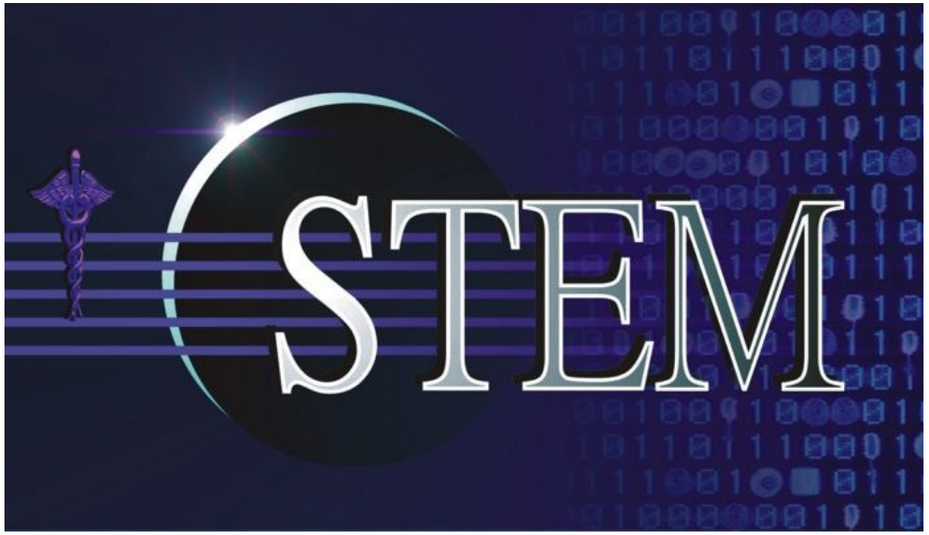
15 JAHRE
Wissenschaft im Dienst des Menschen

BfR
Bundesinstitut für Risikobewertung

BUNDESINSTITUT FÜR RISIKOBEWERTUNG

STEM - Spatiotemporal Epidemiological Modeler:

A Framework for Epidemiological Modelling



Matthias Filter

Starting point at BfR 2010 – Evaluation of available software

Method:

Assessed on the basis of a weighted scoring scheme based on functional requirements

Results:

Functional requirements	Weight	STEM	Epi Grass	JAMS	MATLAB	APSIM	Net logo
Simulation environment integrated	Mandatory	+	+	+	+	+	+
Visualization of simulation results using geographical data	Mandatory	+	+	+	+	-	+
Export / Import functionality for input data and simulation results	Mandatory	+	+	+	+	+	+
Predictive microbiology functionality	20%	-	-	-	-	-	-
Integrated epidemiological models to simulate disease transmission within populations	20%	+	+	-	+-	-	-
Low cost	20%	+	+	+	-	+	+
Customizations possible	20%	+	-	-	-	-	-
Modular extendable software architecture	20%	+	+	+	+	+	+

STEM: Fact sheet STEM

- Open source project, platform independent
- written in Java™; using the Eclipse framework (www.eclipse.org)
- Since April 2009 approved as a top-level Eclipse Technology Project
- Initiated and mainly driven by IBM Research, several universities involved
- http://www.eclipse.org/stem/

STEM (Spatiotemporal Epidemiological Modeler)

Functionalities:

