Modeling for Sustainability

Benoit Combemale (Inria & Univ. Rennes 1)
http://people.irisa.fr/Benoit.Combemale
benoit.combemale@irisa.fr
@bcombemale

Jean-Michel Bruel (Univ. Toulouse)
http://jmb.c.la
bruel@irit.fr
@jmbruel

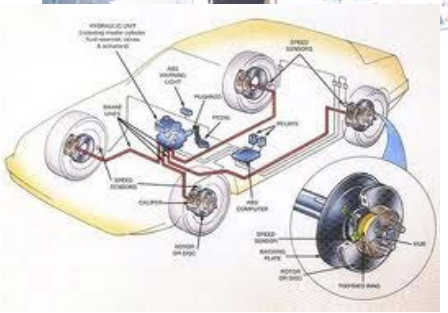
in collaboration with INRA and OBEO
and the support of the GEMOC initiative

(smart) Cyber Physical Systems

AIRBUS

DGA

THALES



beo
Model Driven Company

Software intensive systems

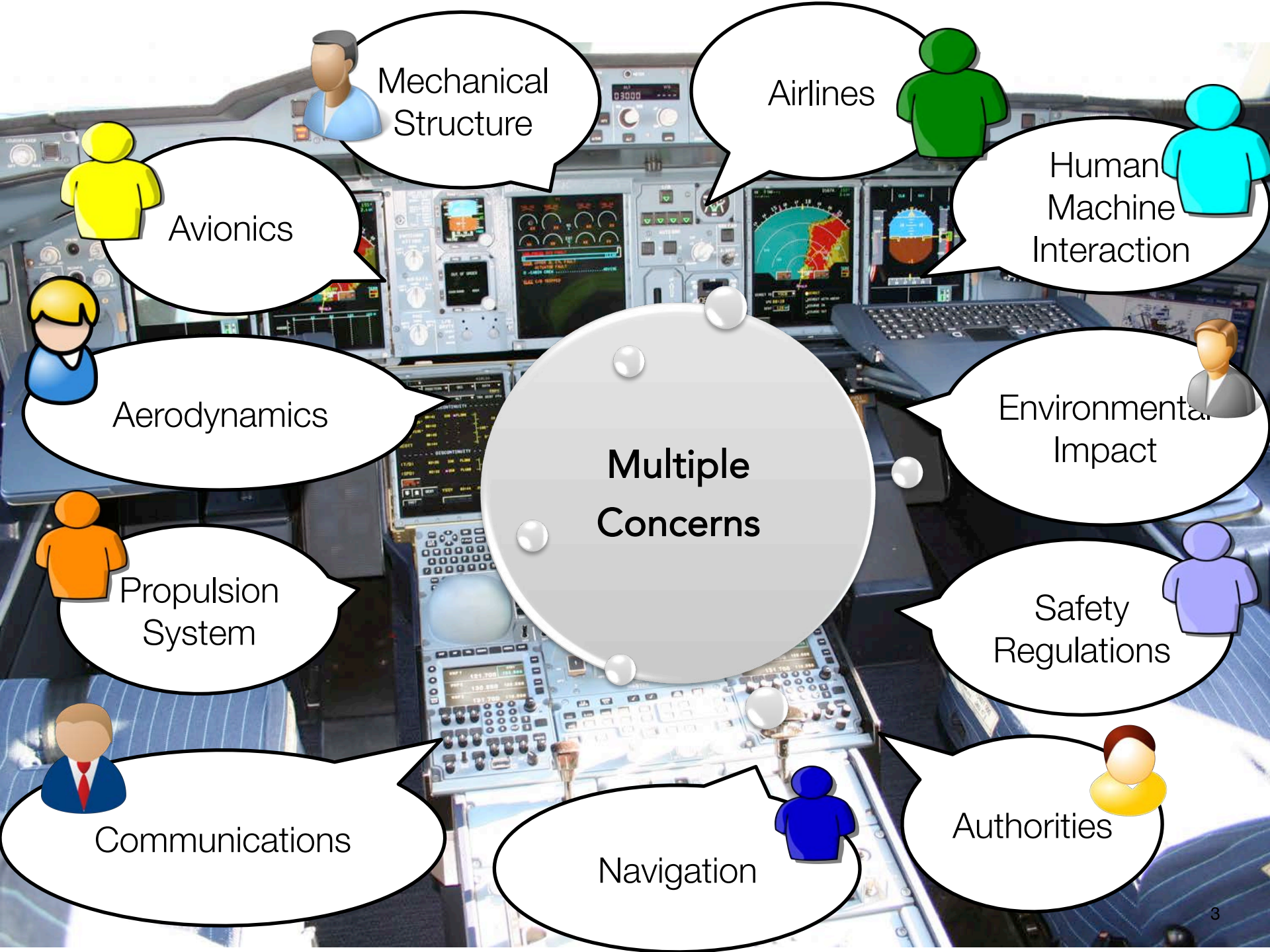
Sodifrance
IT transformation to digital

Atos

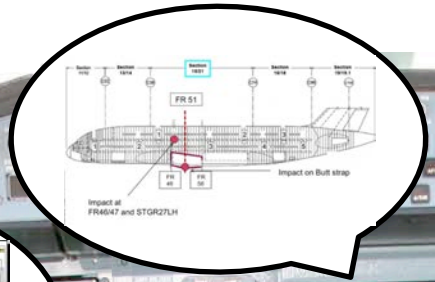
orange

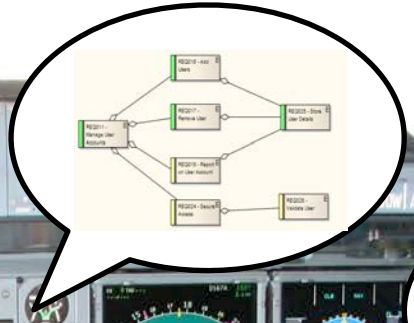
EDF

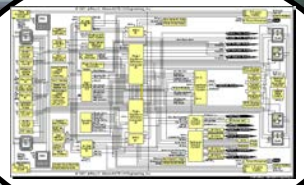
AREVA

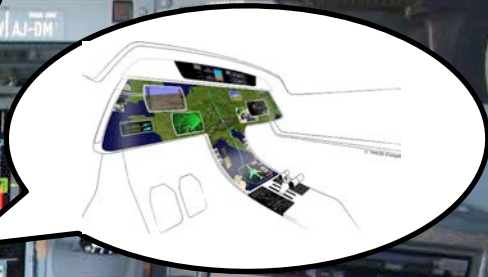

Mechanical Structure
Airlines
Avionics
Human Machine Interaction
Aerodynamics
Multiple Concerns
Environmental Impact
Propulsion System
Safety Regulations
Communications
Navigation
Authorities

