Calhoun: The NPS Institutional Archive

DSpace Repository

Faculty and Researchers | Faculty and Researchers' Publications

2007-03

PAX: Designed for Peace Support Operations

Lampe, Thorsten A.; Schwarz, Gunther J.; Wagner, Gudrun

https://hdl.handle.net/10945/35610

This publication is a work of the U.S. Government as defined in Title 17, United States Code, Section 101. Copyright protection is not available for this work in the United States.

Downloaded from NPS Archive: Calhoun

http://www.nps.edu/library

Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

PAX: Designed for Peace Support Operations

Thorsten A. Lampe*
EADS System Design Centre, Germany

Gunther J. Schwarz
EADS System Design Centre, Germany

Gudrun Wagner
EADS System Design Centre, Germany

Modeling Peace Support Operations

Peace support operations represent a new challenge. The forces have to master a multitude of difficult-to-calculate, asymmetric threats. In recent missions, the soldiers must manage completely new problems which have little in common with the classic conflict situations of former threats. They are not confronted with a heavily armed, militarily organized enemy but with hungry, scared or even enraged civilians. How will they react? Will they remain peaceful or will they become aggressive? Shall the soldiers keep in the background or take strong measures? The answers to these questions are decisive for the operational or tactical proceeding and for the adequate use of material and personnel in crisis regions.

Therefore, instead of concentrating on mutual attrition of relatively symmetric enemies as in the past, rethinking has to take place also in the area of simulation. The highly dynamic character of asymmetric multi-party scenarios must be modeled, non-military groups and the hardly predictable behavior of the civilian population must be appropriately considered and, in addition to weapon employment, active de-escalation and non-lethal methods are becoming increasingly important. Thus, the present and future mission situations of the armed forces are characterized by growing complexity where small changes of the initial situations or of the processes may involve decisive consequences for direct and indirect mission success.

Using agent-based modeling and simulation allows to model these complex dynamics of the real-mission processes (cp. [7]) in which even a misunderstanding between individuals can decide whether a mission is peaceful or not.

The Simulation Model PAX

On behalf of the German Bundeswehr, an advanced agent-based model for the simulation of peace support missions has been developed under the name of PAX (Latin term for "peace") at the System Design Centre of EADS. Analyses with PAX help to better understand the complex dynamics of tactical miniature scenarios, which are so important for peace support missions, and to check alternative procedures. In doing so, a great number of effects can be analyzed in a broad spectrum of realistic mission situations: The simulation of a humanitarian assistance mission, for example, shows not only the apparent success of drastic measures against disturbing elements but also significant side effects, such as arousing agitation, dislike or even hate of a previously friendly group.

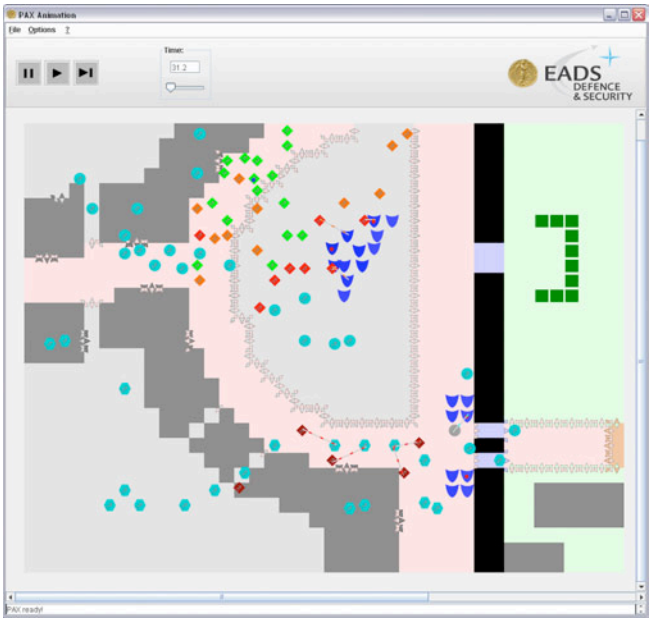


Figure 1: Visualization of a PAX situation in the scenario examined at IDFW14

* For more information contact: sdc-info@eads.com.