- Graphical User Interface for

  construction and editing of simulation models

  analyzing simulation results

  in-time visualization of simulations

  parameter estimation from real-world epidemiological data

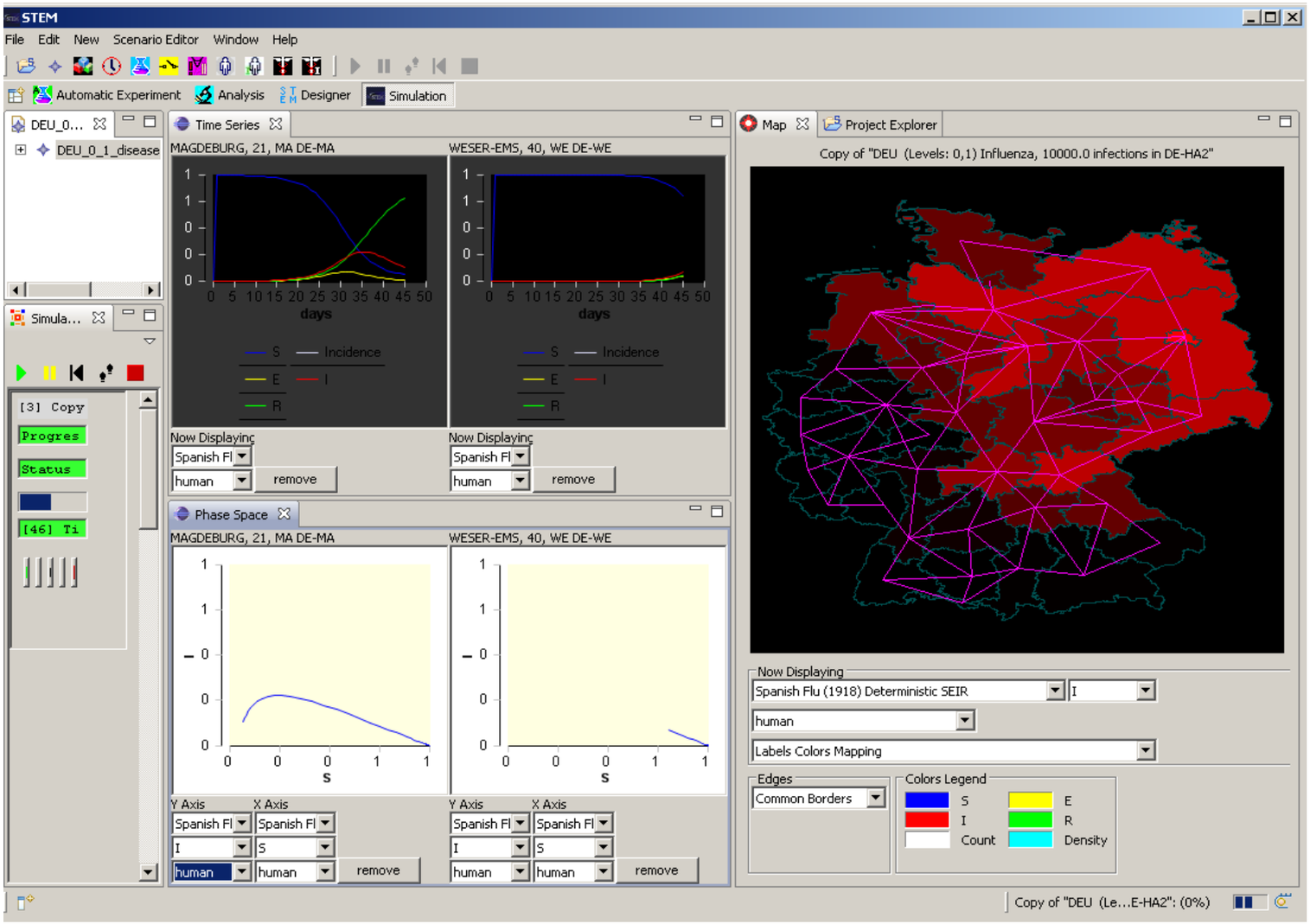
- Engine for deterministic and stochastic simulations including prebuilt compartment models (e.g. SIR, SEIR etc.)
- Data sets on geography, human population, human air transportation

Additional benefits:

- Open source community that share software technologies and data
- Modularity of simulation models guaranties re-usability of components
- EU GIS data available via EuroGeographics

