MULTI-SCALE MULTI-AGENT GEOSIMULATION
- THE MUSCAMAGS PROJECT- TDM-DSD-08

PROGRESS REPORT (APRIL-OCTOBER 2005)

RESEARCH TEAM

PROJECT LEADER :
MOULIN BERNARD / Université Laval

PROJECT DEPUTY LEADER :
SCOTT, DARREN / University of McMaster

OTHER RESEARCHERS :
BEDARD, YVAN / Université Laval
DOHERTY, SEAN / Wilfrid Laurier University
HARRAP, ROB / Queens University
THÉRIAULT, MARIUS / Université Laval

PARTICIPATING ORGANISATIONS :
Alberta Sustainable Resource Development
Center for Spatial Analysis, McMaster University
Centre de recherche en aménagement et développement (Université Laval)
Defence Research and Development Canada Valcartier (DRDC)
Institut national de santé publique du Québec
Joint Program in Transportation (Toronto)
Ministère des transports du Québec
National Research Council of Canada (Institute for Information Technology)
NSim Technology
PROCESSUS Network
SOPFEU : Société de protection des forêts contre le feu du Québec
SONATRAC (Algérie)
Sûreté du Québec
Time Use Research Program, St Mary’s University (Halifax)
Ville de Québec (service de l’amenagement du territoire, service de geomatique, service de police)

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SIGNATURES

BEDARD, YVAN / Université Laval

DOHERTY, SEAN / Wilfrid Laurier University

HARRAP, ROB / Queens University

MOULIN BERNARD / Université Laval

SCOTT, DARREN / University of McMaster

THÉRIAULT, MARIUS / Université Laval
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Summary

In an increasingly interconnected and fast-changing world, decision makers from various sectors (governmental, military, industrial, medical, social) need to deal with multi-actor dynamic spatial situations (MADSS) that involve a large number of actors of different types (human, animal, static, mobile, computer systems, etc.) acting in geographic spaces of various extents. There are numerous MADSSs that need to be monitored in order to insure human security and equipment preservation, the respect of public order or the adequate use of infrastructures. Certain MADSSs occur on a regular basis (ex. daily traffic patterns in an urban area) whereas other MADSSs can evolve rapidly as a consequence of the occurrence of particular events and/or changes in individual behaviors (often in crisis situations). For any particular MADSS, decision makers need to obtain an overall understanding of the situation, monitor its evolution, develop strategies and tactics for adequate intervention, develop and compare alternative intervention scenarios and anticipate the multi-scale consequences of enacting such scenarios. Several issues must be tackled at once: construction of multi-resolution world models with reliable physical terrain models and contextual semantic attribution, population data and physical data; monitoring the evolution of the situation; assessment of various courses of actions, anticipation of the reactions of the actors involved in the situation, etc. Certain MADSSs may occur within the context of another MADSS of larger extent as for example a demonstration of 5000 persons in the center of a city will influence the more global MADSS of car traffic in the city surrounding region. Because of this embedding of MADSSs, decision makers often need to examine various situations simultaneously at different scales (spatial, temporal, quantity and characteristics of actors). This is an important issue since the modeled phenomena and observed patterns may be different from one level of detail to another, and since there can be interferences between phenomena developing in different interrelated MADSSs.

In the MUSCAMAGS Project we aim to develop a methodology and a generic software platform to create multi-scale multi-agent geo-simulations to support operational Decision Support Systems for MADSSs. This project builds on the results that we obtained in the MAGS Project financed by GEOIDE and RDDC Valcartier between April 2002 and March 2005.

This progress report describes the main activities that our team carried out between February and October 2005. This first two months of the project were devoted to setting up the team, launching the project, identifying the responsibilities of each researcher, the complementarities, determining the main research themes for the next two years and the main milestones. Between May and October 2005 each sub-group worked on gathering data and literature documents and preliminary synthesis works have been done in order to prepare the grounds for the project research and development activities. Our partners have been involved in this foundational work thanks to individual meetings during the past 6 months. This led to the second MUSCAMAGS workshop which was held December 8-9 2005 in Quebec city with a large attendance: 5 team researchers, 1 project advisor, 12 graduate students, 2 research professional and 10 representatives of our partners.
1. A) Networking and Partnership

The team of researchers has not changed and is composed of 6 researchers and their students from 4 different universities and 2 different provinces. This is a highly multidisciplinary team and its members have expertise in complementary domains: geomatics (Bédard, Harrap, Thériault), geography (Doherty, Scott, Thériault), computer science, (Moulin) artificial intelligence (Moulin, Harrap), Geology (Harrap). The team coordinates the work of students in geomatics, computer science and geography. Our two advisers are specialists in economics (Harvey), land transportation and geographic information (Lee-Gosselin).

Based on the experience gained during the MAGS project supported between April 2002 and March 2005 by GEOIDE and the Defense (RDDC Valcartier), Moulin and his students at Laval Univ. provide their expertise in computer science, knowledge representation and artificial intelligence techniques to build multi-agent geo-simulations and related tools (creation of multi-scale geo-referenced simulation environments, scenario specification tools, software to analyse and efficiently present data generated by the simulations, tools to support decision makers while using multi-scale geo-simulations).