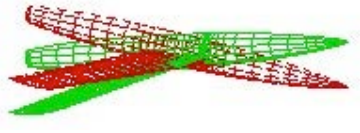
Heterogeneous Modeling

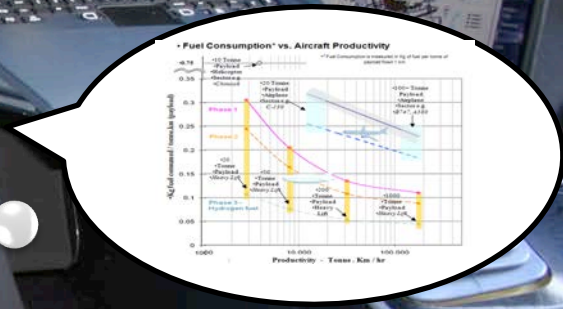


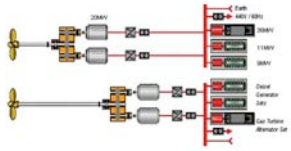


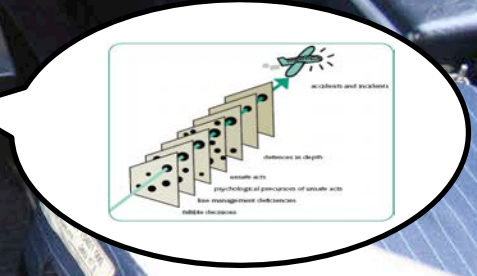


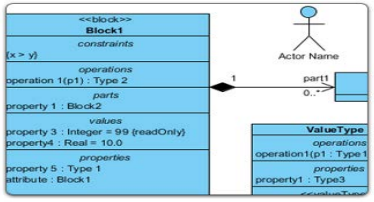


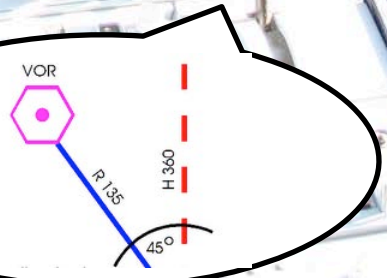




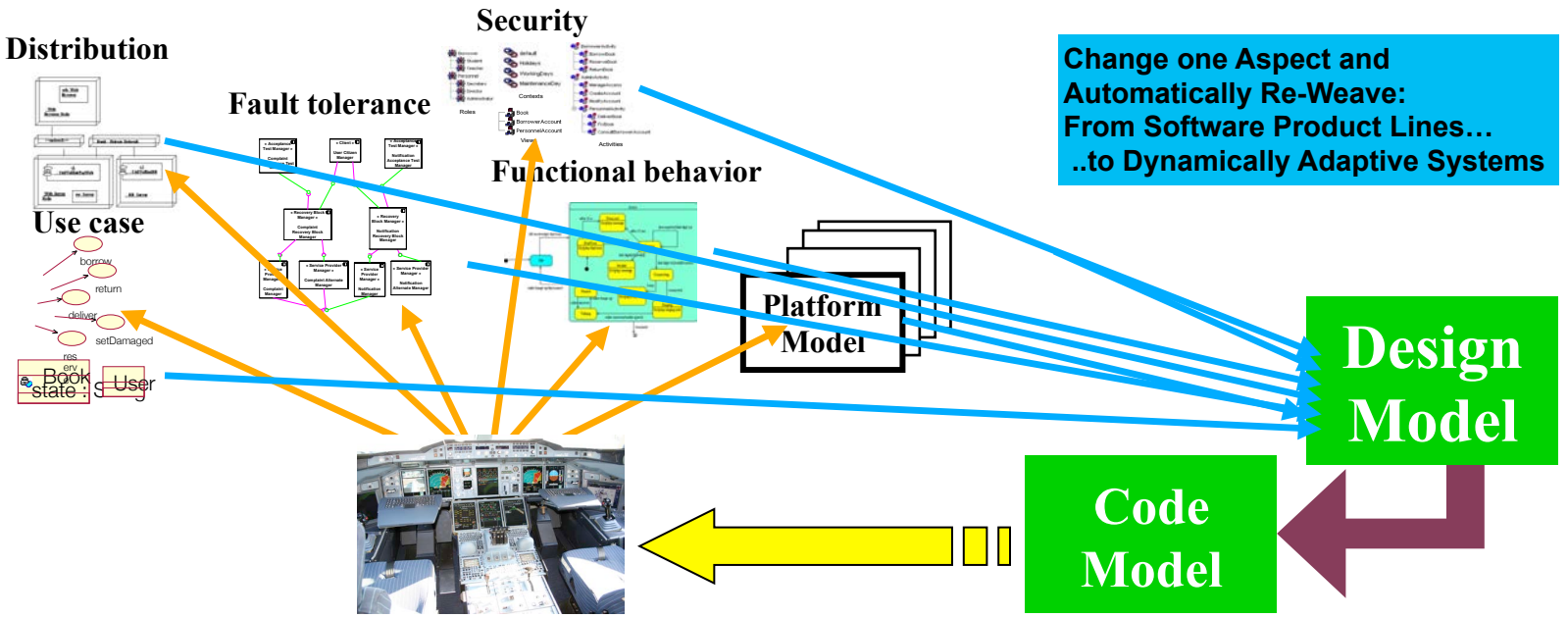








Model-Driven Engineering (MDE)



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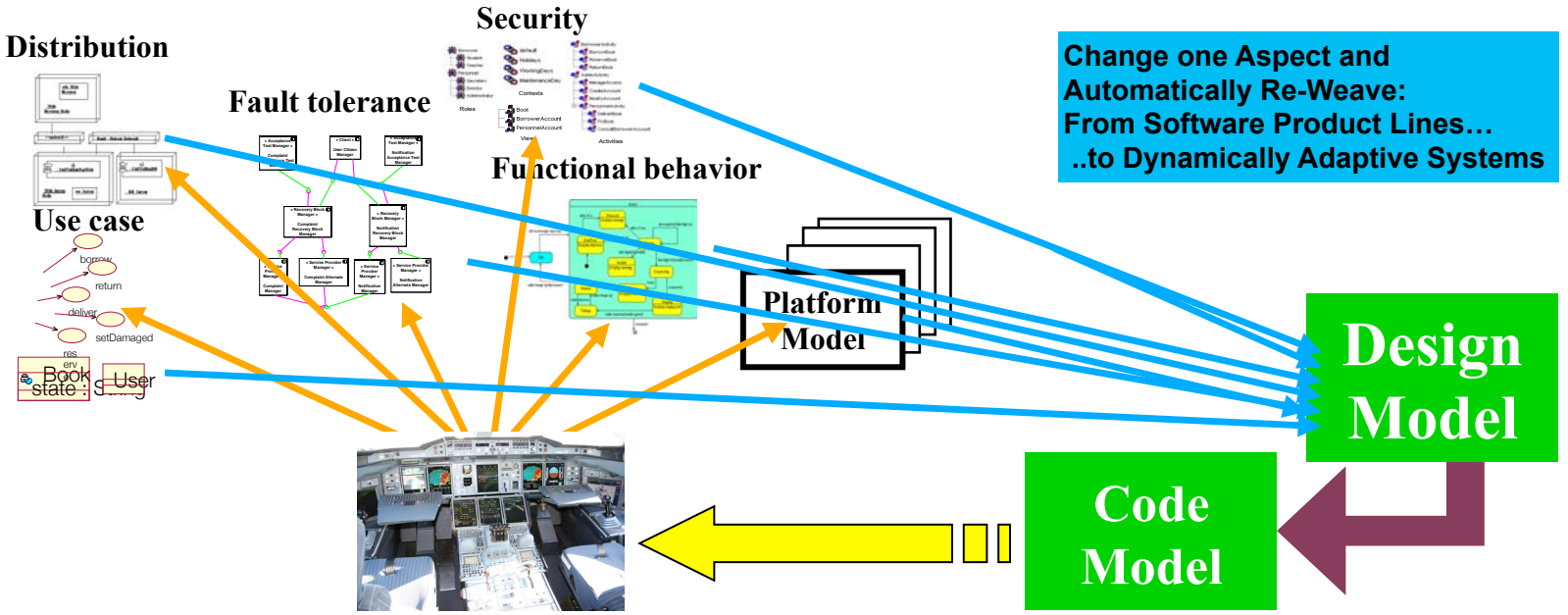


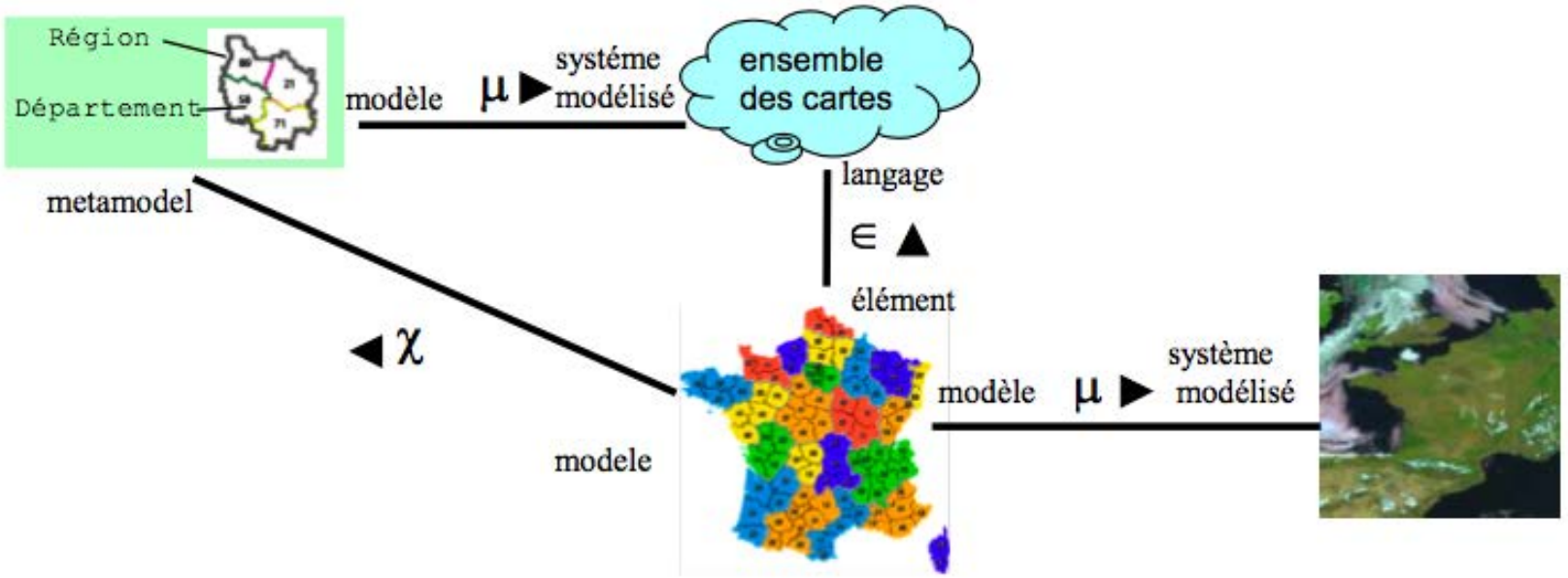
"Perhaps surprisingly, the majority of MDE examples in our study followed domain-specific modeling paradigms"

J. Whittle, J. Hutchinson, and M. Rouncefield, "*The State of Practice in Model-Driven Engineering*," IEEE Software, vol. 31, no. 3, 2014, pp. 79–85.