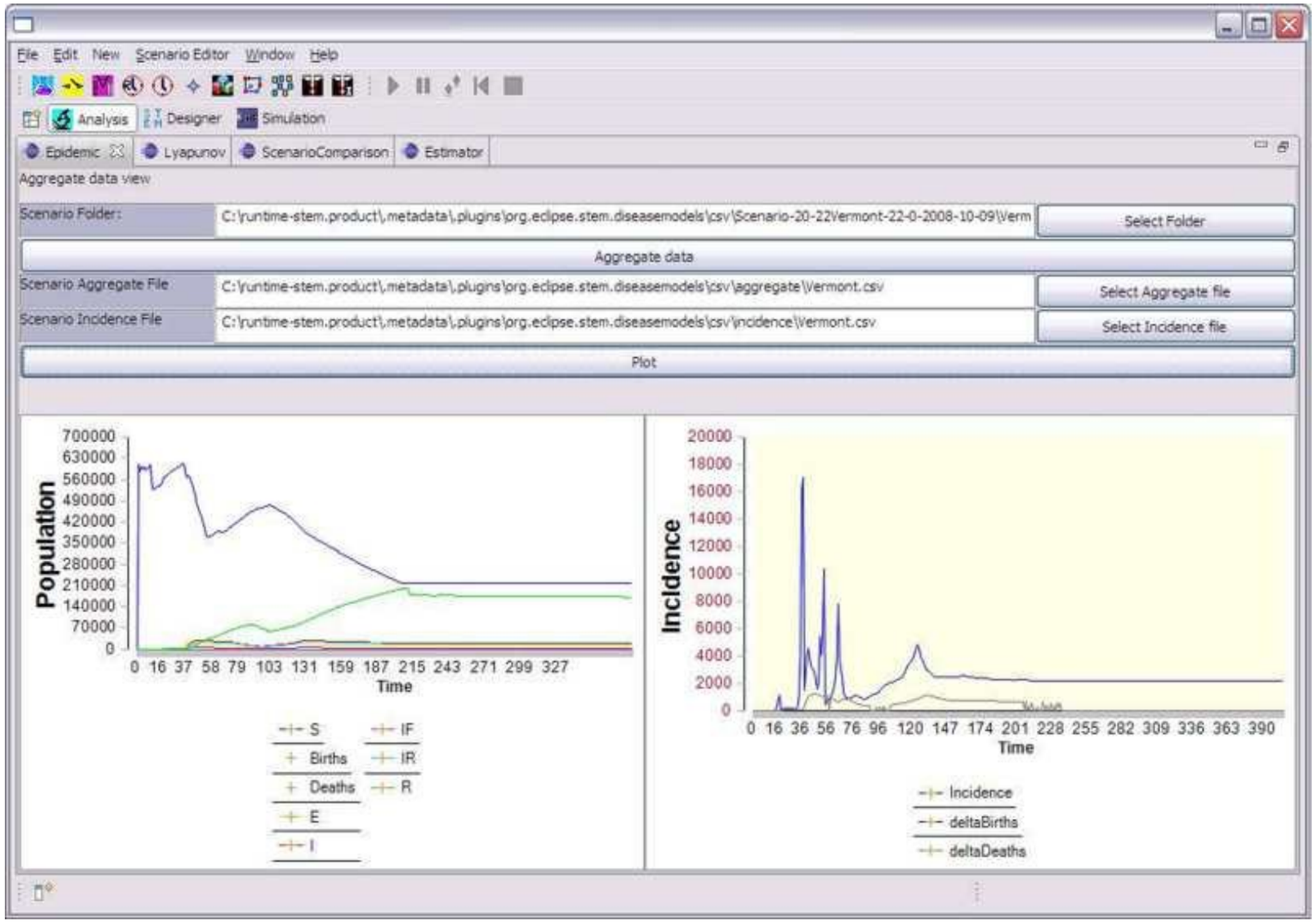
STEM (Spatio-Temporal Epidemiological Modeler)

