SUMMARY

This report describes the development of the first version of a running system dynamics model aimed at supporting prospective studies for long-term environmental planning in Flanders such as the MIRA Environmental Exploration. The environmental projections and policy studies depend on the available data and forecasts which are used for the individual domains (energy, water, air quality, transport …), thereby hampering the cross-disciplinary integration. Long-term environmental planning should among other things take into consideration the uncertain development of the availability of labor forces, material supplies, energy, the accessibility of industry zones or fragmentation of open land scape. The interaction of processes related to different domains is of key importance for the time-dependent behavior of the "System Flanders" and hence the effectiveness of different policy options. Narrative storylines are increasingly used to complete prospective studies and define different world views, and to account for the geo-political, technological, social and other uncertainties in the environment. Quantification of the underlying mental models by means of system dynamics modelling enables a comparison of these world views for policy-relevant results in an explicit and more systematic manner.

System Dynamics (SD) models, or system models, provide a natural framework for describing and analyzing the time-dependent development of complex systems at the outline level of analysis. System Dynamics Modelling originates in the World Model, which was developed for the Club of Rome by the late '60s (Forrester, 1971). A system dynamics model describes the feedback mechanisms between the state variables which determine the dynamic behavior of a system. In this type of model the emphasis lies with a sufficiently complete representation of the system and feedback mechanisms rather than details used to describe the subsectors. This makes it possible to analyze different combinations of environmental and policy scenarios in a coherent manner, and to determine the mid- and long-term impacts of the different alternatives. Therefore, system dynamics models are very useful for supporting long-term prospective studies and policy analyses. A high degree of consistency, flexibility, transparency and computational speed are typical characteristics. System dynamics modelling therefore plays a central role in the 4-step approach aimed at supporting Flemish environmental policy making (Op 't Eyndt, 2012):

1. A qualitative systems analysis to identify the relevant themes, problems, causes and actors etc., relate these to one another at the main level of analysis, and formulate story lines for the different world views.
2. Quantitative system dynamics modelling to process these story lines in an integrated and consistent manner at the main level of analysis.
3. Thematic deepening by modelling the key components of the system dynamics model resulting from step 2 in case these require a more detailed description.
4. Verification of existing and planned policy options for the given objectives by means of the models resulting from steps 2 and 3.

A "blueprint" of a system model for long-term environmental policy in Flanders was developed as a start towards a fully operational version of a systems dynamics model. The model takes into consideration the feedback mechanisms between the state variables for 10 themes (Demography, Economics, Mobility, Energy, Landuse, Agriculture and Food, Water, Air Quality, Nature and Environment, and Waste and Material Use). The model can be run independently to simulate the development of the "System Flanders" for the years 2010 to 2050. The model architecture is based on reusable, generic model building components, which have been implemented in the ExtendSim® software platform. The model can be used to analyze the dynamic development of a large number of policy indicators under different conditions (climate change, energy prices, immigration, economic development …). The external driving of the system depends on demographic, economic, climatological and other exogenous variables, which can affect the system in multiple ways. The temporal evolution of these factors can be set in different ways, to meet the qualitative story lines of environmental projections and future studies such as Megatrends, Welfare and Prosperity, and the MIRA environmental explorations for Flanders. This makes the model useful for multi-actor and interactive applications related to systems thinking and scenario analyses by and with domain and environmental experts. The potential for thematic deepening in view of the application in the 4-step approach has been demonstrated for the spatial-dynamic land use model RuimteModel Flanders.

The system model which is now available provides an analytical framework for analyzing problems across the thematic boundaries. The potential for comparing the dynamics of the system for different world views, open architecture of the model, and flexibility for adaptations simplify such thinking exercises considerably and are strong selling points of the model. In general an iterative procedure is followed for the design of system models such as this blueprint, with stepwise adaptations in order to ensure the results and functionalities meet the requirements and expectations of the clients and potential users as well as possible. A participatory approach has been followed for the development of the model, in which the selection of key variables and causal relationships between these variables, as well as propositions for the quantification of these relationships were presented to a large number of domain-, environmental and MIRA-team experts. The model which has been developed with the available resources and time is a “blue print”. Although the basic principles of system dynamics modelling and thematic priorities and preferences of potential users of the model have been taken into account, the model cannot directly be deployed for supporting long-term environmental policy-making. Anticipating operational use of the model, a follow-up project should first focus on a critical evaluation of the model assumptions and results and, if necessary, adaptation or refinement of the mathematical formulations used for the subsystems with the experts that were involved in the project. The next step would be to select thematic models to test the exchange of data with the systems dynamics model more profoundly. This would benefit the support for and application of systems dynamics models in model-based environmental projective studies as envisaged in the 4-step approach.