Domain-Specific Languages (DSLs)

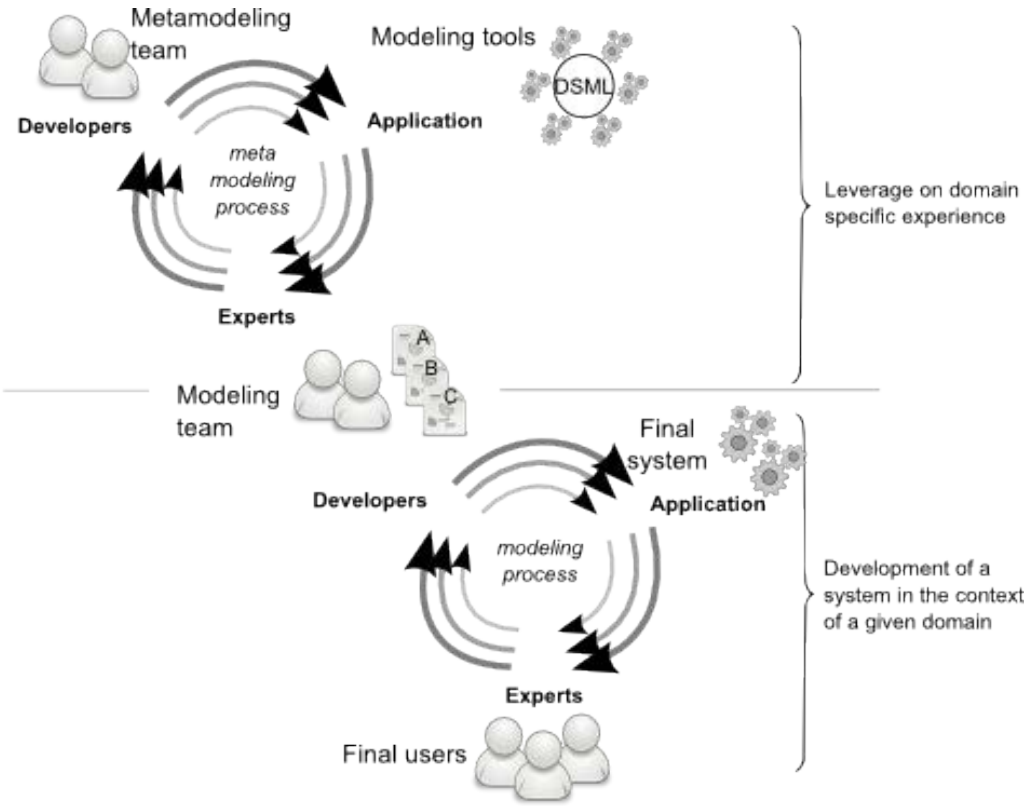
- Targeted to a **particular** kind of problem, with dedicated notations (textual or graphical), support (editor, checkers, etc.)
- Promises: more "efficient" languages for resolving a set of specific problems in a domain

Metamodeling



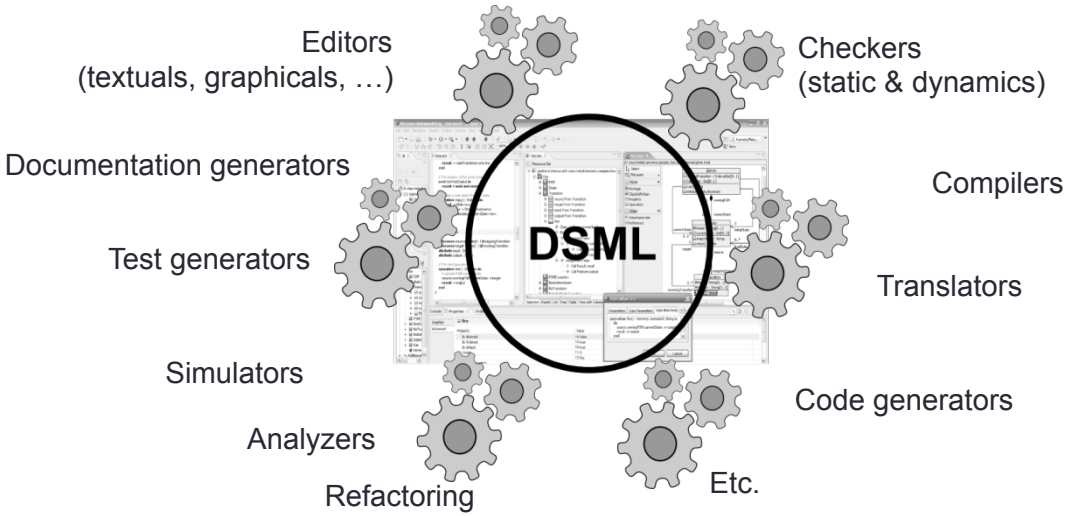
J.-M. Favre, J. Estublier, M. Blay-Fornarino, "L'ingénierie dirigée par les modèles. Au-delà du MDA," Hermes Science Publications, 2006.

Metamodeling



Jean-Marc Jézéquel, Benoît Combemale et Didier Vojtisek, "Ingénierie Dirigée par les Modèles : des concepts a la pratique," Ellipses edition, février 2012

Metamodeling



Jean-Marc Jézéquel, Benoît Combemale et Didier Vojtisek, "Ingénierie Dirigée par les Modèles : des concepts a la pratique," Ellipses edition, février 2012

Software Language Engineering (SLE)

- Application of systematic, disciplined, and measurable approaches to the development, use, deployment, and maintenance of software languages

- Supported by various kind of "**language workbench**"
  - Eclipse EMF, xText, Sirius, GEMOC, Papyrus
  - Jetbrain's MPS
  - MS DSL Tools
  - Etc.

- Various shapes and ways to implement software languages
  - External, internal or embedded DSLs, Profile, etc.

- More and more literature, a dedicated Intl. conference (SLE, cf. http://www.sleconf.org)…

From MDE to SLE: Application Domains

- Initially motivated by industry in complex embedded, critical and/or real-time systems
  - Cf. talk at DevLog-IDM'13: http://videotheque.univ-tlse3.fr/media/composition-and-concurrent-execution-of-heterogene
- Now widely used in most domains of software and systems engineering (home automation, internet of things, adaptive systems…)
- And… what about beyond?

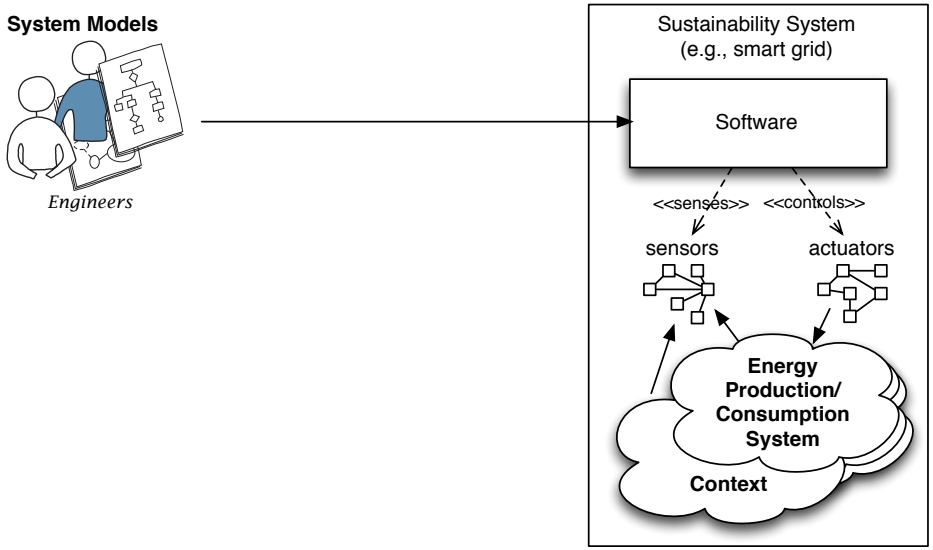
G. Mussbacher, D. Amyot, R. Breu, J.-M. Bruel, B. Cheng, P. Collet, B. Combemale, R. France, R. Heldal, J. Hill, J. Kienzle, M. Schöttle, F. Steimann, D. Stikkolorum, J. Whittle, *"The Relevance of Model-Driven Engineering Thirty Years from Now,"* MoDELS 2014: 183-200

See also the results of the Sustainability workshop at Modularity 2015
Cf. http://sustainability15.inria.fr