GUI for simulation, visualization and analysis



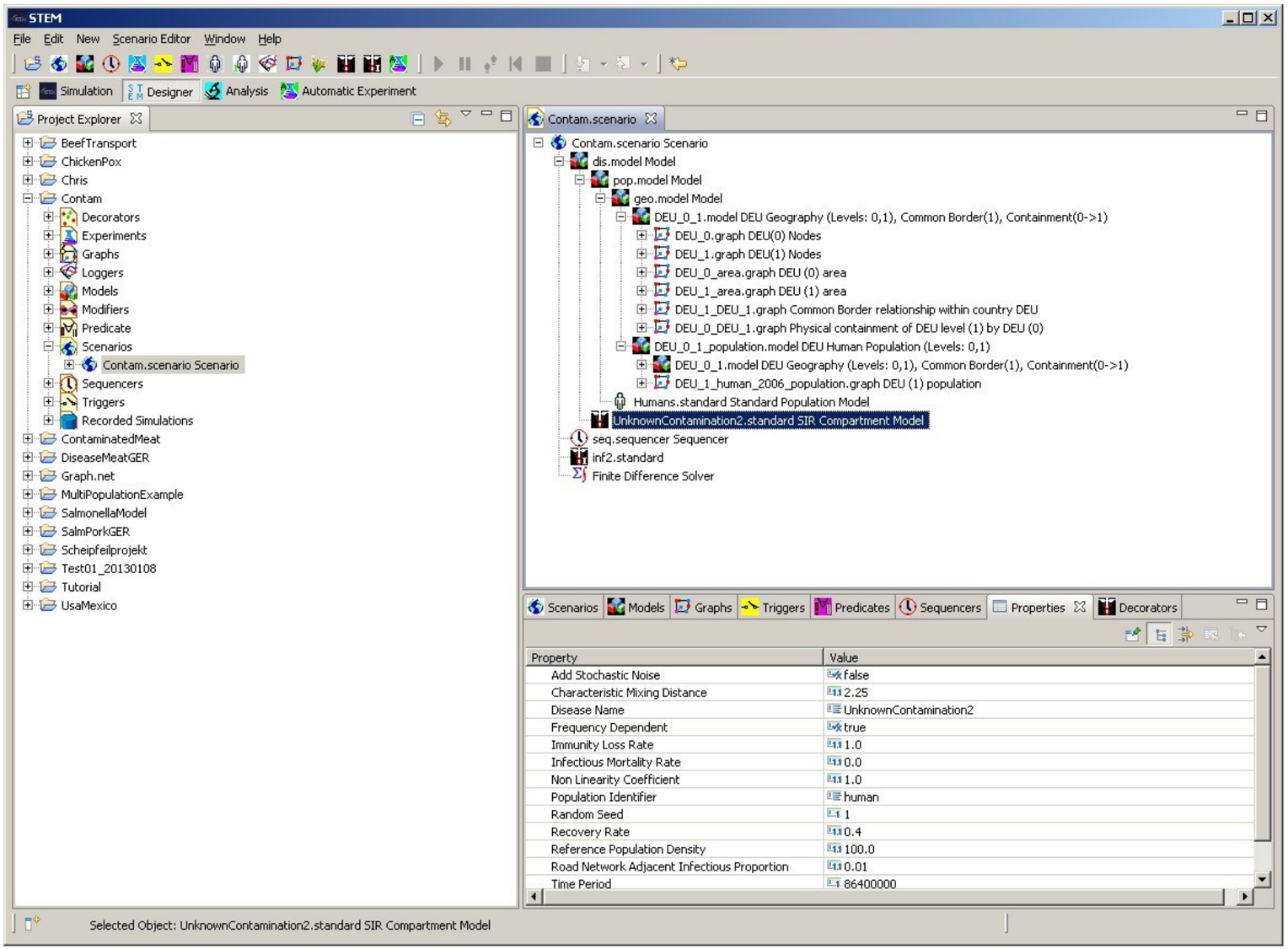
STEM (Spatio-Temporal Epidemiological Modeler)

GUI and algorithms for parameter estimation



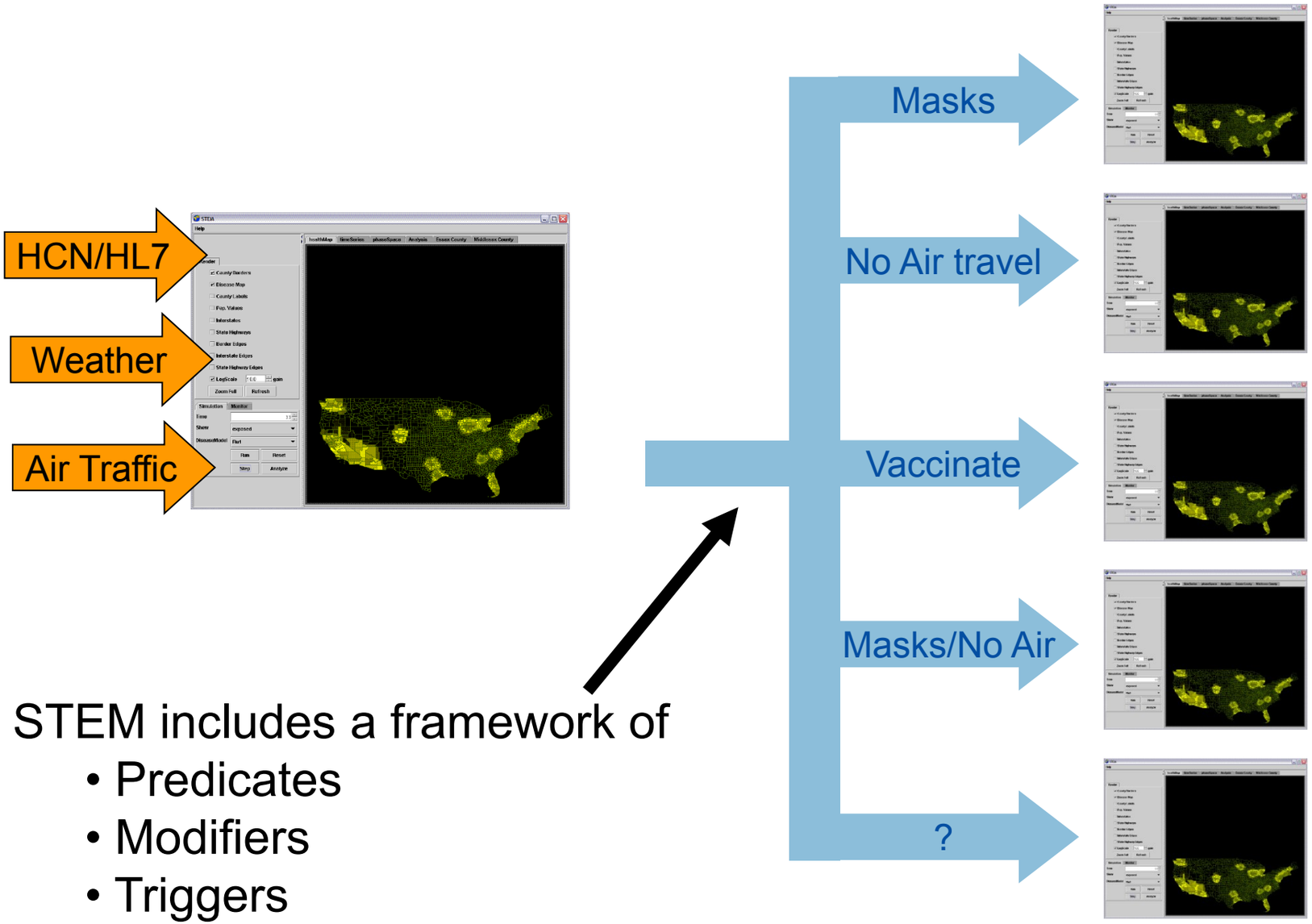
STEM (Spatio-Temporal Epidemiological Modeler)