Based on his work on ‘urban semantics’, Harrap and his students at Queens Univ. closely work with Moulin’s team (especially PhD candidate W. Chaker) on the creation of informed virtual geographic environments (VGEs) that will be used by the agents (pedestrians, cars, etc.) evolving in the geo-simulations. An informed VGE is a virtual geographic environment generated from GIS data (terrain data, building data, etc.) in which specific objects (buildings, doors, urban furniture, etc.) are associated with semantic data (such as ontologic information, scripts that can be used by agents to manipulate the objects, behaviors associated with the objects to simulate the reactions of the objects to various events) in addition to geometric data and coordinates. The challenge is to generate multi-scale informed VGEs as automatically as possible, using GIS data, ontologies and specific information (such as detailed information about the transportation network at different scales, land-use, distribution of services). A. Ménard, geographer and post-doc fellows (PDF) working with Thériault at Laval U. will participate in this work, investigating the advantages of using cellular automata in such VGEs. Considering the representation of the road network, N. Mamane-Sabo, a PhD candidate supervised by Bédard and Moulin, explores the use of cartographic generalization and multiple representation techniques to automatically create road networks at different scales.

A large number of multi-agent geo-simulations in urban environments require the creation of plausible agent populations that adequately reflect the characteristics and behaviors of real populations. Several members of the team join forces and their expertises to develop models and tools that can be used to automatically create significant agent populations (individuals, households) with a large number of agents (several hundreds of thousands of individuals) plausibly representing a real population (the population of greater Quebec city) and plausible behaviors (we will focus on travel
choices and behaviors). As a test area we chose Quebec city since our team member Thériault and advisor Lee Gosselin at CRAD have a large number of data sets related to the population of Quebec city (Origin Destination surveys (OD), Panel surveys, etc.) and that several of our partners have also detailed data in this area (Ville de Quebec, Ministère des transports du Québec, Sûreté du Québec). Chaker (when he was working two years ago with Moulin and Thériault as a research assistant in a Quebec FQRSC-funded project) developed a model and a system that can be used to generate the static characteristics (demographic data, residence, etc.) of a plausible agent population based on the analysis of an OD survey and on equations proposed by Thériault. During the past six months preliminary work has been done on the specification of population travel behaviors. Thériault and his students N. Lachance-Bernard (MA student) and D. Biba (economist and PDF working at CRAD), investigated the use of models of multinomial logistics regression to simulate individual travel destination choices. These models will be used by Chaker and Ménard to create an initial version of individual agents’ travel decisions. With D. Duval, an urbanist working at Ville de Québec, we identified some potential areas of collaboration that will certainly lead to a joint sub-project in 2006. During the past six months, Doherty and Scott have been working closely together to develop a conceptual framework that will be used to forecast urban travel demand. This framework merges traditional space-time prism concepts with more recent activity scheduling process modelling approaches in order to simulate the activity scheduling decisions process that underlies observed patterns of behaviour. This work capitalizes on Scott’s GIS-based tool for operationalizing space-time prisms for activity location choices, and Doherty’s scheduling time horizon models calibrated with CHASE data (collected by Doherty). This work will be at the core of the research of two PhD candidates, D. Papinski and H. Kang, at McMaster. The approaches developed by Thériault for individual travel choices and by Doherty and Scott for individual activity scheduling are complementary and may be applied at different levels of the simulation models (at macro, meso and micro scales). During 2006 we will investigate how to combine them in an efficient way so that they can be used to create the decision and behavior structures of the agents that will simulate the population of Quebec city in our geosimulation platform. These issues were discussed at the December 2005 MUSCAMAGS workshop.

In order to easily specify the agents’ behaviors and simulation scenarios and to verify the coherency of these behaviors and scenarios, we need efficient and user-friendly software tools. This is the research domain of PhD Candidate Garneau which works under Moulin’s supervision and in close relationship with J. Perron and J. Hogan, founders of our private partner NSim Technology which develops a new version of a framework for multi-agent geo-simulations. This framework has been refined during the past year and tested to develop an initial proof of concept using NSim’s SdkSim Platform in the context of the MAGS-COA Project. With NSim Technology (Hogan, Perron), H. Haddad (PhD candidate at Laval), Moulin and M. Bélanger (scientist at RDDC Valcartier) started to investigate the potential of a MAGS approach to support the visual creation of courses of action (COA) and their assessment using a multi-agent geo-simulation approach. One of the mid-term objectives is to investigate how a critiquing system can take advantage of such an approach to support decision makers when creating and assessing courses of
actions. This is an example of a research sub-project taking place within the MUSCAMAGS Project and focusing on the interest of one of our partners.

We need methods and tools to create multi-agent geo-simulations (MAGS), to analyse the results of the simulations and to use them to support decision making. During the past three years W. Ali (PhD candidate at Laval) and Moulin developed an analysis and design method for MAGS. It has been applied to the simulation of shoppers’ behaviors in malls using data gathered from surveys conducted in two malls: in Square One in Toronto area with the help of K. Jones’ team at Ryerson University, and Place de la cité in Quebec city. This method will be tested on several new applications within the MUSCAMAGS Project and extended to take into account the multi-scale aspects of geo-simulations. Tools to analyse the geosimulation results have been developed by Ali and a first integration with a Spatial OLAP tool (Jmap) has been done in collaboration with Bédard’s team in 2005 (M-J. Proulx and S. Rivest). We showed the great potential of SOLAP tools to explore the large amounts of data that can be obtained from geosimulations. During our December 2005 MUSCAMAGS Workshop Ali, Bédard and Moulin had several discussions with S. Létourneau from Conseil National de Recherches Canada (CNRC) who is a specialist in data mining and machine learning. We identified several areas in which the data mining techniques used at CNRC could be applied in the MUSCAMAGS Project, a challenge being to extend these techniques to analyse data with prominent spatial and temporal characteristics obtained from multi-agent geosimulations in georeferenced virtual worlds.