Modeling for Sustainability: Vision

B. Combemale, B. Cheng, A. Moreira, J.-M. Bruel, Jeff Gray, *"Modeling for Sustainability,"* MoDELS 2015 (submitted)

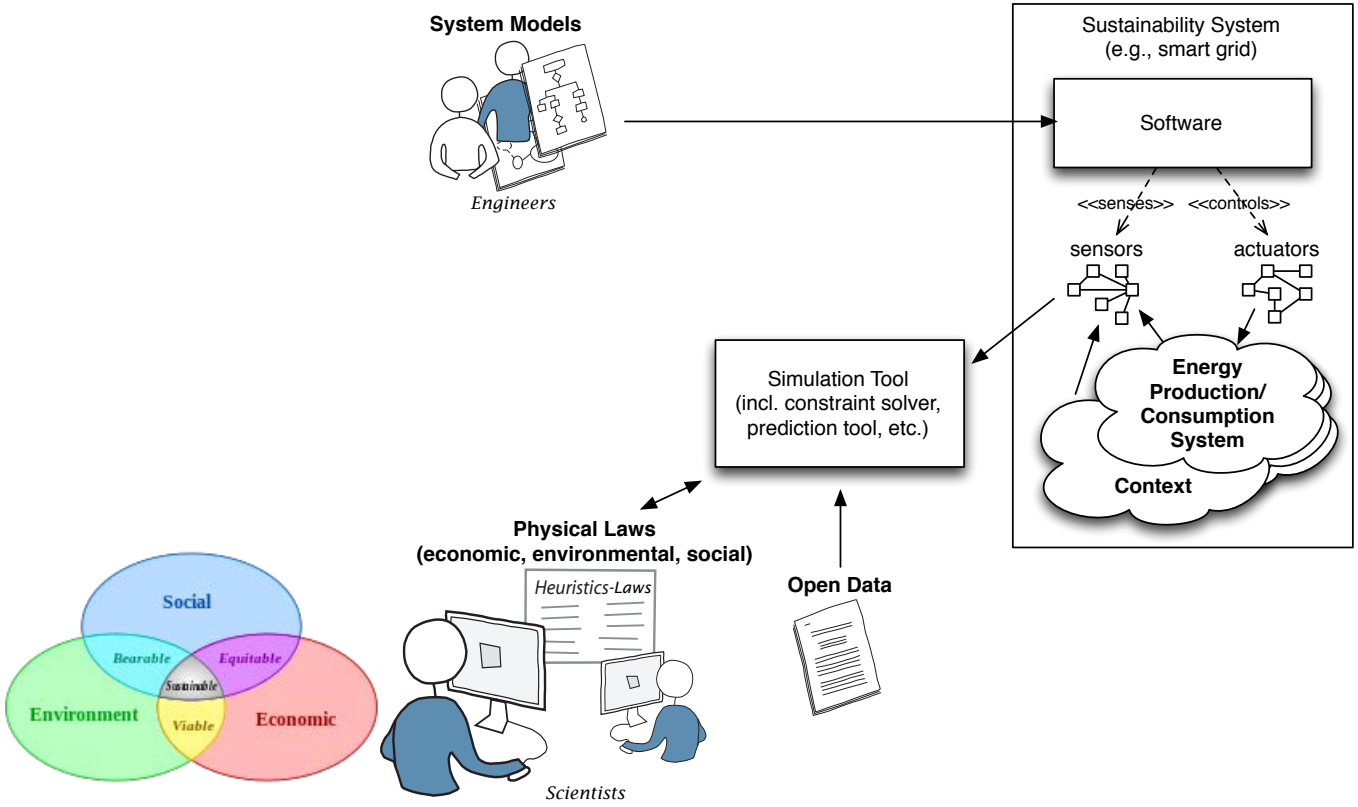
- Smart **Cyber-Physical Systems**



Modeling for Sustainability: Vision

B. Combemale, B. Cheng, A. Moreira, J.-M. Bruel, Jeff Gray, *"Modeling for Sustainability,"* MoDELS 2015 (submitted)

- Based on **informed decisions**
  - with environmental, social and economic laws
  - with open data



Modeling for Sustainability: Vision

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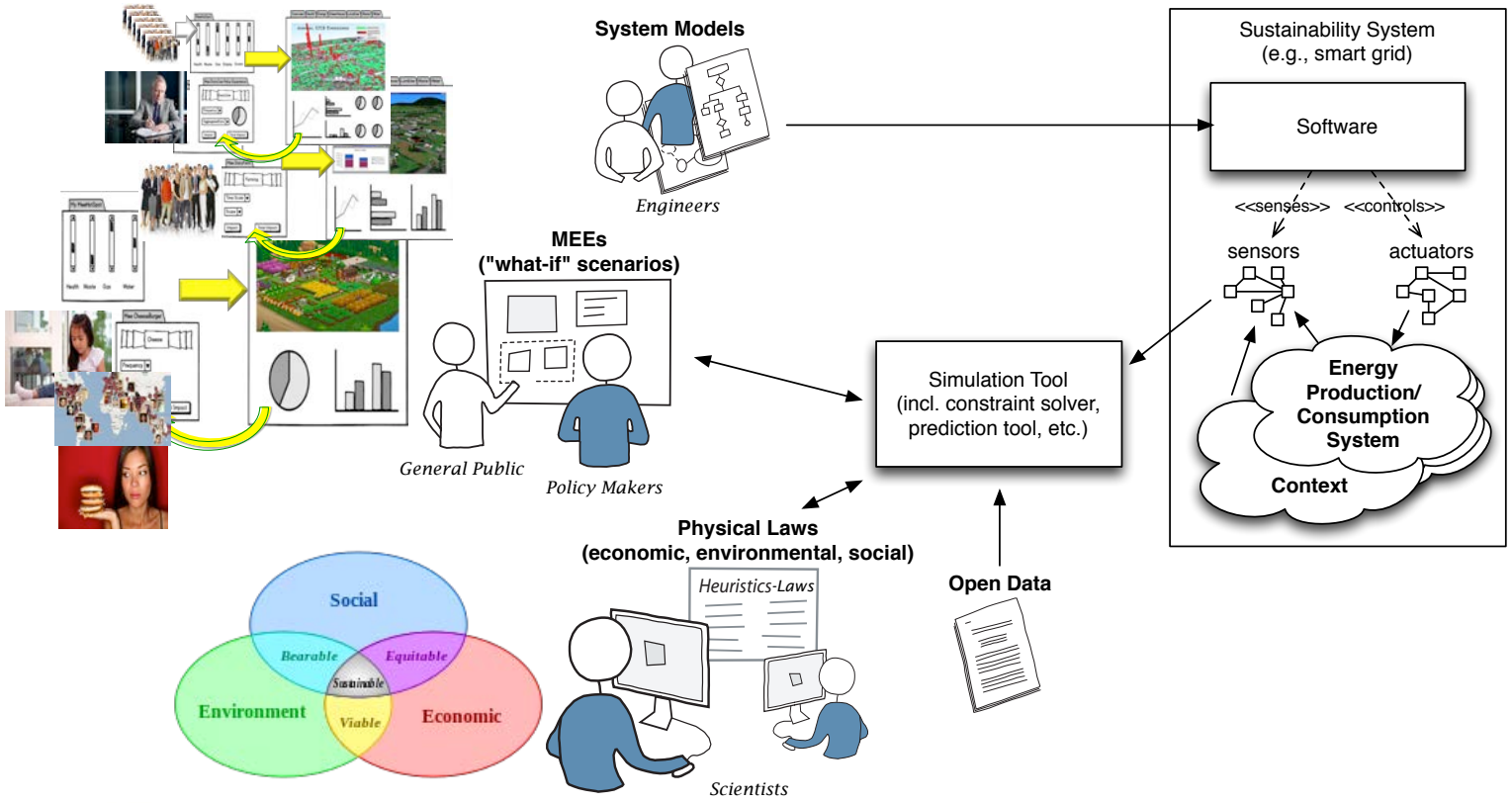
- Providing a **broader engagement**
  - with "what-if" scenarios for general public and policy makers