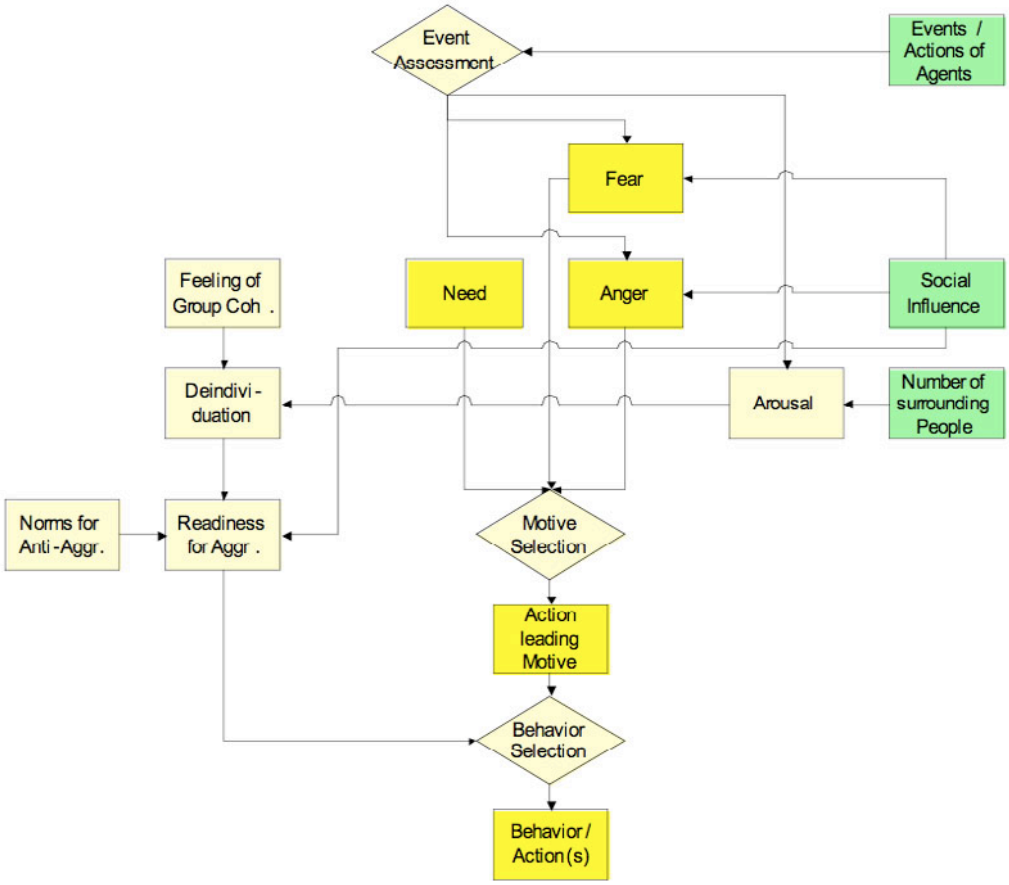


Figure 2: The "model behind the model". Core of a civilian agent in PAX where green blocks represent external variables, yellow ones motives and action

Despite or even because of the technical progress and the automation of many processes, human factors are of great importance in today's mission reality, in particular in peace support missions but also in the scope of Network-Centric Operations (NCO) (cp. [6]). Thus, for example, stress-caused inappropriate behavior in combination with collective aggression may result in the uncontrolled insurgence of crowds. Empirical findings from interdisciplinary areas of psychology, sociology and the military and police sector form the basis for the modeling of human behavior.