During Spring 2005 B. Bergeron (MSc in computer science at Laval and employed by the Canadian Forces at Valcartier) started to follow the first steps of the analysis method for MAGS in order to gather knowledge and expertise and to study techniques used by police forces (Sûreté du Québec) when monitoring crowds. The objective is to prepare the ground for the creation of agents which will simulate police activities and strategies in various scenarios related to crowd monitoring and control. This research direction will certainly gain momentum in 2006, thanks to a 3 year RDDC-funded TIF project that will start in April 2006 under Defense scientist L. Stemate’s leadership in collaboration with Moulin’s team. This project aims at developing models and simulations that describe crowd behaviour in conflict situations involving control forces (military or police) and that could be used to assess the impact of non-lethal weapons (tear gas, water guns, etc.) on crowd dynamics and the resolution of conflicts. To this end, we will use and compare multi-agent geo-simulation techniques and system dynamics approaches. We anticipate that these different techniques will be useful and complementary at different scales of simulation (system dynamics being applied at a macro level, while MAGS techniques being applied at a meso and micro level).

Multi-agent geosimulation might be very useful to support the planning of interventions done by different types of actors participating in operations in response to dynamic and uncertain situations taking place in geographic environments (ex. firefighters controlling the spreading of forest fires, joint operations of military units, joint interventions of police forces). We refer here to new artificial intelligence techniques dealing with distributed continual planning supported by MAGS. N. Sahli (Phd candidate) and Moulin
investigated this domain between 2003 and 2005 and developed a method to help people when solving complex planning problems in real and dynamic large-scale spaces. This research was applied to the fire fighting domain in collaboration with Quebec’s SOPFEU, which provided expert knowledge and cases, and Alberta’s ASRD which provided expertise and a forest fire simulation library PROMETHEUS. The proposed method consists in drawing a parallel between the real environment (i.e. a forest fire) and the simulated environment (i.e. a virtual reproduction of the forest in the MAGS environment). Real planners such as firefighters or bulldozers are simulated in the MAGS environment by software agents which can perceive terrain characteristics and the fireline position (the fire progression is simulated using PROMETHEUS). The geosimulation is used to assess and refine a sketch of a fire-break (to be created by dozers in the area exposed to the fire) that a commander draws on a map. Starting from this sketch, agents explore and assess different possible paths in the virtual environment in order to enhance the position of the fire-break, given the terrain characteristics (tree species, slopes, natural obstacles, etc.) and taking into account the fire’s progress. This work paves the way to further investigations of the use of MAGS approaches to support distributed continual planning (DCP) in complex, dynamic and uncertain environments such as planning and coordinating the activities of distributed shipping organizations (ex. federated shipping companies, Army warehouses) trying to optimize the shipment of goods to distributed clients and to adapt shipment plans when unexpected events occur (truck breakdown, traffic congestion, closed roads, etc.). Again, it appears that considering such distributed planning situations at different levels of granularity (multi-scale) would help manage the large complexity of this kind of problems. This domain will be investigated by PhD candidate M. Barkaoui at Laval Univ under Moulin’s supervision in collaboration with Defense scientist J. Berger at RDDC Valcartier. To push further the investigation of the use of a MAGS approach to support DCP, J. Berger is also interested in exploring how machine learning algorithms (such as reinforcement learning and hybrid methods) and MAGS techniques can be be used to exploit geospatial information and reasoning as well as user and domain knowledge in order to create simulations in which autonomous agents may learn to coordinate their plans (ex. cooperative target search for a group of drones flying over a large territory). An initial investigation of these issues will be conducted in 2006 by our team in collaboration with NSim Technology. Such problems may be of interest to S. Létourneau’s team at CNRC as it was discussed during the December MUSCAMAGS workshop.

Another example of a collaboration with our partners is the VNO-MAGS, sub-project supported by the Institut national de santé publique du Québec (INSPQ) in which we investigate the use of multi-agent geo-simulation to simulate the spreading of the West Nile Virus (WNV) in the southern part of Quebec (project leader: Moulin, co-leader P. Gosselin from INSPQ) This innovative multi-disciplinary research (entomologists, ornithologists, public health officers, artificial intelligence specialists) develops models and uses our MAGS tools to simulate the evolution and spatial interactions between mosquitoes and crows which are the main vectors of the virus. In the long run, the objective is to provide public health officers with a decision support tool to monitor the spreading of the WNV and to explore the possible impacts of different intervention scenarios (larvicide application) in the context of various atmospheric (temperature and
rainfall) conditions. In this project it will be worth considering the dynamics of populations from different scales (global view of the province vs the detailed view of each municipality).

Our partners come from different sectors: Defence (RDDC Valcartier), Provincial government (Ministère des transports du Québec, Sûreté du Québec, SOPFEU: Société de protection des forêts contre le feu du Québec, Alberta Sustainable Resource Development), Municipal government (Ville de Québec: service de l’aménagement du territoire, service de géomatique, service de police), Research institutions in the transportation sector (Center for Spatial Analysis - McMaster University, Centre de recherche en aménagement et développement CRAD - Université Laval, PROCESSUS Network, Joint Program in Transportation –Univ. of Toronto, Time Use Research Program, St Mary’s University - Halifax), Federal Research Institutions (National Research Council of Canada - Institute for Information Technology in Ottawa), Provincial institutions in the medical sector (Institut national de santé publique du Québec), the private sector (NSim Technology – Québec and SONATRAC - Algeria).

