Carnegie Mellon

# MUSES Heavy Metal Flows

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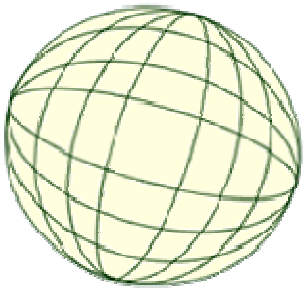

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## Background

The Green Design Institute received a grant from the National Science Foundation as part of the Materials Use: Science, Engineering, and Society (MUSES) program to develop models to track heavy metal flows (i.e. cadmium, chromium, lead, mercury and nickel) through the U.S. economy and environment. We use the models to identify scenarios involving both new technologies and management strategies that lead to long-term sustainable economic activity and material use.

## The Models: MUIO and IPCRM

We have developed two models under this grant: a mixed-unit input-output (MUIO) model and an industry production to county risk model (IPCRM).

The MUIO model combines material flow analysis and input-output modeling in order to better track economic transactions and material flows associated with changes in production throughout the economy. We augment a 13 by 13 economic input-output direct requirements matrix developed by the U.S. Bureau of Economic Analysis with material flow data from the U.S. Geological Survey and emissions data from the U.S. Environmental Protection Agency (EPA) to formulate the model. The resulting model provides the capabilities of both material flow and input-output models, with detailed material tracking through entire supply chains in response to any monetary or material demand.

The IPCRM combines industrial process modeling and health risk assessment in order to track the major industrial sources of toxic air pollutant emissions and assess associated health risks at a county level for the U.S. The model allows sector outputs to be adjusted to evaluate the impact on county health risks. We use EPA's AERMOD dispersion model and our own exposure and risk model to estimate the fate and transport and associated risk resulting from emissions reported by the EPA. We use industry output data from the U.S. Census Bureau to estimate how changes in economic activity will affect emissions. By estimating localized risks our model can be used to avoid policy responses that lower overall average risk but create isolated hot spots of high risks. Additionally, IPCRM can inform life cycle analysis of industrial processes and products to go beyond crude assumptions about the effects of emissions discharges.

## Specific Projects

We are using the MUIO model in two projects. One is to investigate the development, uncertainty and application of the model itself for cadmium and nickel. The other is to investigate the fate, transport and impacts of lead use in U.S. product manufacturing. We are using the IPCRM to model the fate of hexavalent chromium air emissions and evaluate potential risk reduction in response to several policy scenarios. We intend to use the IPCRM for modeling several heavy metals or pollutants at the same time in order to better evaluate the trade-offs of policy choices.

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