Both military expertise and empirical findings from psychological research on aggression were used in the construction of PAX. The psychological model on which the civilians in PAX are based is described in [1], while Figure 2 shows a very simplified diagram of the qualitative correlations in the model. Psychological factors having an influence on the decisions and the behavior of all persons concerned may have a considerable effect on the development of an operation.

PAX concentrates on modeling peace support operations on a detailed tactical level. Since being of secondary interest in the question sets examined, terrain is modeled in a fairly abstract way in a grid-based environment with a distinction between normal cells, built-up cells and obstacles. Due to its nature and objectives, the model focuses on the detailed representation of the individual civilians and their internal states, including emotions such as fear or anger and their interrelation. The military forces modeled in PAX, on the other hand, have the possibility to not only use different types of weapons, as in existing military simulations, but to also take measures of active de-escalation, such as trying to calm down people or talking to the leader of a civilian group.

Toolbox PAX

The current PAX version 3.0 concludes a development aimed at providing the military analyst with means to examine question sets in a variety of easy to set up PSO scenarios. Thus the main goals in the development of this "Toolbox PAX" were to make the model flexible enough to be used in a broad variety of scenarios, examining different aspects of PSO missions, while at the same time keeping the user interface easy and intuitive enough for the military expert to use it without an excessive introduction.

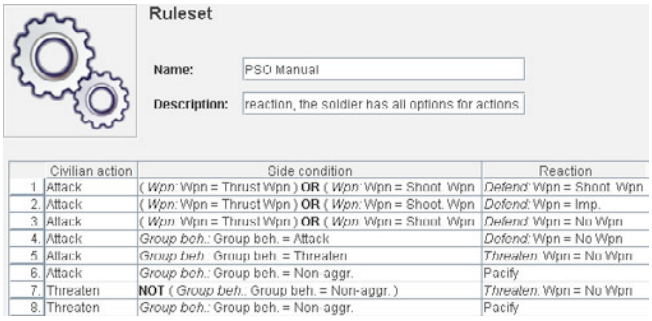
The improvements in the functionality of PAX are best explained by looking at two of the new tools that have been created – namely the Ruleset Editor and the Motive Editor, which are briefly introduced in the following sections.

PAX Ruleset Editor

Different behavior of the soldiers is represented by different rule sets in PAX. These rule sets represent soldiers' rules of engagement, training and TTPs up to a certain extent. While in previous versions of PAX the user was able to choose between different predefined rule sets, the Ruleset Editor now enables the user to define his / her own set of rules.

In doing so, the user may choose from a range of conditions including actions performed by civilians, gender and age of that civilian, the overall behavior of certain groups, the level of escalation, weapons or the force and condition of the own squad.

Using these conditions, the military user can distinguish different cases and situations and thus define the desired reaction of a soldier under any given circumstances.



	Civilian action	Side condition	Reaction
1.	Attack	(*Wpn*: Wpn = Thrust Wpn) **OR** (*Wpn*: Wpn = Shoot. Wpn	*Defend*: Wpn = Shoot. Wpn
2.	Attack	(*Wpn*: Wpn = Thrust Wpn) **OR** (*Wpn*: Wpn = Shoot. Wpn	*Defend*: Wpn = Imp.
3.	Attack	(*Wpn*: Wpn = Thrust Wpn) **OR** (*Wpn*: Wpn = Shoot. Wpn	*Defend*: Wpn = No Wpn
4.	Attack	*Group beh.*: Group beh. = Attack	*Defend*: Wpn = No Wpn
5.	Attack	*Group beh.*: Group beh. = Threaten	*Threaten*: Wpn = No Wpn
6.	Attack	*Group beh.*: Group beh. = Non aggr.	Pacify
7.	Threaten	**NOT** (*Group beh.*: Group beh. = Non-aggr.)	*Threaten*: Wpn = No Wpn
8.	Threaten	*Group beh.*: Group beh. = Non aggr.	Pacify

Figure 3: One of the default rule sets

Figure 3 shows the "PSO Manual" rule set, one of the rule sets built into previous versions of PAX which is 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 laisser-faire attitude. Using the Ruleset Editor this rule set can be easily adjusted or even changed completely.