During the past 6 months we increased the number of partners that were initially proposed when the MUSCAMAGS project was submitted for evaluation in 2003. More specifically, we got the support of several new groups of scientists at RDDC Valcartier (Micheline Bélanger with the MAGS-COA Project, and Lumina Stemate with a new Defence funded TIF-RDDC project called Crowd Control Modelling and Simulation Capability to start in 2006 in collaboration with the MUSCAMAGS team). We also interacted with senior employees at Ministère des transports du Québec who renewed their interest in the project: the possible participation of specific services of this huge institution will be discussed after our MUSCAMAGS Workshop in December. We have also been working with Sylvain Létourneau (Research Officer at the National Research Council of Canada, Institute for Information Technology) to launch a joint research work on spatial data mining and learning in the context of the MUSCAMAGS Project. We also had several meetings with officers of the Service de l’aménagement du territoire of Quebec city and we are investigating different areas of collaboration with respect to urban planning in relation to the new Master Plan for the development of Quebec city (2005). Finally, we established strong ties with the start-up company NSim Technology which is licencing some parts of the MAGS Technology that we developed in the MAGS Project (Funded through Geoide’s Phase 2). NSim Technology is creating a new development framework for geo-simulations called SdkSim which greatly extends the capabilities that we developed in the MAGS platform. The agreement that we have with NSim Technology is that we will be able to use their framework as a software foundation to develop the MUSCAMAGS simulation environment. Representatives of the PROCESSUS Network, RDDC Valcartier, Ville de Québec, Ministère des transports du Québec and National Research Council of Canada have participated in our MUSCAMAGS workshop in Quebec city 8-9 December 2005.

We also kept ties with former MAGS Project’s partners such as the management of the Shopping Mall Place de la Cité in Quebec city (where we presented a demo in June
2005), which may lead to a renewal of the partnership next year, depending on the availability of funds to develop customer behavior simulations for them.

Here is our collaboration strategy with our partners. Our academic team (from Laval, McMaster, Queens and Wilfried Laurier universities) develops the core research of the MUSCAMAGS Project. We also intend to develop specific applications in cooperation with specific groups of partners which have common interests in the MUSCAMAGS Project. To this end, we will set up working groups made up of some of our partners on specific themes. For example, in the domain of crowd behavior and control, we intend to organize a group gathering teams from RDDC, Sûreté du Québec and Police de la Ville de Québec. In the domain of urban planning in relation to the simulation of travel behaviors and the characteristics of different sub-populations (such as senior citizens, students), we will gather a group of partners such as Ville de Quebec (service de l’aménagement du territoire), the PROCESSUS Network, Laval Univ.’s CRAD, McMaster Univ.’s Center for Spatial Analysis, Univ. of Toronto’s Joint Program in Transportation and the Time Use Research Program of St Mary’s University. The creation of some of these groups was decided at our MUSCAMAGS Workshop in December 2005. In 2006, we will organize specific meetings with each sub-group. The intensity of work with each particular group will depend on the funding available to support students and research professionals working in their specific areas. We hope that the partners involved in these working groups will have the means to support the research from which they will benefit most.


Our NCC strategy is based on different activities and means to build and maintain networking, communication and collaboration links between team members (researchers, students and research professionals), our partners as well as external groups (Geoide groups and other research groups).

Communication means: To support the sharing of information between team members and partners, we are building a MUSCAMAGS website. The website was shown to the participants of our December MUSCAMAGS workshop and some adaptations have been suggested, especially in order to offer specific web pages to each working group. The Web site will also be used to advertise the project on the web and make information about the project accessible worldwide. The web site will be adjusted and put on-line in January 2006. The web site will display lots of information on the project and related sub-projects. A private section will allow sharing of information, documents and data between team members. The information that our partners would require to be kept confidential will be gathered in private sub-sections (some being reserved to specific working groups).

1. Intra-project networking and collaboration

Workshops
In 2005 we held two MUSCAMAGS workshops: the kick-off workshop in February 2005, and a second workshop with team members and partners in December 2005.
We held a two days kick-off workshop on February 2005 at Laval University since S. Doherty had to leave the country in March for the next six months (Sabbatical leave). D. Thiblault, a representative of RDDC Valcartier attended the workshop. During this workshop the researchers and students presented their areas of interest with respect to the project goals. The main orientations of the project were presented and discussed. The last part of the workshop was devoted to the identification of the main themes that the researchers wanted to explore during the first two years and the involvement of researchers and students in these themes (See Section 5A).

We held a two day workshop on December 2005 at Laval University. The objective was to discuss the progress done during the first 8 months of the project and to involve some of our partners. 28 persons attended the workshop: 5 researchers (Harrap had another Geoide meeting at the same time and could not attend), 12 students, 2 research professionals, 1 advisor (Lee Gosselin), 10 representatives of our partners (RDDC Valcartier, Nsim Technology, Ministère des transports du Québec, CNRC, Ville de Québec). We had presentations by our researchers and advisor (Moulin, Thériault, Doherty, Scott, Lee Gosselin), our graduate students and research professionals (Chaker, Ali, Garneau, Haddad, Bouden, Rivest, Sahli) and our partners (Duval, Létourneau, Berger, Stemate). We had fruitful exchanges on the research, discussed the work to be done during the next year, discussed several potential projects and involvements with our partners. The MUSCAMAGS web site was presented and suggestions were made. We decided to set up specific working groups to focus the work of sub-groups of partners and researchers on specific themes of interest. Students have been involved in the organization of the workshop and greatly benefited from the interaction with our partners and researchers from other universities.

The sub-groups will be activated in January-February 2006. Meetings will be organized for the sub-groups during 2006 at the initiative of team members. For each subgroup, a researcher will be responsible for animating the activities. Each sub-group may coordinate the activities of related sub-projects. A page of the MUSCAMAGS Website will be assigned to each sub-group.