GUI for scenario and model generation



STEM (Spatio-Temporal Epidemiological Modeler)

GUI for Simulation & Comparison of Interventions



STEM includes a framework of

- Predicates
- Modifiers
- Triggers

Integrated Data supporting Global Simulations

Global population data by admin region validated against *LandScan 2007*™

High Resolution Global Population Data Set

© UT-Battelle, LLC, operator of Oak Ridge National Laboratory

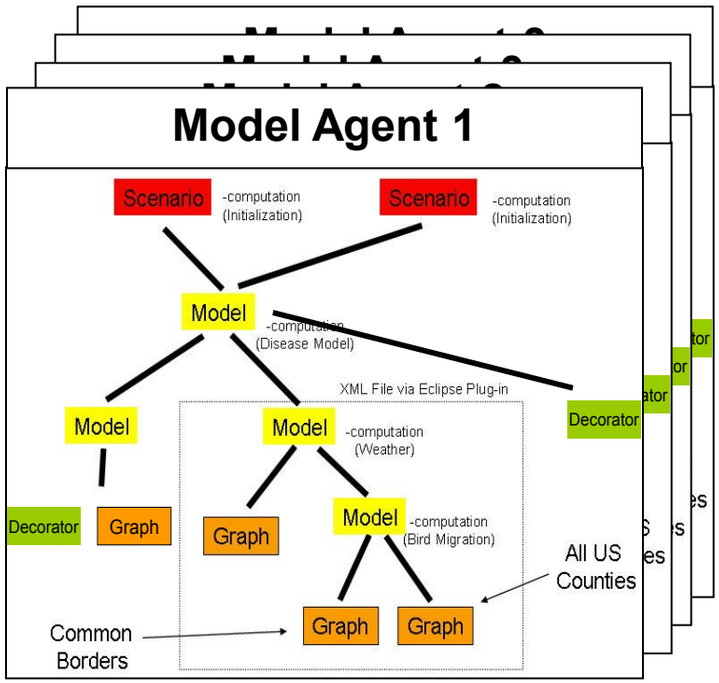
STEM (Spatio-Temporal Epidemiological Modeler)

