**Master internship (6 months)**

# Implementation of an integrated model in a multidisciplinary optimization framework: application to aviation and climate change

**Keywords:** System Dynamics, Multidisciplinary Optimization, World3, aviation

Europe faces a formidable challenge in reducing both energy consumption and greenhouse gas emissions, especially for air transportation. The improvement of energy efficiency combined with the development of new energy carriers (such as biofuels and electro-fuels) raises new questions for the sector that require the development of innovative approaches to draw possible future trajectories for the aviation sector. With the help of computational techniques, Environment-Economy models started to flourish in the early 1970s with Forrester's World Dynamics [1]. The model was then improved into the well-known "World3" model developed by the MIT (USA), highlighted in "The Limits to Growth" [2], a reference study that ignited the debate of an ever-growing material footprint in a finite world.

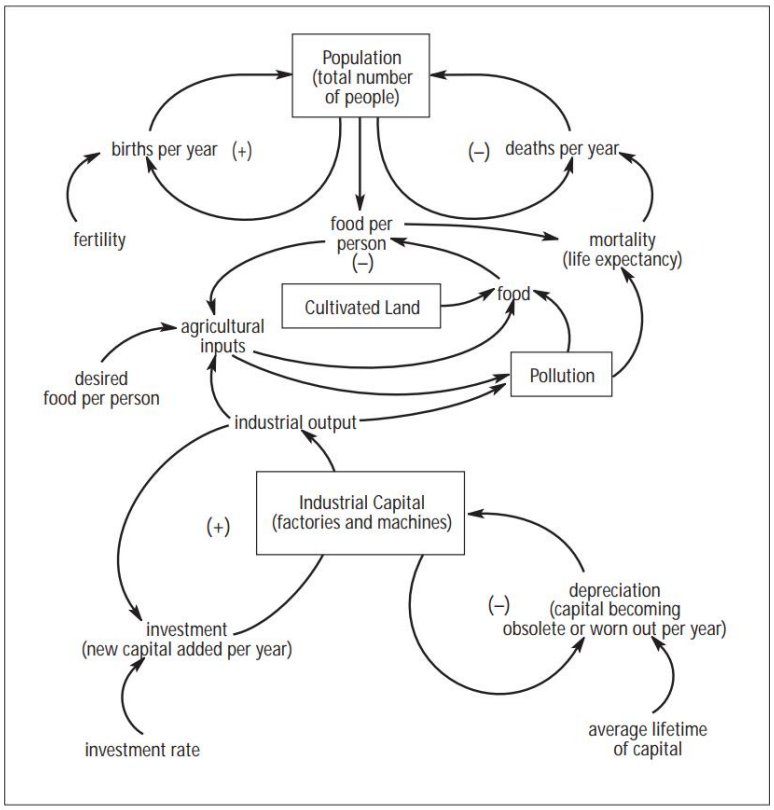


Fig. 1 Overview of an integrated multidisciplinary integrated model ("World3" model)

The interest for such an Environment-Economy models has also risen in recent years, due to their overall ability to understand the coupled and feedback phenomena that rule the physical, social and economic world and improve long-run decision-making, despite their stakeholder biases. Some application for those models can include: forecasting impacts of changing carbon-tax policies, estimate cost-optimal trajectories for mitigation targets, assess hypothesis for macro-economic systemic change and impact on transportation systems. The aviation sector is one example of an application case: several different architectures may be employed (batteries,

biofuels, hydrogen, hybrids), each with their own systemic challenges (modification of the top-level aircraft requirements, land use increase, fuel production & transport, clean electricity production) that must be properly considered when estimating cost and emissions reduction for each choice. For example, to tackle with such issues, WITNESS is an optimization-based model of the energy-economy-environment-society system that divides the total investment for each available technology to achieve mitigation targets with cost-optimal trajectories. Source: https://os-climate.org/transition-analysis/

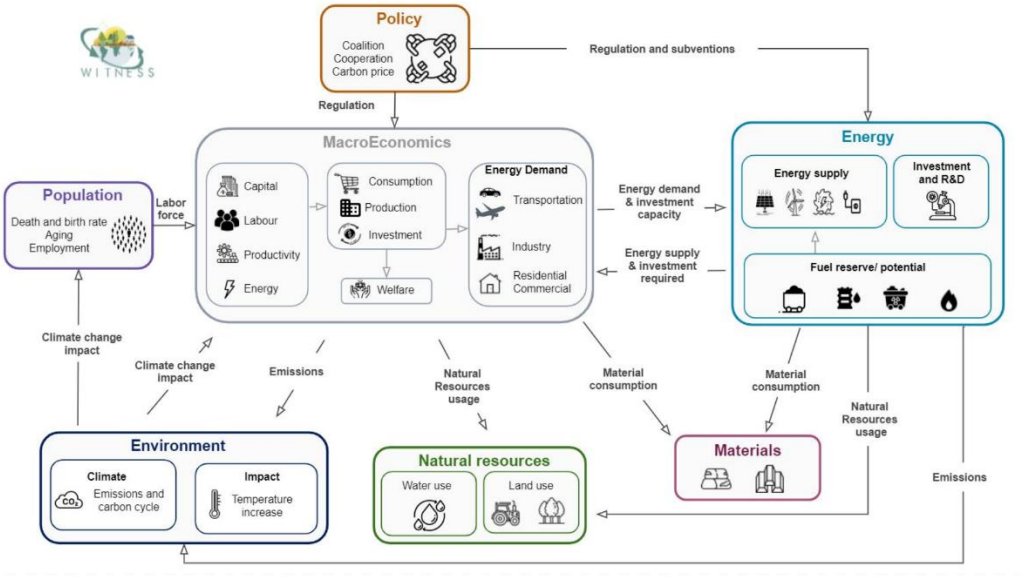


Fig. 2 Overview of the multidisciplinary WITNESS model

This internship focuses on implementing the World3 model in a multidisciplinary optimization framework (GEMSEO [3]) developed by IRT Saint Exupéry, and exploring the synergies between the System Dynamics and MDO methodologies. The objectives of the internship are:

- Implement the World3-based model within the GEMSEO framework
- Improve the numerical methods to handle parameter interpolation based on modern tools for surrogate modeling
- Formulation of optimization-based forecasts, considering various hypothesis for the perception delay and forecasting capacities of the "planner"

Candidate: engineer school and/or Master with a background on engineering sciences and/or multidisciplinary optimization. Good skills in Numerical methods related to system dynamics and Python programing language are mandatory. The trainee will be jointly supervised by ISAE-Supaero and IRT Saint Exupéry, so a good capability to work in a multidisciplinary environment will be necessary. She (he) will have in charge the valorisation of her (his) work through reports, scientific papers and/or oral presentations.

Duration: 6 months (start scheduled in April or June 2023)

Location: IRT Saint Exupéry (Toulouse, France) and ISAE-Supaero (Toulouse, France)

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[2] D. Meadows, et al. The limits to growth: A report for the club of rome's project on the predicament of mankind. 1972.
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