2. Inter-project networking and collaboration

Workshops

Several team members (Bédard, Harrap, Moulin, Scott, Thériault) and several of their students participated in GEOIDE General Meeting in Quebec city in June 2005. That was the occasion for networking with members of other Geoide projects, to meet representatives from the governmental and industrial sectors. This was also an occasion to have informal discussions between MUSCAMAGS team members and students. We had six posters presented by our students and W. Ali won a prize for his poster.

Networking and collaboration takes place between the MUSCAMAGS Project and two other Geoide Projects.

Harrap and Moulin are also team members of the GIST II GEOIDE Project, Intelligent Sensor Data/Knowledge Fusion for Geotechnical and Policy Decision Support (Leader:
Jean Hutchinson). In the GIST II Project Harrap works on spatial reasoning and ontology negotiation issues and explores with Moulin how a geosimulation approach can be used to simulate infrastructure failure events in areas of geotechnical risk and the impact on human populations and the built environment. Hence, progress in the MUSCAMAGS Project will directly benefit the GIST II Project and the GIST II Project provides a new area of application (and of potential problems to solve) to the MUSCAMAGS Project.

Bédard is also a team member of the Geoide Project The Development of M2G - A Mobile Multi-sensor Geomatics System for Inventory and Analysis of Highway and Road Network Features (Leader : Naser El Sheimy). An inter-project collaboration with MUSCAMAGS will start in January 2006 with PhD candidate Mamane-Sabo for a jointly-supported sub-project related to the combination of generalization algorithms and multiple representations of road network elements. The expected results of this 5 month sub-project should contribute to both GEOIDE projects.

3. Non-Geoide domestic and international collaborations

Several of our researchers are part of other non-Geoide groups and this facilitates networking and exchanges of expertise between our team and these groups.

- Thériault and Lee Gosselin are active researchers at CRAD, the Centre for Research in Regional Planning and Development (Laval Univ.) which groups over a hundred professors, graduate and undergraduate students, PDFs, and professionals working on projects in urban planning and regional and local development. W. Chaker is also a student member of CRAD.
- Doherty, Thériault and Lee Gosselin are active researchers in the PROCESSUS Network, which has been investigating for the last five years the Behavioural Foundations of Integrated Land-use and Transportation Models. The PROCESSUS Network is primarily funded by Canadian SHHRC (Major Collaborative Research Initiative), gathers researchers and students from 8 Canadian Universities, has collaborators from 11 academic institutions in Australia, France, Sweden, Switzerland, UK and the US. This team held two international Colloquiums (2002 and 2005) with the publication of two books presenting the main results of their projects. This productive team of researchers and students produced more than 400 papers and conference presentations over a 5 year period. The exchanges between the MUSCAMAGS team and the PROCESSUS Network is very fruitful. Our team benefits from the experience of PROCESSUS Network’s researchers, research results (models, pieces of software) as well as a wealth of data gathered during Panel surveys during the past 3 years and made available by the PROCESSUS teams in a usable digital format.
- Bedard leads the Canada NSERC Industrial Research Chair in Geospatial Databases for Decision. His research professionals and students provide an expertise which is very important to the MUSCAMAGS Project in the domain of geospatial data analysis, as well as advanced spatial OLAP technologies and know-how.
- At the end of December, Moulin established a link with P. Dubé, director of Laval Univ.’s LAMIC (Laboratoire de muséologie et d’ingénierie de la culture) who got a large
FCI grant to create an advanced research infrastructure in order to explore innovative techniques and approaches in museology. LAMIC representatives expressed a strong interest in the MAGS approach and tools and said that they may be used in the context of several projects at LAMIC. More specifically, MAGS models and techniques may be used to formalize (and simulate) the experience of a visitor in a virtual museum (represented by a rich and complex virtual environment). MUSCAMAGS techniques and tools would also be very useful to create populations of agents that would simulate different kinds of actors that can be found in exhibits. Another potential collaboration area is related to the creation of systems that will provide new experiences to visitors who will be able to interact with these virtual worlds and hence learn more about culture, artefacts and ways of life in the context of an enhanced reality. LAMIC’s team and Moulin will meet early January to set up the foundations of this promising collaboration.

At the international level, contacts have been established with other teams working in the domain of crowd simulation. During the First International V-CROWDS Workshop held in Lausanne (November 2005), Moulin established good contacts with the teams of D. Thalmann (EPFL, Switzerland), Soraia Musse (Brazil), Donikian (IRISA France), MAIA Institute (Monaco). The workshop was a good opportunity to present our work on a design method of multi-agent geo-simulations and to position our work relative to leading teams in the field.

Thanks to our researchers, advisors and partners, the team has access to a large community of international researchers in various domains: transportation, geography, GIS, artificial intelligence, data mining, etc.

2. A Participation of HQPs

The MUSCAMAGS Project benefits from the momentum gained in the MAGS Project and in the works carried out in the PROCESSUS Network. The MUSCAMAGS Project already gathers a large team of students (11 PhD students, 4 Masters, 2 Bachelors, 2 part-time PDFs) and research professionnals (1 full time, 2 part time).