Modeling for Sustainability: Vision

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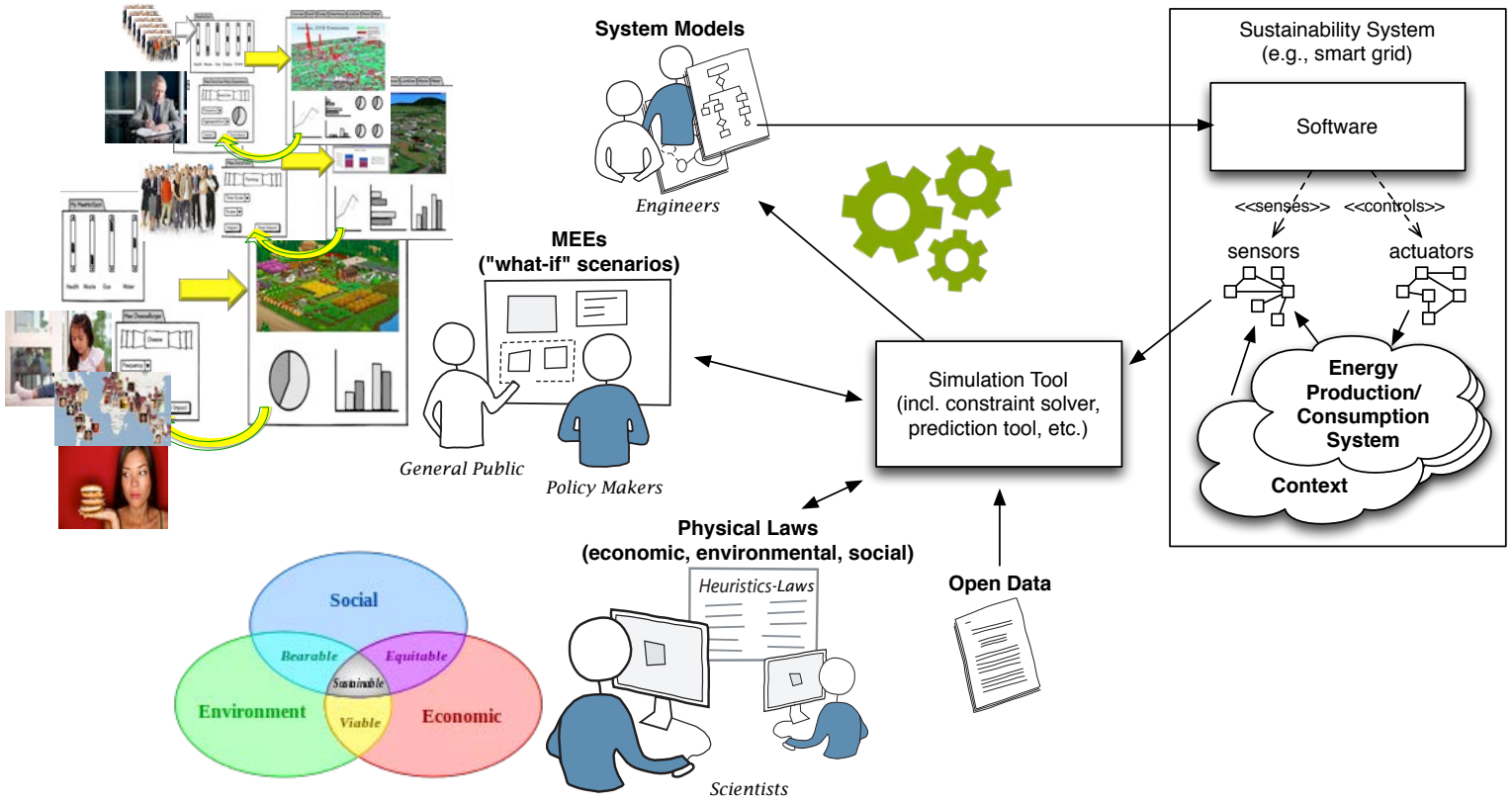
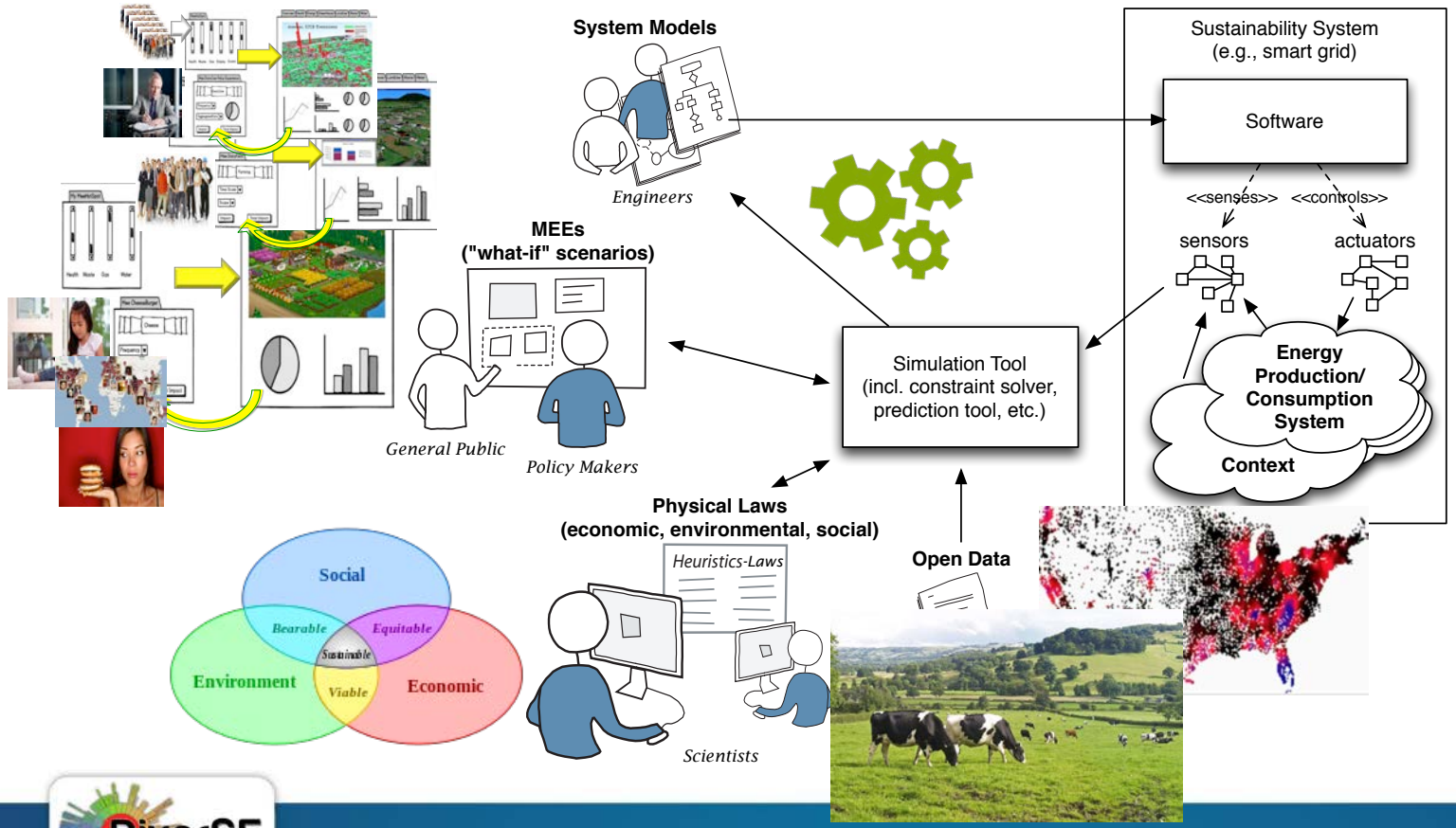
- Supporting **automatic adaptation**
  - for dynamically adaptable systems



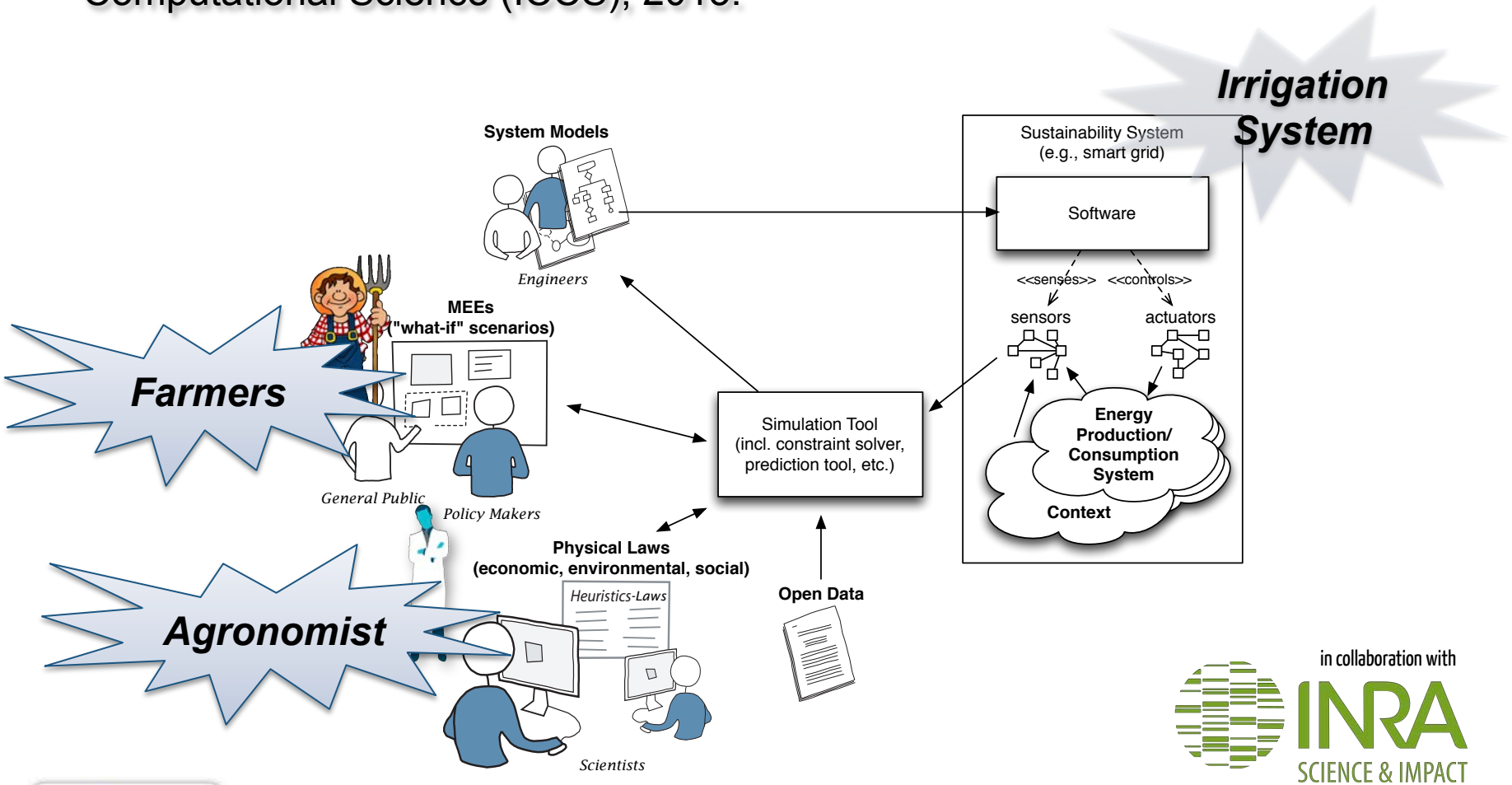
Modeling for Sustainability: Use Cases

- Health, farming system, smart grid…



Farming System Modeling

Jean-Michel Bruel, Benoit Combemale, Ileana Ober, Hélène Raynal, *"MDE in Practice for Computational Science,"* International Conference on Computational Science (ICCS), 2015.