PAX Motive Editor

While the Ruleset Editor provides the analyst with new means of modeling tactics, techniques and procedures of the soldiers, the behavior of the civilian agents in PAX is a lot more complex. Just like in a real mission, the civilian agents in PAX make their own decisions and follow their own goals, not seldom leading to an unexpected behavior of individuals and – as a consequence – of the crowd. Although this again matches the real-life experience of PSO forces, the analyst often needs a way to not only define the initial state of the civilians in the simulation and then watch the dynamics evolve, but to also make the civilians have certain user-defined objectives or motives.

The Motive Editor accounts for this desire to model predefined goals of a civilian. It 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*, both used to be defined as "regular" (already pre-defined) motives in PAX. 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. Thus, 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 medium-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. The new flexibility provided by these cognitive motives was already used by team 1 at IDFW14 by setting up a cognitive motive for one group so they would explicitly assault another group. Figure 4 shows the Motive Editor with the mentioned cognitive motive "Assault" loaded.

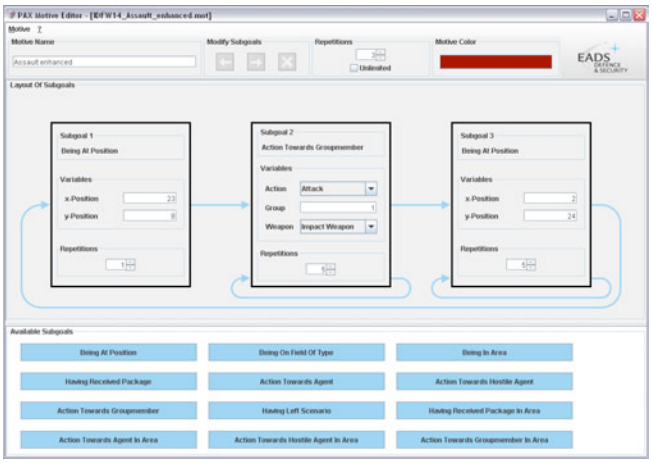


Figure 4: PAX Motive Editor

Each civilian assigned this motive will try to sequentially achieve the sub-goals 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 strength.

Of course, other motives still can *get* a higher motivational strength while a civilian is processing a cognitive motive just due to the dynamic processes in the model.

Example: A civilian has a quite high motivation (strength of the cognitive motive) to cross a checkpoint to go to work. If heavy shooting is taking place on his way around him, the civilian may – depending on his cognitive assessment of the situation and the resulting effect on his emotional state – become fearful and try to run away. In this case, the motivational strength of fear exceeds that of the motivation to cross the checkpoint.

Other Features of the Toolbox PAX

Apart from the editors just described and the according changes to the simulation model, further enhancements have been made to the model as well as to the graphical user interface to allow for a better, easier and more realistic analysis of the question sets at hand.

Improvements to the model include enhanced movement algorithms for the agents, the ability of soldiers to arrest and disarm civilians in a given situation or the possibility of agents entering the scenario at a certain point in time and leaving it under certain conditions.

Another important feature from the analytical point of view is the ability to set every numerical parameter using not a fixed initial value but rather a mean value and a given distribution. This allows both an easier and more realistic setup of scenarios and accounts for random variations of the scenario situation that soldiers are facing in real missions, too.

Some improvements have been made to the user interface, such as the use of tooltips to explain the various parameters that can be defined in PAX or the visualization of different civilian groups using different shapes.

To conclude the description of the toolbox and its capabilities, it should be mentioned that all of the important components of a scenario, such as agents, motives, rules or rule sets, can be saved and thus reused in various other scenarios.