Ali and Sahli, 2 PhD students supervised by Moulin will defend their thesis in January 2006 and certainly continue to work with the MUSCAMAGS team in 2006. Their work on the methodological aspects of MAGS, the use of SOLAP tools for the analysis of simulation results and the application of MAGS to support collaborative planning will be invaluable to pursue the research in the MUSCAMAGS Project. They will also greatly contribute to the animation of the student team at Laval. Mamane-Sabo, a PhD candidate under the supervision of Bédard (co-supervised by Moulin), brings to the team his expertise in cartographic generalization and the use of multiple representation. His work which started in the Phase II Geoide Project Gemure (Bédard: leader, Moulin: deputy leader) will contribute to the creation of VGEs. A. Ménard, geographer (PDF working at CRAD with Thériault) also participates in the investigations to enhance the creation of VGEs in collaboration with Chaker, PhD candidate.

Under Moulin’s supervision, Chaker (co-supervised by Thériault), Haddad, Garneau and Barkaoui are PhD students who carry out their research works directly in MUSCAMAGS’s core research themes. B. Boulekrouche and F. Boultache will start their
PhD studies respectively under Moulin’s and Bédard’s supervision. Their works will support key research areas (exploitation of geo-simulation results, spatial analysis) in the MUSCAMAGS Project. In the same way, under Scott’s supervision, PhD candidates H. Kang and D. Papinski (who did his MA under Doherty’s supervision, Doherty co-supervises his PhD) carry out research works on individual activity scheduling and the use of the space-time prism approach which complements the work done by Lachance-Bernard (MA student) and D. Biba (PDF working at CRAD with Thériault) on the use of models of multinomial logistics regression to simulate individual travel destination choices. S. He (MA student under Scott’s supervision and GEOIDE student network Coordinator) is estimating constrained destination choice models using data from Louisville, Kentuky. Such models will be implemented in our forecasting framework. H. Kang, a PhD student, will be focusing on household interactions for her research work, using Doherty’s CHASE data. All these models will be used by Chaker and Ménard to create an initial version of individual agent’s travel decisions and behaviors. In 2006 all these students will be involved in the working group dealing with the creation of a plausible and certified agent population for our ‘virtual Quebec city’.

Chaker works also on the creation of multi-scale informed VGEs. Harrap will closely follow his work and a new MSc student may join the team under Harrap’s supervision on this theme. S. Mclean, an undergraduate student working with R. Harrap at Queens Univ., visited our lab at Laval Univ. in May 2005. He worked with Moulin, Chaker and Ali to become acquainted with the MAGS Platform. He pursued his summer internship at Queens Univ.’s GIS Laboratory exploring different themes related to the work on urban semantics: spatio-temporal grammars and languages, surveys of practices in architecture, computer graphics and computer games toward the creation of a MUSCAMAGS ‘virtual world editor’. L. Cwik (Bachelor at Waterloo Univ. and working as a research assistant with Doherty) plays a key role in providing technical support related to the GPS data collection components of the project at Wilfrid Laurier Univ.

During Spring 2005 B. Bergeron (MSc in computer science at Laval and employed by the Canadian Forces at Valcartier) had several meetings with an expert at Sûreté du Québec in order to gather knowledge and expertise and to study techniques used by police forces, when monitoring crowds. The Forces granted him with two week days to carry out his research. Unfortunately, Bergeron’s assignment recently changed and he had to put his research on hold. Hopefully, he will be able to resume it in 2006.

Our research professionals also play a key role in the team. Bouden (Former Moulin’s MSc student who worked in the MAGS project on the use of particle systems to simulate the propagation of smoke and dense gaz) animates with Moulin and P. Gosselin (from INSPQ) a multi-disciplinary sub-team which works on the use of a MAGS approach to simulate the propagation of the West Nile Virus (WNV) in the southern part of Quebec. M-J Proulx and S. Rivest (working with Bédard) provide a strong support to MUSCAMAGS’ students on the issues related to SOLAP and spatial data analysis. C. Sheriff (working with Harrap) provides his expertise to the team on the development of simulation techniques to determine urban line of sight and sensory scaling in relation to a DND-funded project led by Harrap on urban semantics (generation of measures of intervisiblity, scale-of-sight, and exposure risk). Finally, the student team at Laval Univ. in charge of developing the MUSCAMAGS platform benefits from the technical support
of Perron and Hogan from NSim Technology. Moulin granted them access to his lab (and its resources) where they still work on the development of the SdkSim framework almost three days a week. This greatly facilitates the cross-fertilization of ideas between them and the MUSCAMAGS team. Haddad, Ali, Sahli, Chaker and Garneau will start as early as January 2006 to intensively use SdkSim for different applications and experimentations. This will provide NSim Technology with a group of people intensively using their software, and consequently they will be able to get feedback and enhance the product.

Students will be involved in the organization and operation of the working groups (animation, maintenance of web site, minutes of meetings, etc.) and will learn how to effectively manage such groups with people located in various institutions across the country. They also actively participated in the organization of the MUSCAMAGS workshops. They are also very much involved in the preparation of publications according to our publication plan (discussed by the team at the kick-off workshop). Thanks to the working groups, the students involved in sub-projects of interest to some of our partners will interact more intensively with the partners’ employees involved in the project. They will gain additional experience thanks to these exchanges. The networking that take places between our team, other related GEOIDE Projects and the PROCESSUS Network provides a unique occasion for exchanges between students of different disciplines and world-class researchers in geomatics, artificial intelligence and social sciences. Our objective is really to use this project to educate graduate students in a most favorable environment providing opportunities to collaborate with other team members, project advisors, involving state-of-the-art equipment and data, professional support, recognized international collaborators, major industrial and governmental partners, co-advising, etc.