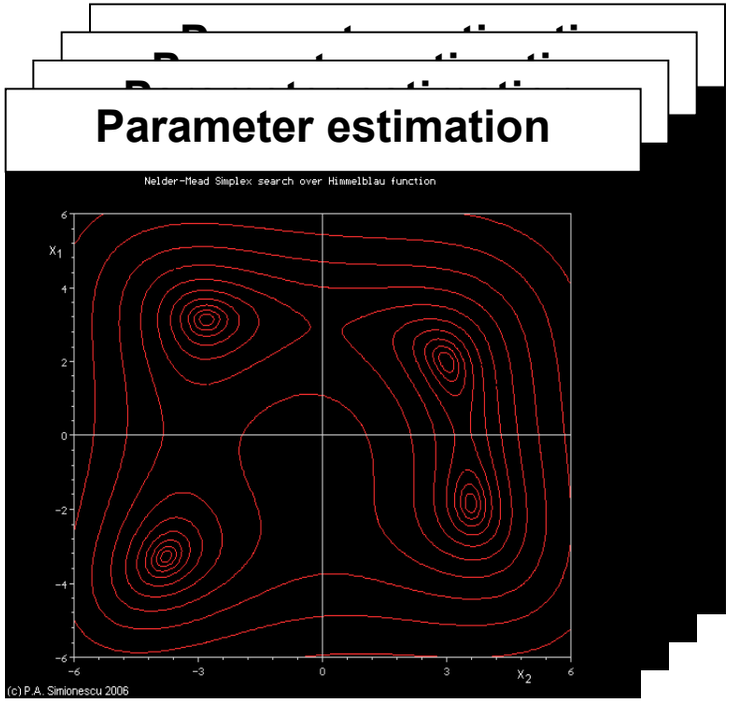
GUI for modelling zoonotic diseases from Farm-to-Fork

STEM (Spatio-Temporal Epidemiological Modeler)

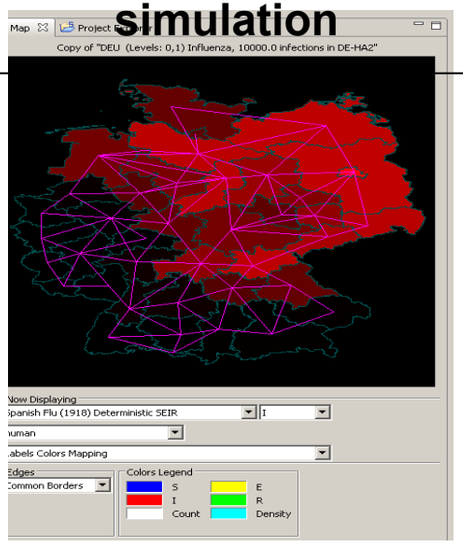
User groups

Knowledge Engineer / Statisticians





Library of models for visualization and simulation



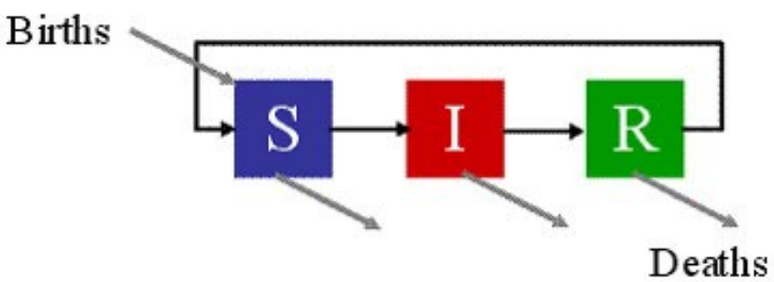
Public Health Risk Assessor / Manager

STEM - Conceptual Basis

Basis 1: Epidemiological Models

- Deterministic and stochastic simulations including pre-built compartment models (e.g. SIR, SEIR etc.)
- Code generation tool for new models

Standard SIR model



Int J Health Geogr. 2006 Jan 17;5:4.
An extensible spatial and temporal epidemiological modelling system.

Model Equations

$$\Delta S = -\beta (S/P) I + \alpha R + \mu (P-S)$$

$$\Delta I = \beta (S/P) I - \gamma I - \mu I$$

$$\Delta R = \gamma I - \alpha R - \mu R$$

Total Population $P = (S + I + R)$

Model compartments:

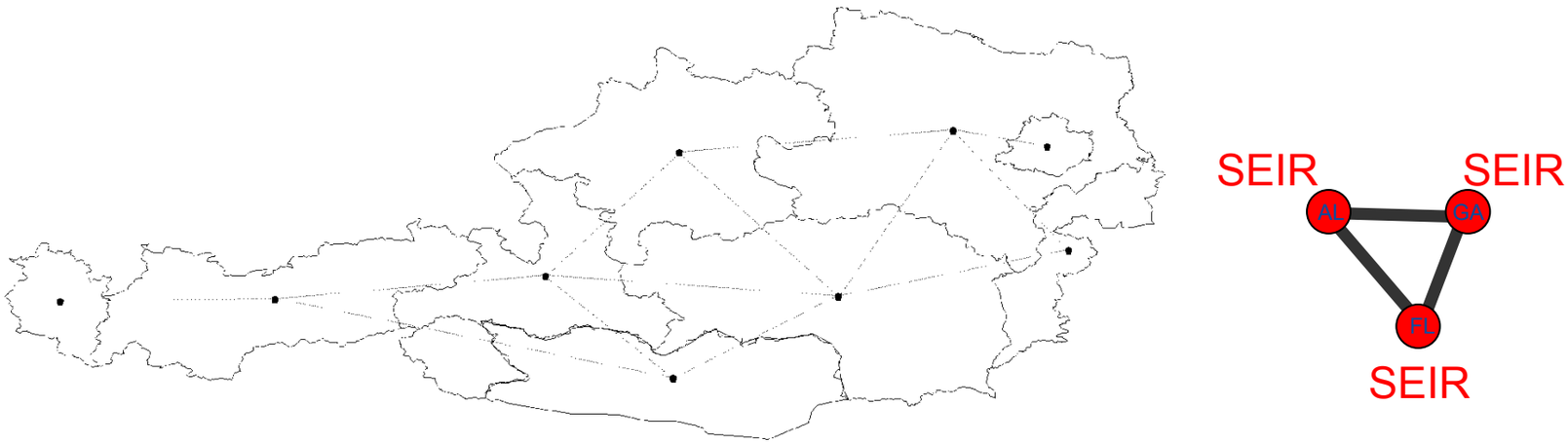
S: Susceptible
I: Infectious
R: Recovered

Model parameters:

- Transmission rate β
- Recovery rate γ
- Immunity loss rate α
- Birth/death rate μ

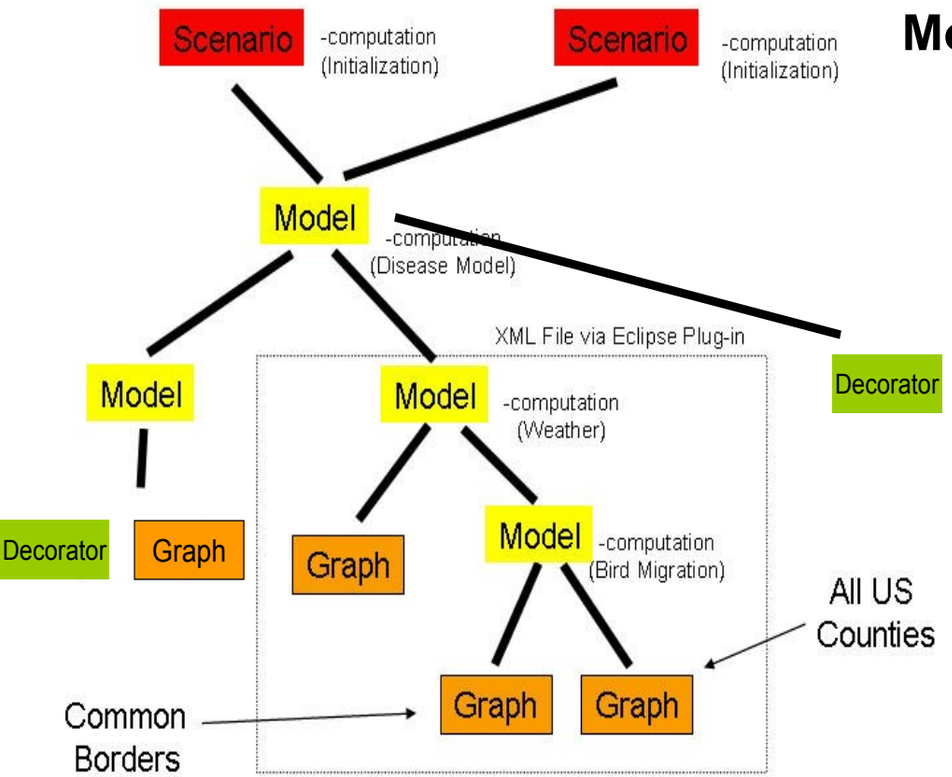
Basis 2: Spatial distribution of diseases

STEM treats the World as a “Graph”



- Graph = nodes, edges; with labels & decorators
- Graph Framework makes it easy to *build one model on top of another*
- Existing plug-ins define
    - Geography
    - Populations
    - Transportation systems
    - Land area

Basis 3: Canonical Graphs (Integration of all components)