Data Farming with PAX

Analysis with PAX using the method of data farming has been done since PAIW8, both during following Project Albert International Workshops / International Data Farming Workshops (cp. [2]) and in other work done by EADS and by students of the Naval Postgraduate School in Monterey, CA (cp. [3]).

Since then, PAX' support for data farming has been continuously improved so that PAX now assists the user in the whole process of scenario and study creation, execution of the study on either a local computer or a super-computing cluster and analysis of the results. PAX provides an experiment editor for creating OldMcData studies (see [4]) as well as an easy-to-use, Excel-based visualization tool for analyzing data farming studies.

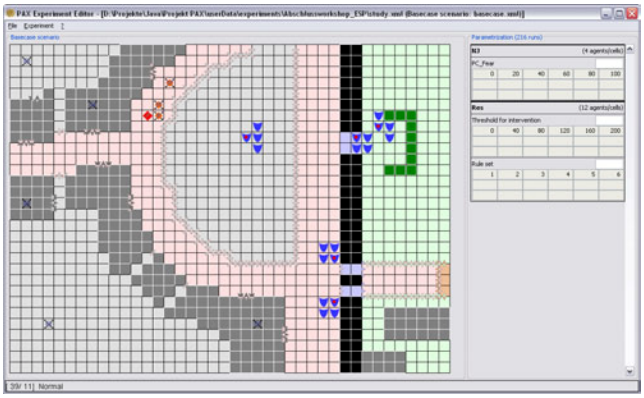


Figure 5: PAX Experiment Editor

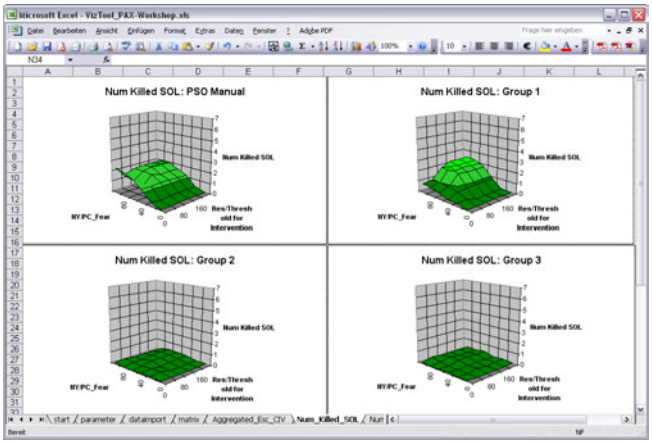


Figure 6: PAX VizTool

Although PAX supports any data farming procedure the user wishes to follow, at International Data Farming Workshops the groups working with PAX usually roughly followed a certain "cookbook":

1. Select a high-level scenario (such as "food distribution" or "demonstration").
2. Build a base case scenario matching the high-level scenario developed in step 1.
3. Find the most significant model parameters using an efficient design (e.g. NOLH) and fitting a regression model to the results.

4. Decide which parameters to data farm (using the parameters found in step 3 and any additional parameters of special interest).
5. Define a gridded study and send the runs to a computing cluster.
6. Analyze the results using statistical tools and methods like regression models and fitness landscapes.
7. Optionally examine single simulation runs in more detail using the PAX animation.

Areas of Application

The main focus of the current version of PAX is the process of analysis and planning. The agent-based modeling approach, combined with the experimentation method of data farming and the usage of high performance computing add up to a powerful instrument for doing a holistic analysis of a variety of question sets with regard to peace support operations. Being able to compare different TTPs on both the military and the civilian side while taking into account human factors on both of these sides creates a new quality of analysis. In addition to the use of PAX for analyzing tactical miniature scenarios, the existing interfaces and modules also enable the use of the model as a zoom function for operational or strategic analyses in the scope of the "Concept Development & Experimentation" (CD&E) process.