3. A Leverage

In-kind support
As already mentioned, we benefit from the expertise of our different partners (Sûreté du Québec, RDDC Valcartier, Ministère des transports du Québec, Ville de Québec, NSIM technology, SOPFEU, ASRD).
NSim Technology provides us with their framework SdkSim and support to the MUSCAMAGS team when it will test and use the framework.
CRAD, PROCESSUS Network, Ministère des transports du Québec, Ville de Québec provide us with a wealth of data (and the related documentation): OD surveys and analyses, compiled results of panel surveys’ data, GIS data (Quebec-city maps, transportation network, maps at different scales, etc.).
We have not yet been able to precisely assess the monetary value of all these in-kind contributions, but, we estimate that they amount to several hundreds of thousands of dollars.
Cash support
Even if we did not received yet the money which was promised by some of our partners, we hope to get 35 000$ from the defense (RDDC Valcartier) in January 2006. We also count on a 10 000$ contribution from the Plan de géomatique du Québec (involvement of the Ministère des transports du Québec). INSPQ also contributed 30 000$ between April and December 2005, which enabled Bouden to work full-time on the WNV-MAGS Project.

Indirect support
Moulin helped NSim Technology to get contracts from RDDC Valcartier in 2005, especially on the above mentioned MAGS-COA Project (35 000$) and on a project that may start in January 2006 (around 50 000$) on the investigation of how machine learning algorithms (such as reinforcement learning and hybrid methods) and MAGS techniques can be used to exploit geospatial information and reasoning.

Future support
The working groups will be the occasion of launching new sub-projects with partners and we expect that this will provide the project with new contributions both in-kind and in cash.
NSim Technology actively seeks funds to support the development of their own products. A Precarn grant application is currently in the works. Moulin’s lab is one of the academic partners in this Research and Development program. This again shows the close association between NSim Technology and the MUSCAMAGS team.

3. B Knowledge Transfer

Knowledge transfer to the community will be done in several ways.

Publication of results
At our kick-off meeting we set up a publication plan, identified potential areas of publication for the team emphasizing joint publications, publications with students, participation in key international forums in relation to our multi-disciplinary research. For more details see Section 4. It is clear that our web-site will play a role in disseminating general information about our project worldwide. This may be an occasion to have contacts with teams and potential partners we are not aware of yet.

Knowledge transfer from and to our partners
As mentioned earlier, the team strongly benefits from the expertise of our different partners. This is an invaluable contribution to the project and an important input in the training of our students. In return, and as it was acknowledged by all participants in our December MUSCAMAGS workshop, our partners benefit from the results that our team produces, both in terms of fresh views of their specific domains, knowledge sharing on new technologies and approaches, as well as advances done in the core research that our team carries out. Through the working groups and specific sub-projects, our partners will receive deliverables of interest to them. In addition, they will be able to share experience and information with our team members and other collaborators.
Since the development of MUSCAMAGS will be realized in close collaboration with our partners (thanks to our working groups), the results will be readily available to them in the form of software components or demos that they will be able to use in their organizations. When these deliverables will be made available to them, we will decide how they will be disseminated in their user communities.

**HQP and partners**

It is clear that our students will have the opportunity to better know our partners. In return our partners may like to hire some of our students when they will have completed their degrees.

**Technology utilization**

Technology utilization in our project takes place in two directions. First, our partners provide us with data (ex. RDDC Valcartier, CRAD, MTQ, Ville de Québec, ASRD, SOPFEU, PROCESSUS Network) and licenses (ASRD, NSim Technology). Second, the concepts and prototypes that we will develop will take advantage of their data, of the technology they use and of their know-how, so that they will be able to immediately see the impact and applicability of their contributions and see applications created by the MUSCAMAGS team. The partners’ participation in the project orientations demonstrates a high interest into knowledge and technology transfer/utilization.

The results will be provided to our partners according to our project plan that we discussed at our December MUSCAMAGS Workshop and that will be regularly adjusted during the four years. Our workshops and ad hoc meetings with partners are also occasions to transfer research results.

**International workshop**

In 2006, as the MUSCAMAGS research gains speed, we will plan the preparation of an international workshop to be held in Canada with GEOIDE’s support, certainly in 2007. Several domains are worth considering such as: Crowd simulation, geosimulation and urban planning, multi-agent geosimulation and its applications in various domains (transportation, public security, etc.). Our partners at RDDC Valcartier and CNRC may be interested in participating in the organization of such an event. We intend to gather an international program committee and the results of this meeting will lead to the publication of a book.

**Disseminating results in larger communities**

The MUSCAMAGS results may be relevant to organizations dealing with disaster management and public security in Canada such as OCIPEP (Office of Critical Infrastructure Preparedness) and NRCAN (with respect to their new mandate of addressing socially relevant issues like earth hazards and related policies). This may be done in conjunction with the team which manages the GIST II Geoide Project. In due course we will establish contacts with these organizations and possibly develop sub-projects with them. Let us mention that NSim Technology currently targets the market of public security in relation to the organization of large public events.
MADDSs (multi-actor dynamic spatial situations) are not a “commercial issue” yet. However, given the current worldwide emphasis on security issues, we anticipate that in the coming years, commercialization opportunities will arise in this domain for geo-simulation systems. We will be ready to make alliances with companies to commercialize our technology, giving priority to NSim Technology. Our team already has a large experience of working with governmental and industrial partners, including several of the present partners, and is used to facilitating knowledge transfer and technology utilization. In the case of technology transfer, some of our team members also have good experience with administrative and legal issues (Bédard with the Jmap software and Moulin with the MAGS technology transfer to NSim Technology). If new results are of interest to certain partners, we will follow the path we already know: disclosure, negotiation of licences with university authorities and commercial partners. We know that this may be a lengthy process and some tricky issues may arise. In order to avoid future problems as much as possible, we work on a highly modularized research so that it will be easy to identify the inventors of the disclosed inventions.