in collaboration with INRA SCIENCE & IMPACT

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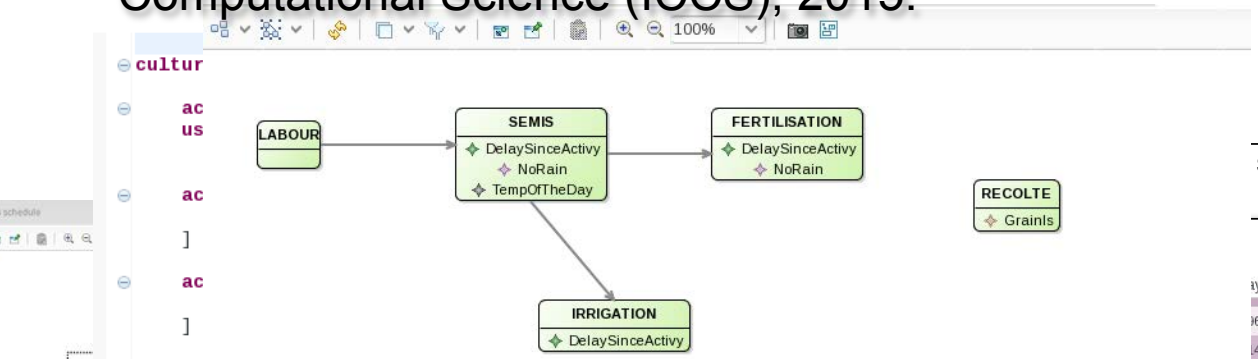
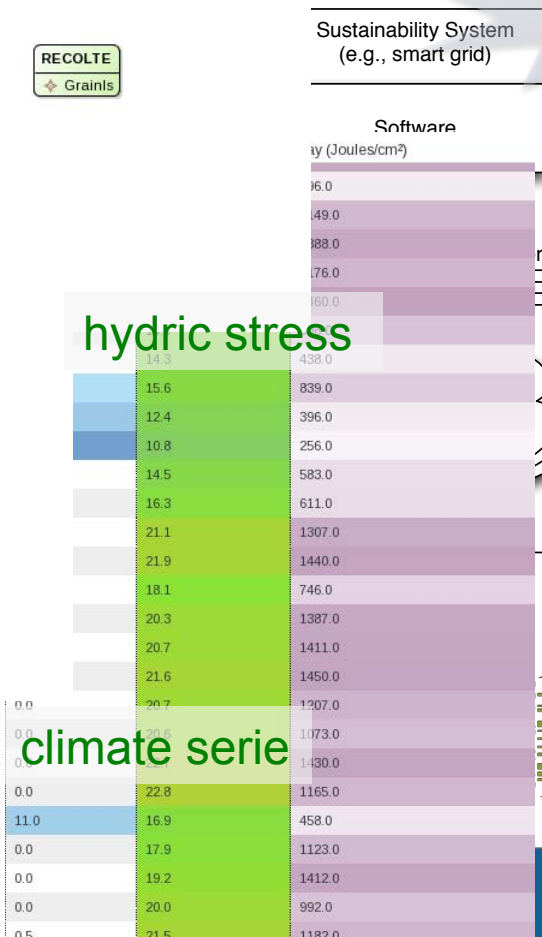



```
culture {
    ac
    us

    ac

    ]

    ac

    ]

    ac


    ]

    activity RECOLTE from 1 sept to 30 sept  [
        grain is "mature"
    ] using 1 Tractor and 2 People

}

culture weat {

    activity LABOUR from 1 sept to 30 sept [
        no rain since 3 days
    ] using 1 Tractor and 1 People

    activity SEMIS from 1 oct to 31 oct  [
        after LABOUR &&
        no rain since 3 days &&
        temperature > 5°C
    ] using 1 Tractor and 1 People

    activity FERTILISATION from 1 feb to 28 feb [
        after SEMIS is done since 30 days &&
        no rain since 1 days
     ] using 1 Tractor and 1 People

    activity RECOLTE from 1 jun to 30 jun  [
        grain is "mature"
    ] using 1 Tractor and 1 People
```

activity description



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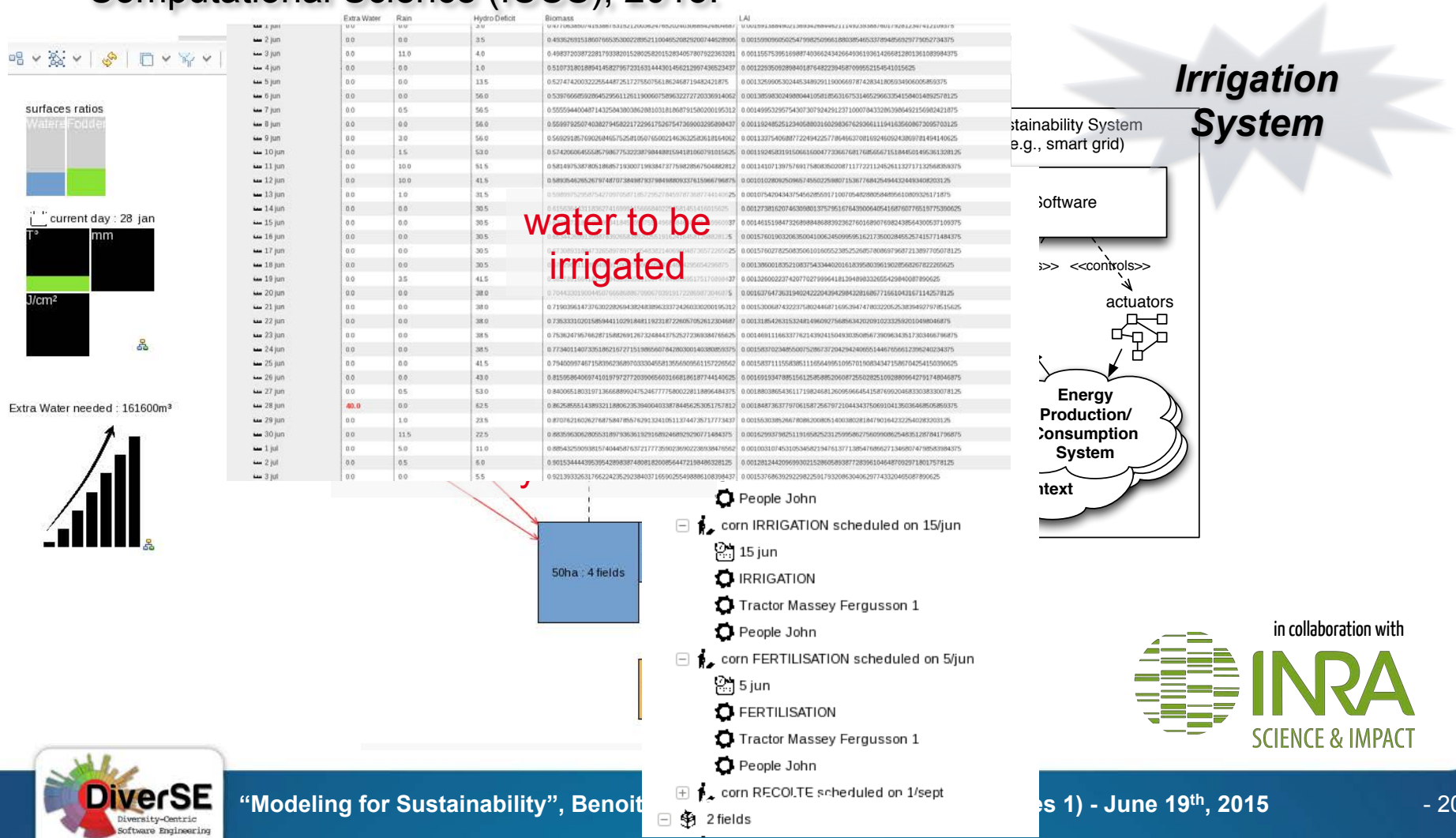
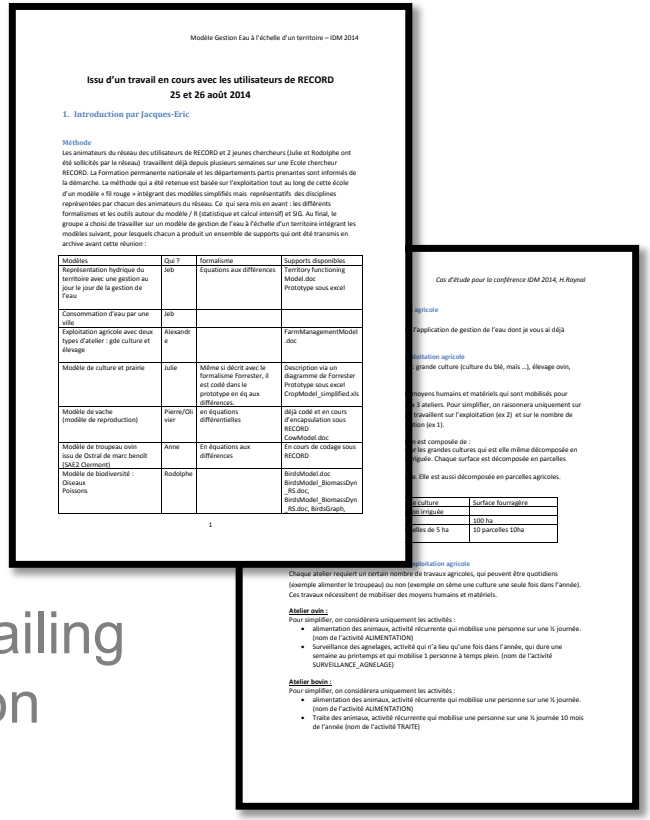


in collaboration with INRA SCIENCE & IMPACT

Farming System Modeling: Use Case

① 10-page document introducing the wide spectrum of the scientific fields (incl., 8 application domains: *crop, beef/lamb, farming exploitation, water, city, biodiversity, economics*)



Modèle Gestion Eau à l'échelle d'un territoire – IDM 2014

Issu d'un travail en cours avec les utilisateurs de RECORD
25 et 26 août 2014

1. Introduction par Jacques-Eric

Méthode

Les animateurs du réseau des utilisateurs de RECORD et 2 jeunes chercheurs (Julie et Rodolphe ont été sollicités par le réseau) travaillent déjà depuis plusieurs semaines sur une Ecole chercheur RECORD. La Formation permanente nationale et les départements partis prenantes sont informés de la démarche. La méthode qui a été retenue est basée sur l'exploitation tout au long de cette école d'un modèle « fil rouge » intégrant des modèles simplifiés mais représentatifs des disciplines représentées par chacun des animateurs du réseau. Ce qui sera mis en avant : les différents formalismes et les outils autour du modèle / R (statistique et calcul intersit) et SIG. Au final, le groupe a choisi de travailler sur un modèle de gestion de l'eau à l'échelle d'un territoire intégrant les modèles suivant, pour lesquels chacun a produit un ensemble de supports qui ont été transmis en archive avant cette réunion :

