the same sites as the black rat and their ecological niches identified. Mosquitoes sandflies and ticks will be killed in cold, identified on the basis of morphological characters and then counted. Sets of female will be formed and stored in liquid nitrogen. We will assess the degree of contact between potential vectors of arboviruses and rodents. Amplification methods random genome sequencing of pathogens followed by conventional or high speed will be used in mosquitoes, sand flies and humans (see below).
3) Assess the exposure of humans to arboviruses associated with the black rat: The human samples will be chosen after the first year of studies in rodents. At each site, there will be a random sampling of the human population (aged over 2 years) and for all individuals selected and giving their consent a blood vein sample will be taken. The serum will be used to search for markers of infection with the viruses mentioned above. The study of habitats and lifestyles based on the characteristics of families will be conducted through questionnaires and will allow identifying the social processes generating different frameworks and ways of live. This typology will then allow putting into perspective informations coming from serology, rodentology and social behavior, in order to understand transmission of diseases.

- *Deliverables*
- Identification of arboviruses associated with the black rat
- Identification of arthropod vectors of arboviruses associated with the black rat
- Identification of risk factors for exposure and contamination to humans

- *Partners' contributions*

The laboratory of entomology (IPD) will be responsible (coord: Y. Ba and M. Diallo) for the collect and identification of vectors and also identification of blood meal in vectors. The virology laboratory (IPD) will perform all diagnostic tests (virus isolation and RT-PCR) on arthropods (mosquitoes, sandflies, ticks), human sera and rodent (Coord: O. Faye and A.Sall). P. Handschumacher and Y. Sy will be responsible for household surveys conducted by a post-doctoral student and a local investigator. J. Gaudart will perform multilevel statistical analysis.

- *Risk analysis.*

Blood sampling in the villages may be subject to refusal by a part of the population. Consciousness raising through meetings and individual information, presenting the project objectives can in the vast majority of situations drastically reduce that risk. Moreover, in case of a collective denial and as for the previous task, the villages are sufficiently numerous in this area, to allow the selection of another community.

Task 6: Interdisciplinary joint production of indicators and scenarios of the black rat dissemination and its associated human health risk

- *objectives and possible indicators of success*

This task aims at providing a measure of the relative importance of the various factors evidenced in the preceding tasks with respect to *(i)* vulnerability of spaces to diffusion/propagation of the black rat and *(ii)* vulnerability of societies to pathogens transmission to man.

This task will produce on one hand indicators characterizing the exposure of the areas concerned and on the other hand management schemes and possible scenarios of change of the Mali-Senegal spaces. Success indicators will consist in the effective production of deliverable of this task.

- *coordinator and partners involved*

This task will be coordinated by J. Gaudart (UMR 912 SE4S) assisted by P. Handschumacher of UMR 912 SE4S and J. Le Fur from CBGP. All participants within the project will be involved in the realization.

- *Detailed program*

Determinants of the rodents' spatial dynamics that will be evidenced at various spatial and temporal scales during the preceding phases will be joined according to their contribution to the diffusion/propagation phenomenon.
We will build several formalizations of the spaces studied and will study the fluctuation of the environment and flow parameters on the short and long time.

1. We will first propose an estimation of the distribution of black rat in Mali and Senegal. This will be achieved by using on the one hand the statistical data coverage of the flow of people and goods, demographics and the changing of the urban system and on the other hand the parameterization of landscape variability.
2. within areas colonized by black rats at the front of colonization of the rodent, a similar approach will be adopted at a local and micro levels to identify the risk determinants of anthropozoonosis transmission to man.
3. Within the same spaces, we will evolve a typology of human communities following the vulnerability indicators formerly developed.
4. A control survey will permit to validate the adequacy between the vulnerability indicators at the levels proposed and the practical movement of medical indicators in the various human populations concerned.

We will be able then to develop and study various prospective scenarios of the evolution of the black rat distribution and the risk of Anthropozoonoses transmission. We propose in this respect to build on the potential of simulation tools to develop an integrated picture of the knowledge acquired in the project as a concrete mean to implement the project results as part of a decision process. This modelling module includes:

5. The development of a simulation platform to test the role and the hierarchy of factors and processes identified by each of the tasks dedicated to the analysis process. The completion of this module will consist of a preparatory phase of consultation followed by the coding of the simulator including data management, coding of the entities involved (human societies, rodents, communication channels, business units...), their support (cities, habitats, barriers, boundaries, sources, sinks...) and their population dynamics (*e.g.*, dispersal, growth) and finally the management of outputs / models: maps, graphics, storage.

