied:
 - Northern Youngsters: PC_Anger
 - Min 0, max 100, step size 20
 - Reserves: Threshold for intervention
 - Min 0, max 200, step size 40
 - All soldiers: Ruleset
 - "PSO Manual"

¹ Note that this parameter cannot usually be influenced by military forces in a real world situation since it represents personality characteristics of the individual civilians.

- "Peacemaker"
- "Hard but fair"
- "Arrest & Pacify"
- "Sensible"

- Number of replications: 20

Comparison of the rule sets

The analysis of the result landscapes of the gridded experiment showed that the "standard" rule set "PSO Manual" that had been in use so far still proved to be very robust with regard to not only a single MoE like "Overall Aggregated Escalation" but also considering others like "Number of Civilians that passed the checkpoint" or "Number of Casualties". While other rule sets proved to be more effective on some MOEs such as reducing the important probability of soldiers being killed, they had major disadvantages with respect to other MoEs such as the number of civilians being killed or the overall escalation.

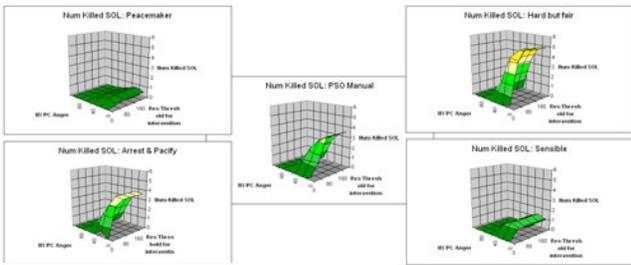


Figure 4: Performance of Rule Sets: Killed Soldiers

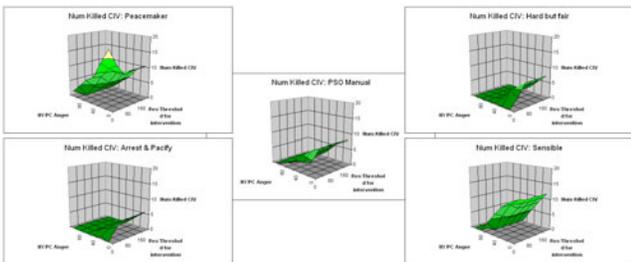


Figure 5: Performance of Rule Sets: Killed Civilians

The results were examined in more detail looking at the course of action (CoA) of relevant single PAX runs which provided insights into specific reasons for the performance of the different RoEs, such as showing that an early show of force can have advantages in scaring potential aggressors away or that a restricted area of responsibility of the reserves can lead to severe escalation between the civilian groups, to name only two examples.

Comparing different cognitive motives

Another new tool of the PAX version 3.0 is the Motive Editor that allows the user to define *cognitive* motives a civilian is to follow in addition to the existing motives like anger or fear built into PAX. Examples for such a cognitive motive are *need* or *voting motivation*, motives which used to be defined as regular motives. In the new version of PAX these motives are defined as cognitive motives, giving users the ability to flexibly modify them to fit their needs. A cognitive motive can be seen as a "plan" the civilian wants to follow and allows the user to program scripted behavior for the civilians up to a certain extent.

In the mid-term the ability to change TTPs not only for the soldiers but also for the civilians paves the way for some sort of war-gaming applications with PAX where BLUE TTPs can be improved to match RED TTPs and vice versa. A first attempt at testing the new flexibility provided by these cognitive motives was made by team 1 at IDFW14 by setting up a cognitive motive for a subgroup of the group of northern youngsters so they would assault the southern workers. Figure 6 shows the Motive Editor with the mentioned cognitive motive "Assault" loaded.

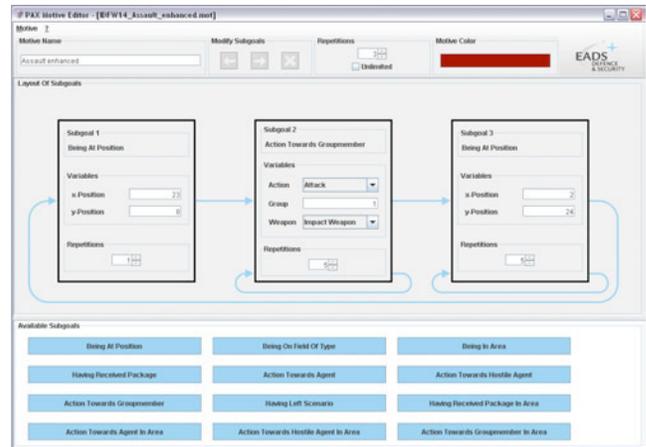


Figure 6: PAX Motive Editor

This example of a cognitive motive consists of three subgoals:

1. Approach the southern part of the area near the checkpoint where the southern workers are expected.

2. Perform five attacks against southern workers.
3. Retreat to the northwestern part of the area².

Each civilian assigned this motive will try to sequentially achieve these subgoals for three times (see global number of repetitions) as long as no other motive (such as a high anger or high fear) has a higher motivational power.