Doherty’s person-based GPS data collection system and processing algorithm is being commercialized with the assistance of the University of Toronto Innovation Foundation - a leader in the field of technology commercialization, staffed by over 20 professionals with a wide variety of technology and business experience. Continued improvement and application of this system as part of the MUSCAMAGS project will support these efforts.

4. A Quality of the research results

Publications
In 2005 our team had several publications: 2 in journals and 14 in conference proceedings and book chapters. We certainly benefit from our previous works on multi-agent geo-simulation, SOLAP and spatial analysis, spatio-temporal modeling, modeling of transportation and urban processes and individual activity scheduling. More publications are in the works, some being directed to journals (to be submitted during the first quarter of 2006). This production shows that the MUSCAMAGS team builds on strong fundations: models and results that are already being accepted at the international level.

We emphasize a strong implication of our students in the preparation of publications and the presentation of our results in international conferences. This strengthens their apprenticeship of research and knowledge dissemination in international forums.

New collaborators
Several of our new collaborators (J. Berger, M. Bélanger, L. Stemate) are defence scientists at RDDC Valcartier. They are willing to actively participate in the project in different ways: offering their expertise, participating in the preparation of publications, co-supervising students, financing specific aspects of the project.

S. Létourneau at CNRC is a very productive researcher. We are establishing a convention between Laval Univ. and CNRC that will enable CNRC to fund students to carry out
research works on subjects of interest for both CNRC and the MUSCAMAGS team. The expertise of S. Létourneau in data mining and machine learning will strongly benefit our students. At our December Workshop, we set up initial plans with Létourneau, Ali and Chaker to use more advanced techniques to further analyse their data and simulation results (Customer behavior application and Quebec population generation from the OD survey). This may rapidly lead to publishable results.

After our recent meetings with P. Dubé and LAMIC’s team (Laboratoire de muséologie et d’ingénierie de la culture), we are optimistic that new collaborators may join our team in the year to come.

5. A Project Management

Our management strategy relies on the exceptional past experience of the team members. Bédard and Moulin have been directors of the Centre for Research in Geomatics (CRG) and Thériault is still the director of CRAD. Lee-Gosselin has managed very large projects, among which is the PROCESSUS Network. Bédard, Harrap and Scott have managed Phase II Geoide projects. Moulin has been deputy leader of several Phase 1 and Phase 2 Geoide Projects. All team members have participated in several Geoide projects. Scott acts has deputy leader in the MUSCAMAGS Project and Moulin works in close contact with him to steer the course of the project.

The project has a well defined management plan, in which each project objective is associated with a main task. Each task is supervised by at least one of the team’s researchers. The plan is constantly coordinated, monitored and adjusted. Students will learn precious skills by participating in this planning exercise, especially by their involvement in working groups and the maintenance of parts of the web-site. For each sub-project involving one or several partners, the plans will be discussed with the partners who will get regular progress reports and be able to influence the project orientations. We did that already in 2005 in the context of two sub-projects: WNV-MAGS Project with INSPQ (P. Gosselin) and the COA-MAGS project with RDDC Valcartier (M. Bélanger).

The private section of the project web site will be used to coordinate project management activities. Hence, everybody in the team will know about the activities taking place in the other sub-teams. This will facilitate transmission of information, knowledge sharing and decision making. A special section of the web site will be devoted to networking activities (links with our partners, with other related GEOIDE projects, with the PROCESSUS Network, with relevant portals, Forums, etc.).

The last part of our two-day kick-off workshop held in February 2005 at Laval Univ. was devoted to the identification of the main themes that the researchers wanted to explore during the first two years and the involvement of researchers and students in these themes. Here is a list of these themes and the researchers who are responsible for them:

- Theoretical model of Multi-Scale Agent-Based Geo-Simulations (Moulin, Harrap)
- Create plausible and significant agent populations (Scott, Thériault, Doherty)
- Manage agent population persistency (Moulin)
- Create Multi-Scale Informed Virtual Environments (Moulin, Harrap)
- Develop the Multi-Scale MAGS Platform (Moulin)
- Develop a behavior and scenario specification system (Moulin, Harrap)
- Develop method and tools to exploit simulation results (Moulin, Béard)
- Develop a method to create MUSCAMAGS Simulations (Moulin and all team members)
- Develop various experiments and systems of interest to our partners (see MUSCAMAGS’ application areas) (all team members)

We looked at the plan during our MUSCAMAGS December workshop and it appeared that it did not need adjustments. All scheduled activities were carried out according to the plan. It is clear that adjustments will be done when needed by the researchers. We need also to mention that the creation of working groups early in 2006 will involve setting up specific plans in collaboration with the involved partners. For each new sub-project plan, we will have specific deliverables and milestones as we already have with the WNV-MAGS and MAGS-COA Projects.

We think that we have set up an efficient project management plan, adapted to the context of our multi-disciplinary team and our diverse partners. We are aware of the flexibility that will be required to manage this diversity of projects and sub-projects. We think that we have already demonstrated that the MUSCAMAGS Project works as a mini-network as a typical GEOIDE project, based on diverse networking activities and taking advantage of rich interactions between researchers, HQPs and partners. Our management approach also favors the set-up of sub-projects with partners. The researcher who is instrumental in setting up a sub-project, manages it and his team directly benefits from the partners contributions. This approach provides an incentive for researchers to start interesting sub-projects. This approach also insures that the partners interact directly with the MUSCAMAGS researcher with whom they set up the sub-project and who is responsible for delivering the results expected by them.