Modèles	Qui ?	formalisme	Supports disponibles
Représentation hydrique du territoire avec une gestion au jour le jour de la gestion de l'eau	Jeb	Equations aux différences	Territory functioning Model.doc Prototype sous excel
Consommation d'eau par une ville	Jeb		
Exploitation agricole avec deux types d'atelier : gde culture et élevage	Alexandre		FarmManagementModel.doc
Modèle de culture et prairie	Julie	Même si décrit avec le formalisme Forrester, il est codé dans le prototype en éq aux différences.	Description via un diagramme de Forrester Prototype sous excel CropModel_simplified.xls
Modèle de vache (modèle de reproduction)	Pierre/Olivier	en équations différentielles	déjà codé et en cours d'encapsulation sous RECORD CowModel.doc
Modèle de troupeau ovin issu de Ostral de marc benoît (SAE2 Clermont)	Anne	En équations aux différences	En cours de codage sous RECORD
Modèle de biodiversité : Oiseaux Poissons	Rodolphe		BirdsModel.doc BirdsModel_BiomassDyn_RS.doc, BirdsModel_BiomassDyn_RS.doc, BirdsGraph_

1

Cas d'étude pour la conférence IDM 2014, H.Raynal

…agricole

…l'application de gestion de l'eau dont je vous ai déjà

…ploitation agricole

…grande culture (culture du blé, maïs …), élevage ovin,

…moyens humains et matériels qui sont mobilisés pour …3 ateliers. Pour simplifier, on raisonnera uniquement sur …travaillent sur l'exploitation (ex 2) et sur le nombre de …sion (ex 1).

…est composée de : …r les grandes cultures qui est elle même décomposée en …rriguée. Chaque surface est décomposée en parcelles

…. Elle est aussi décomposée en parcelles agricoles.

…culture	Surface fourragère
…on irriguée	
…	100 ha
…elles de 5 ha	10 parcelles 10ha

…ploitation agricole

Chaque atelier requiert un certain nombre de travaux agricoles, qui peuvent être quotidiens (exemple alimenter le troupeau) ou non (exemple on sème une culture une seule fois dans l'année). Ces travaux nécessitent de mobiliser des moyens humains et matériels.

Atelier ovin :
Pour simplifier, on considèrera uniquement les activités :
- alimentation des animaux, activité récurrente qui mobilise une personne sur une ¾ journée. (nom de l'activité ALIMENTATION)
- Surveillance des agnelages, activité qui n'a lieu qu'une fois dans l'année, qui dure une semaine au printemps et qui mobilise 1 personne à temps plein. (nom de l'activité SURVEILLANCE_AGNELAGE)

Atelier bovin :
Pour simplifier, on considèrera uniquement les activités :
- alimentation des animaux, activité récurrente qui mobilise une personne sur une ¾ journée. (nom de l'activité ALIMENTATION)
- Traite des animaux, activité récurrente qui mobilise une personne sur une ¾ journée 10 mois de l'année (nom de l'activité TRAITE)

② 4-page document detailing the farming exploitation use case

③ Calls with INRA (H. Raynal)

See all materials at: https://github.com/gemoc/farmingmodeling

Farming System Modeling: First Experiments

- Modeling and analysis thanks to a set of external DSLs
  - Tooling: EMF, xText, Sirius and GEMOC
  - Collaboration INRIA / Obeo
- Modeling and analysis thanks to a UML profile
  - Tooling: EMF and Papyrus
  - Collaboration IRIT / CEA

See results at DevLog-IDM'14:
http://videotheque.univ-tlse3.fr/media/devlog-benoit-combernale-idm-par-la-pratique-dans-

Farming System Modeling: First Experiments

- DSLs for farming modeling
  - Focus: edition and animation
  - Collaboration INRIA (B. Combemale) and Obeo (C. Brun)
  - Large leeway!
- Organization:
  - 3h video-conference INRIA/IRIT/INRA (H. Raynal)
    - + 2-page description of the domain + examples
  - 3h meeting INRIA/Obeo
  - 10h distributed work INRIA/Obeo through the github repository
    - including the POC, and the preparation of the demo and slides!
  - 2h video-conference INRIA/Obeo

  ⇒ 26 hours of work!

See results at DevLog-IDM'14:

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Farming System Modeling: Metamodeling Approach

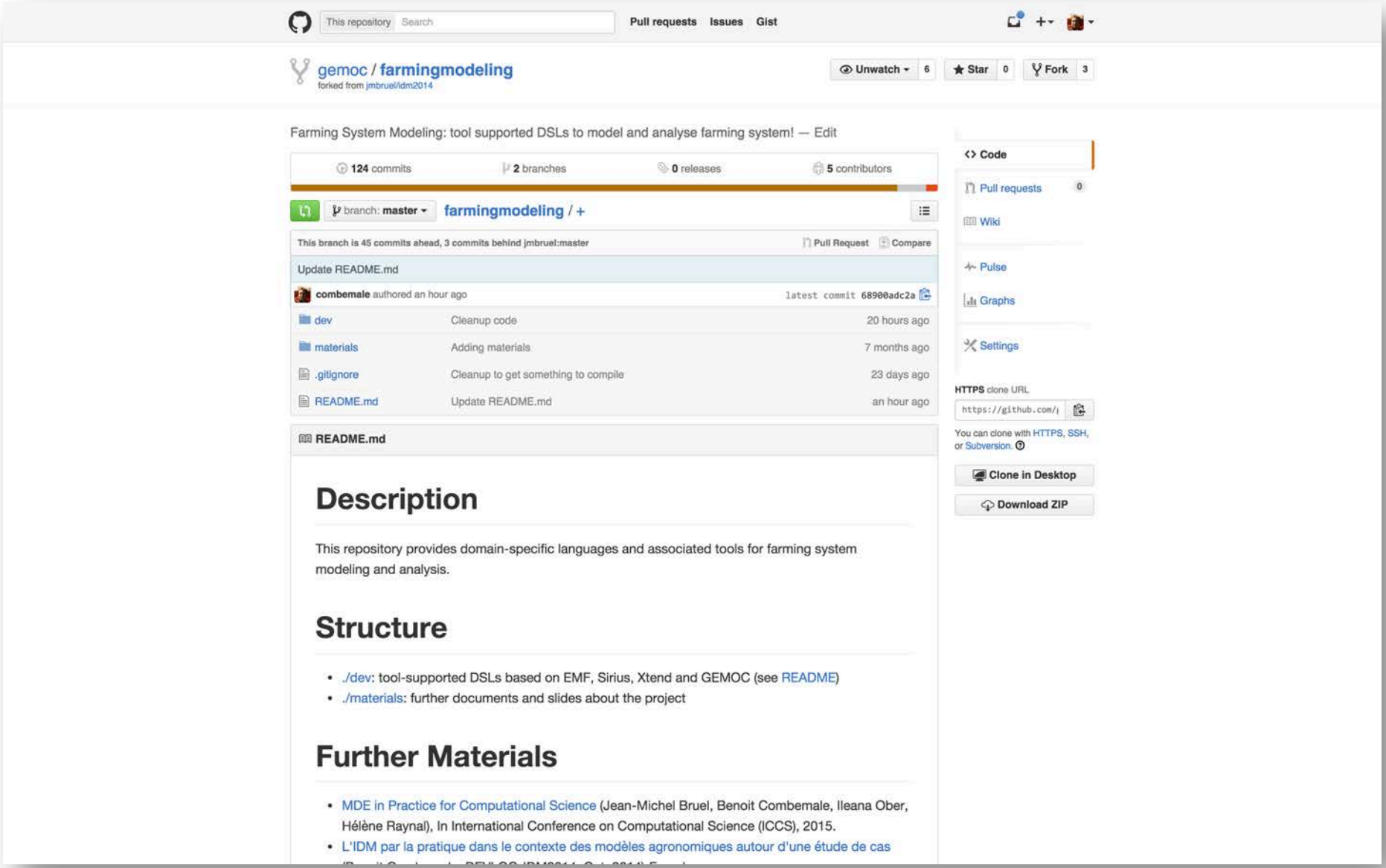
	emf (Eclipse Modeling Framework)	Sirius	Xtext	Gemoc
Language Engineers	Domain	Viewpoint (graphical editor)	Grammar (textual editor)	Behavioral semantics (animator)
Language Users	Data	Views and static checking	Textual editing and static checking	Globalization, execution, simulation and animation

See results at DevLog-IDM'14:
http://videotheque.univ-tlse3.fr/media/devlog-benoit-combernale-idm-par-la-pratique-dans-