Scenario: Model + Infector + Sequencer

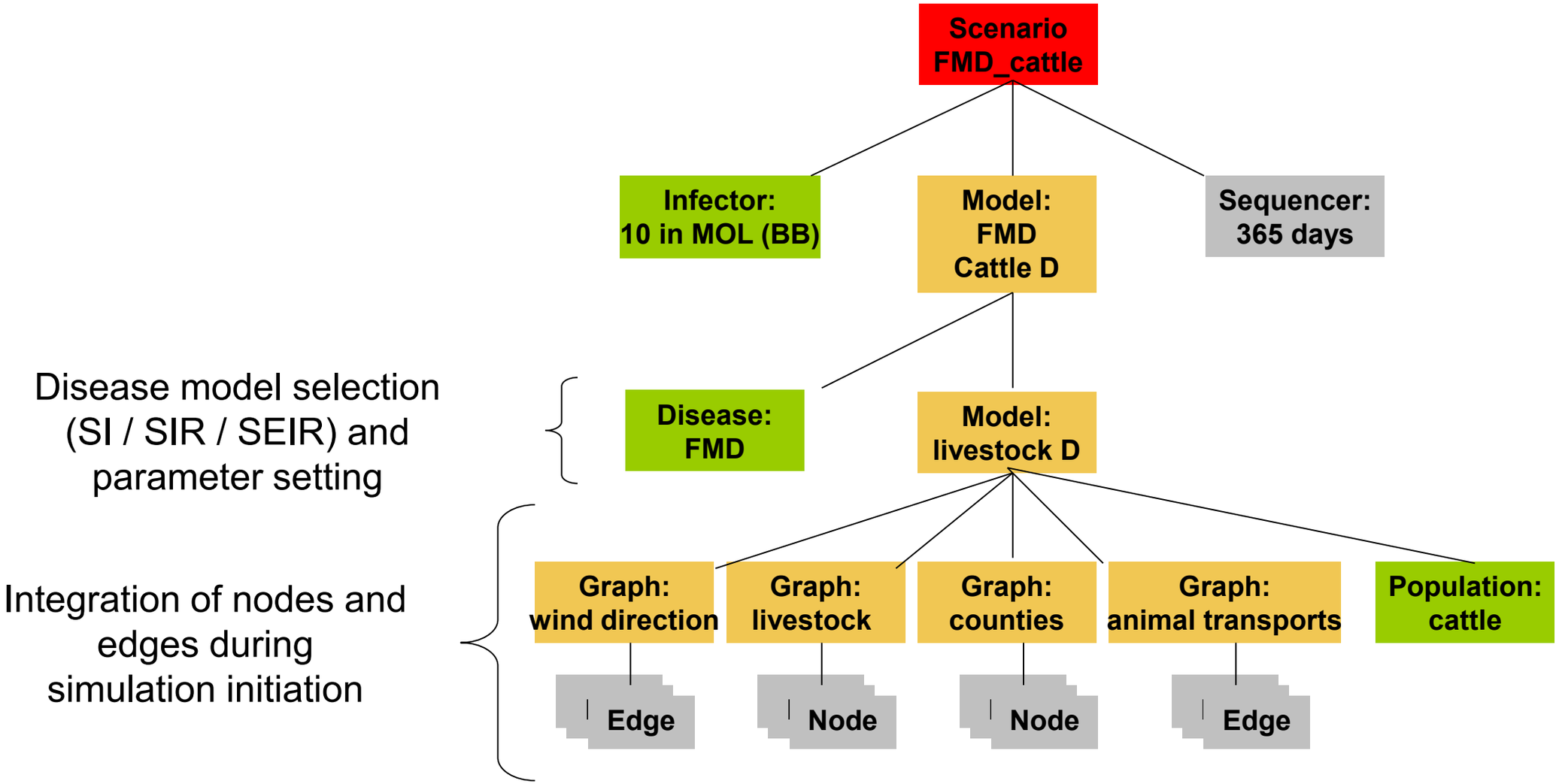
Model: Graphs + Decorators

- **Graphs**: Nodes (Labels) + Edges (Labels) may comprise several subgraphs
  - Nodes: i.e. places, regions
  - Edges: i.e. relationships, connections between nodes, vectors
- **Decorators**: denominator data and model parameters
  - Disease: Disease model parameter
  - Modifier: Parameter tuning components

Infector: Disease initiation parameters

Sequencer: Simulation time parameter

Example: Scenario FMD in cattle



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Thank you for your attention

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