Up to now, no activities have been conducted with PAX in the direct context of requirements determination and fulfillment. However, PAX could be applied to analyze the cost-benefit ratio, in particular, of military material used on tactical level. This would require the development of additional modules allowing a more detailed simulation of the technical aspects of the systems used than this has been possible so far with PAX.

As a basis for the future use of PAX in the scope of computer-assisted training, a user interface has already been created which enables the user – in this case the platoon commander to be trained – to directly move in a virtual 3D environment and to interact with the civilians and soldiers simulated by PAX. In order to impart practical skills and behavior patterns in a realistic environment, using this so far prototypical synthetic environment, it would be possible in the future to complement the practical training by additional virtual experience gained with simulation. Special cases as well as "best case" and "worst case" scenarios can be considered and different assumptions on the intentions and behavior patterns of the cultural, ethnic or political groups encountered in operations can be taken into account. In after-action reviews, the trainee can see the consequences of his decisions under didactical aspects as well as potential action alternatives. Especially in the important PSO context, these after-action reviews offer the opportunity of seamless integration of simulation systems into training.

Summary and Outlook

The "Toolbox" version 3.0 of PAX proves to be a useful instrument for the military analyst, even though further calibration is necessary. This conclusion was drawn during International Data Farming Workshop 14 in March 2007 as well as at a national PAX workshop held in April 2007 in Germany with participants from a military and psychological background.

PAX already proves to be applicable for performing useful analyses. But, to further improve the model quality and applicability it is recommended to add further enhancements to the model such as better possibilities for defining tactical courses of action, and to conduct a comprehensive model calibration and further validation.

Follow-up activities are considered in all mentioned areas of application, such as using PAX for training purposes, or to develop and review operation doctrines. Analysis with PAX may become even more powerful in combination with the use of evolutionary algorithms. First ideas for such an approach have been presented in [5].

References

[1] Schwarz, G. and Mosler, H.-J. Investigating Escalation Processes in Peace Support Operations: An Agent-based Model about Collective Aggression In Proceedings of the 3rd Annual Conference of the European Social Simulation Association (ESSA 2005), ESSA, Koblenz, Germany, 2005.

[2] Schwarz, G. and Erlenbruch, T. Experiments with the Model PAX: Investigating Escalation Processes in Peace Support Operations. In Maneuver Warfare Science 2003. USMC Project Albert, Quantico, VA, USA, 2003, 63-79.

[3] Soon Tan, P., Using Agent-based Modeling to Assess the Impact of Martial Law on a Representative Iraqi Town, Master Thesis in Operations Research, Naval Postgraduate School, Monterey, CA, USA, 2004.

[4] Koehler, M. T., Upton, S. and Tivnan, B. F. Clustered Computing With NetLogo And RepastJ: Beyond Chewing Gum and Duct Tape. In Proceedings of the Agent 2005

Conference on Generative Social Processes, Models, and Mechanisms, University of Chicago, IL, USA, 2005.

[5] Lampe, T. and Schwarz, G., Using Evolutionary Algorithms to Improve Tactics, Techniques and Procedures in Peace Support Operations, At the Military and Security Applications of Evolutionary Computation Workshop (MSAEC 2006), MSAEC, Seattle, WA, USA, 2004.

[6] Schwarz, G, Command and Control in Peace Support Operations: Model PAX – Approaching new Challenges in the Modeling of C2 /– In: The 9th ICCRTS at the House of Engineers in Copenhagen, Denmark (14-16 September 2004) ; (http://www.dodccrp.org/events/2004/ICCRTS_Denmark/CD/papers/062.pdf).

[7] Schwarz G.; Kunde D.; Urban C., Agent-Based Modeling in Military Operations Research: A Case Study – In: 3rd Workshop on Agent-Based Simulation / C. Urban (ed.), SCS – Society for Computer Simulation Int. ; Delft ; Erlangen ; Ghent ; San Diego, 2002, p. 55-60.