The motivation behind this cognitive motive was to make the northern youngsters "smarter" in directly addressing the southern workers instead of randomly engaging in fights with the patrol on the square. This expected behavior was indeed observed when looking at single simulation runs using the "Assault" cognitive motive. Figure 7 shows the situation shortly after the beginning of the simulation – while the majority of the northern youngsters have already started to fight the patrol and reserves on the square and are even starting to back off, a small group of five has made their way down to the southern part where they concertedly attack southern workers.

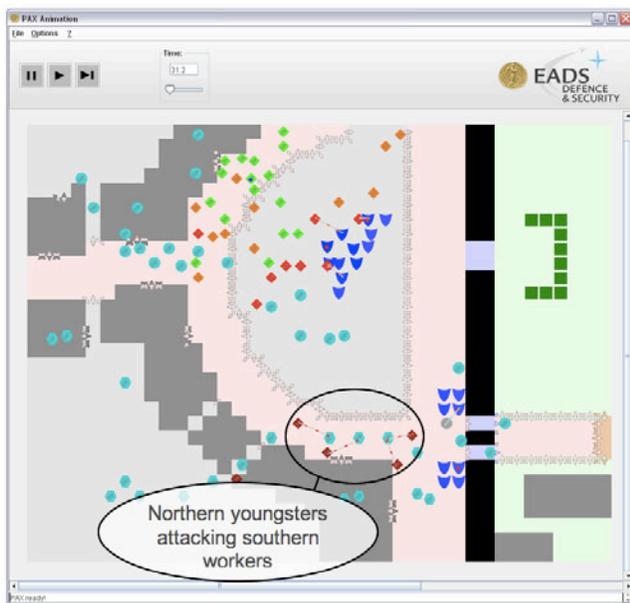


Figure 7: Effects of the cognitive motive "Assault"

Due to the limited amount of time available the team could only scratch the surface of what can be modeled using the Motive Editor. Other cognitive motives were briefly examined including one in which a subgroup of the northern youngsters picks a fight amongst themselves, which was not possible

before the introduction of the Motive Editor (see Figure 8). This shows that the new PAX version provides many possibilities yet unthought of.

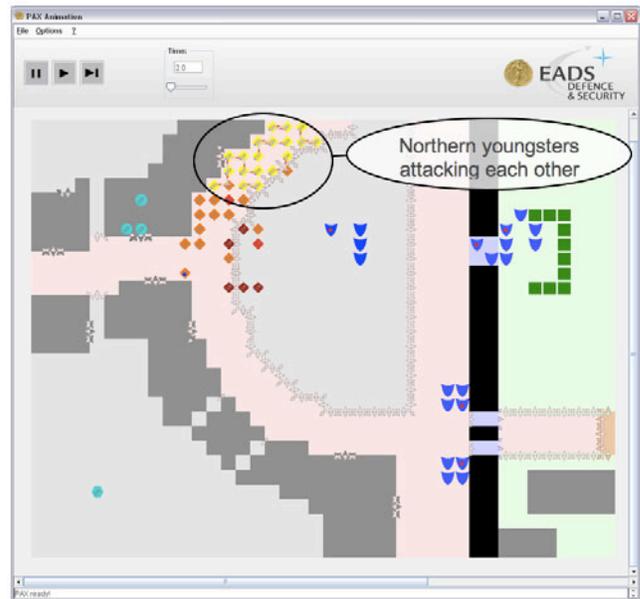


Figure 8: Cognitive motive "Self-attack"

SUMMARY / OUTLOOK

The "Toolbox" version 3.0 of PAX proved to be a big enhancement, even though further calibration is necessary. The rule set editor allows to set up RoEs of soldier agents in a flexible user-definable way. The editor for cognitive motives of the civilians allows users to define how specific (groups of) civilians try to achieve a set of sub goals. These new possibilities make it significantly easier to model a real-world scenario or examine different TTPs on both the soldiers' and the civilians' side and seem to even provide a lot of potential for future applications in fields like border security or disaster relief operations.

Having an international participant with a psychological background tremendously helped to broaden the view and to get new perspectives and insights for the further development of PAX as well as other possible fields of activity.

² This subgoal is set to be achieved five times in order to make the civilian stay at the specified position for five time units. A subgoal "Wait" will make this technical artifice obsolete in future versions of PAX.