Farming System Modeling: Further Experiments

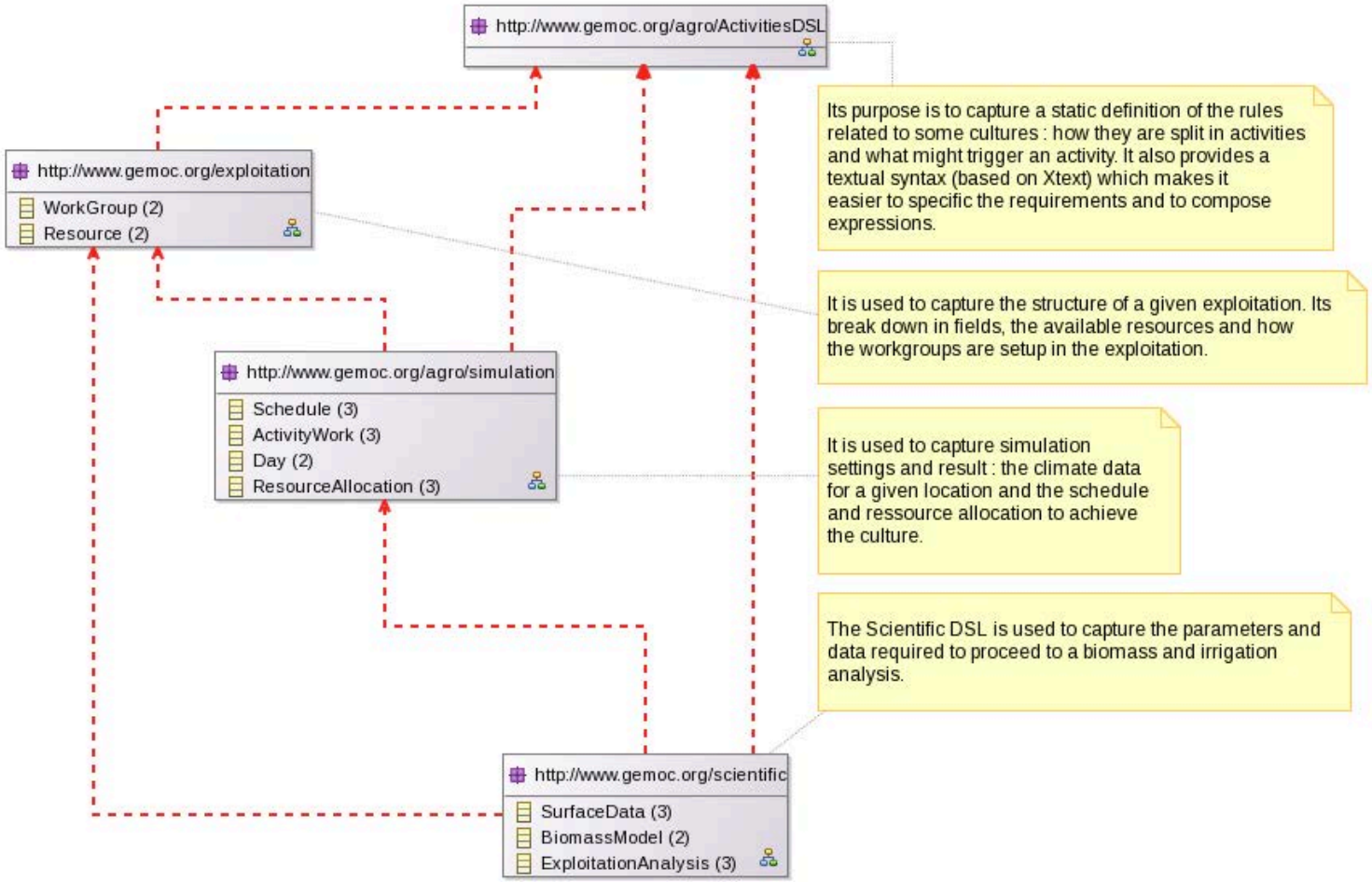
- Computation of the biomass evolution and water consumption
- Integration of a planner
- New HTML generators
- Creation of new views, and improvements in the existing ones

Results presented at RII/FuturEnSeine "Transition énergétique":
http://www.inria.fr/centre/saclay/innovation/rii-transition-energetique/demos/modelisation-pour-l-economie-d-energie



https://github.com/gemoc/farmingmodeling

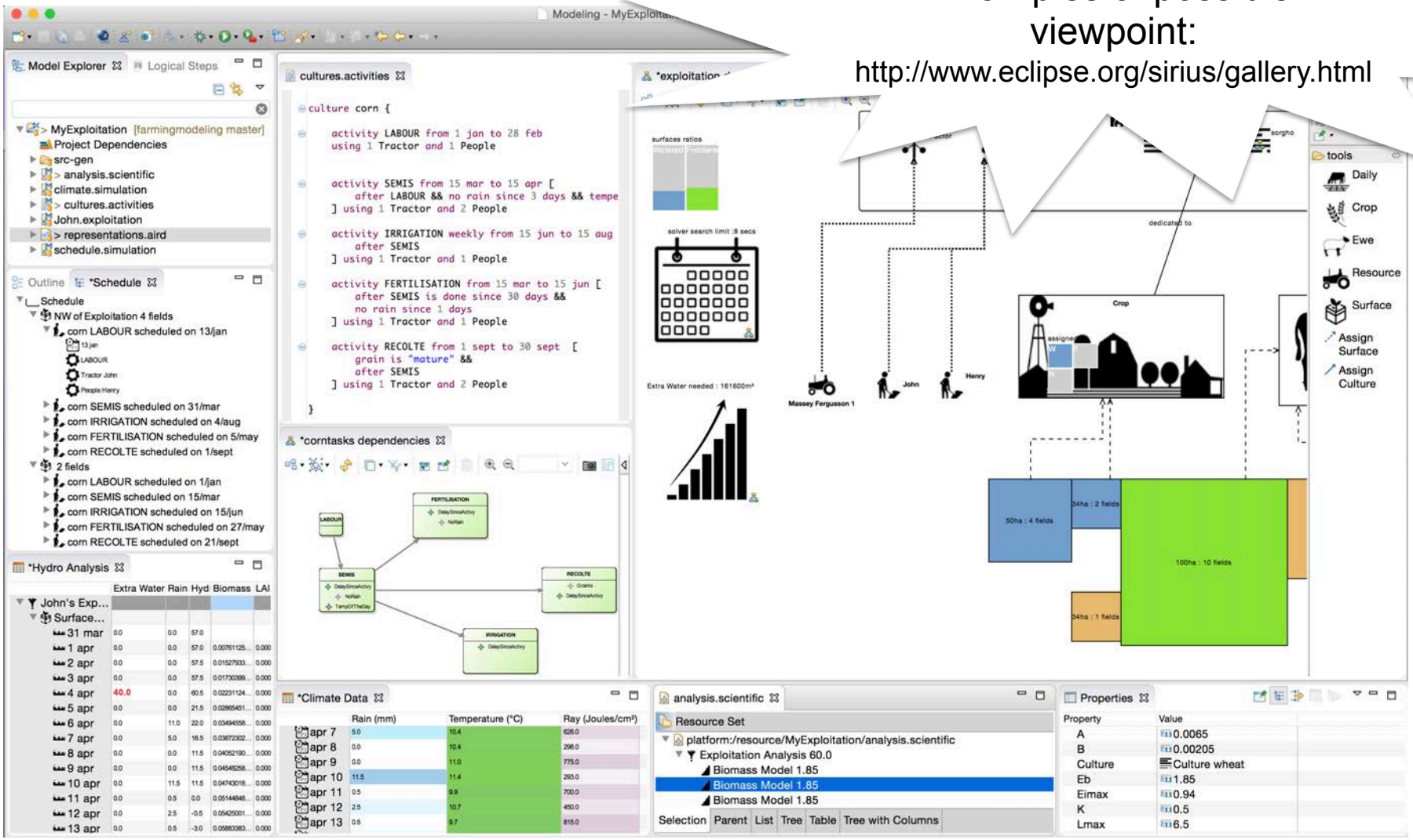
Results



https://github.com/gemoc/farmingmodeling

Results

Examples of possible viewpoint:
http://www.eclipse.org/sirius/gallery.html



https://github.com/gemoc/farmingmodeling


DEMO

Demonstration: conclusion

- Explicit domain models (metamodels)
- (Structural) Integration of metamodels
- Combination of graphical and textual editors (+sync)
- Model transformation (POC)
  - Operation semantics (~VM)
    - Implementation of some (discrete) functions (biomass, water)
  - Translational semantics (~compiler)
    - Integration of a constraint solver and a planner
    - HTML generation
- Early animation

Demonstration: perspectives

- Relevant model transformations
  - static and dynamic analysis
  - import / export
- Concurrent execution of heterogeneous models
- Domain-specific property languages
- DSL deployment to the web

Wrap-up

- Intuitive modeling for global problems
  - Use of DSLs in the experiments
- Immediate benefits
  - Fast prototyping, and expert in the loop
  - Easy adoption (incl., learning curve)
- Future challenges for MDE
  - MEEs
  - Collaborative design of conceptual models
  - Model integration (incl., engineering and scientific models)

Community

- Collaborations: B. Cheng (USA), J. Gray (USA), A. Moreira (Portugal)

- Related and complimentary work:
  - The Karlskrona Manifesto on Sustainability Design (http://sustainabilitydesign.org)
  - Open data: https://rd-alliance.org
  - Track SEIS (@ICSE), Workshops GREEN (@ICSE) and RE4SuSy (@RE)
  - CIRAD (Muller *et al.*)
  - Keynote at MODELS'15: *"Modelling the Climate System: Is model-based science like model-based engineering?"* (Steve Easterbrook)

Discussions

- Current state of the practices?
  - And possibly current limitations? difficulties?
- DSLs vs. GPLs?
  - Domain abstractions?
  - Requirements in terms of alignment with the standards?
- Intended users (scientists, public…)?
- Intended use: communication? simulation? Interoperability?

Next steps?

- *Future collaborations?*
- *Master/PhD co-advising? Engineers?*
  - *INRA? INRA/INRIA? CNRS? Région? etc.*
- *Calls (COST Action, H2020, ANR, FUI, PIA/ADEME…)?*
- *Broader consortium?*
- *Community building / Events?*
- *Value / Supply chain?*

Next steps?

- *A possible lean scenario*