6. The multi-scale exploration, by means of simulation and sensitivity analysis, of the joint dynamics of populations of reservoir rats in their anthropogenic environment; the comparative evaluation of the weight of the processes occurring at different scales.

- *deliverables*

We will first obtain a set of indicators at the scale of the unit cell of transmission that will characterize:

- the areas colonized given the epidemiologic risk,
- the vulnerability of human communities at risk of anthropozoonoses,
- the dissemination / propagation of the black rat across the space between Senegal and Mali.

The synergy between the task will permit to make maps available for :

- the regional diffusion/propagation given several scenarios,
- local exposure to the risk of contamination by anthropozoonoses.

Regarding the modelling section, we will construct scenarios of plausible futures that will prioritize the role of variability attributable to key factors identified in other tasks (*e.g.*, anthropization dynamics of the environment, structure of the communication channels, dynamics of rodent populations, long-term and short-term levels). Indicators of health risk and spread of rats will be used to characterize the simulation outputs. In terms of decision support, we will conduct such testing on various scenarios (introduction-growth-invasion) and make inferences about key parameters to change the implementation of these scenarios.

- *Partner contributions*

- The statistics section will be mainly managed by J. Gaudart who will ensure both the relative importance of determinants in the diffusion/spread/contamination system and the construction of indicators in association with P. Handschumacher.
- Application scenarios and prospective will be implemented by J. Le Fur with the collaboration of J. Lombard, O. Ninot and F. Dumont for the spread of black rat; with the collaboration of J.M. Duplantier, M. Diallo and O. Faye for the circulation risk for anthropozoonoses
- The modelling work will be conducted by a team composed of J. Le Fur and students who will follow one another in computer and modelling science.
- The indicators field validation will be realized by J.M. Duplantier and its team for the rodent study part and M. Diallo, O. Faye and their team for the anthropozoonose part.

- *Methods description and technical choices*

Uni- and multivariate statistical methods will be used to study the relative weight of factors involved in the spread of black rat at different time and space scales. Research of spatio-temporal aggregates will permit to identify geographical areas of particular interest. The systemic approach that will support this stage of research will focus on multivariate statistical methods. It will enable the development of the typology at the different scales considered in the project. The relative weight of the factors and the risk indicator construction will involve the usual statistical techniques (data analysis or regression models)

GIS oriented tools concerning multicriteria investigation and selection will permit the identification of vulnerable areas given the environmental changes planned (Sambangalou dam) and the various scenarios developed.
Modelling will be of the computer-based type, using an individual based scheme. For each task, a heterogeneous space will be formalized that will permit to simulate the various environment types and, dynamically, the changes of key indicators (population, resources, communication networks ...). Within the simulated spaces, rodent and human agent will be formalized with mechanisms for environment perception, interaction and action with the environment (movement, contact, feeding, reproduction …). Model development will build on existing computer environment (Repast simphony) that will overcome several technical problems associated with managing and coordinating a multi-agent simulator type.

- *Risks and solutions*

Task 6 summarizes the rationale of the project. The statistical methods are tried and tested techniques. This task poses a risk in relation to the validity of the indicators and the confrontation between the forecast and the field. However, going back onto the field during this phase will permit, if the fit between indicators and reality proves unfit to produce information to calibrate the forecast more efficiently.
A key lock of the spatial analysis is the multi-scale approach and the corresponding faults and alignments. These are problems due to a "format shifting" (COSP - Change of support problem). This occurs when the variables to explain and the explanatory variables are observed using different "support", *i.e.* different observation tools (case records, demographic data from censuses, environmental variables from satellite imagery ...). COSP has two consequences: the change of spatial scales (multiscale problem) that we will take into account using the SAR, CAR, frequentist or Bayesian models, and the inference from observations made on different spatial units (*e.g.*, postcodes, houses, departments…), also known as misalignment which will be addressed by covariates kriging or interpolation by bidimensional splines. Methodological developments will be needed if problems are raised concerning errors in the integration of prediction methods of interpolation in the estimation of disease risk
Concerning the simulator development section, the individual based model is also a widespread approach with well managed technical tools. Nevertheless, occurrence of technical problems during construction of the various modules of the simulator should be considered. It is usually possible to overcome or circumvent them, but at the cost of a time overhead. Preliminary work to set up technically the simulation platform has been realized before the beginning of project to identify bottlenecks.