Model-based Development for Embedded Control Systems

- Which embedded control systems?
- Aérospatiale pioneering role
- State of the art
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Which Embedded Control Systems?


safety critical systems


mission critical systems, time to market

Two Questions

Knowing the low reliability of computing technology

- **thousands of car "recalled" for computing bugs**
- **Ariane V accident**
- **your personal computer . . .**

1. *Is it wise to use this poor technology in safety critical systems?*

2. *Why, nevertheless, things are not as bad as could be expected?*

A Tentative Answer

The safety-critical control industry has designed a very strong model-based development method

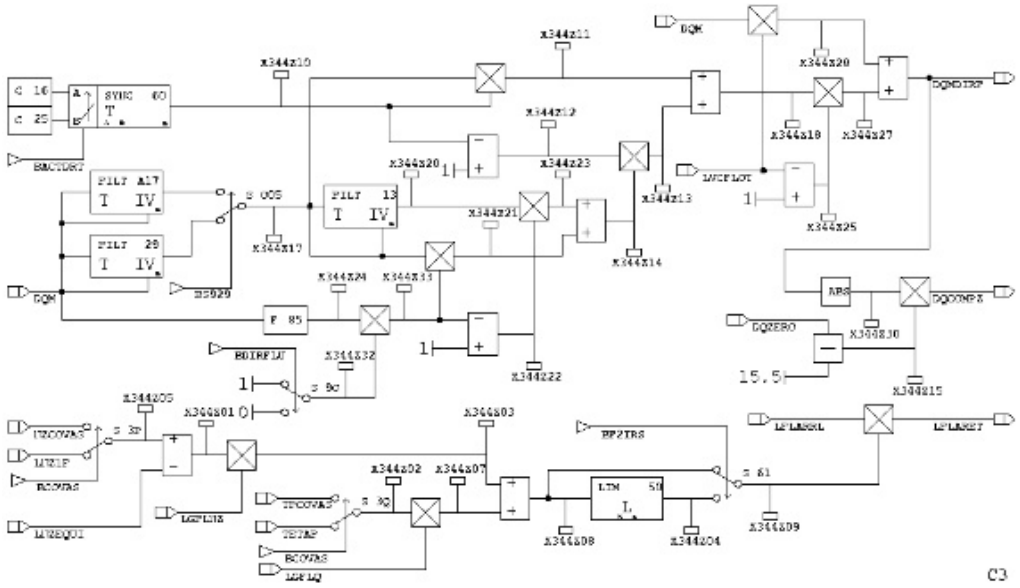
A short story of this method:

- **Aérospatiale pioneering role**
- **How things evolved since then**
- **State of the Art and perspectives**

Are academic people really aware of this story?

Aérospatiale pioneering steps in the early eighties

control models (block-diagrams)



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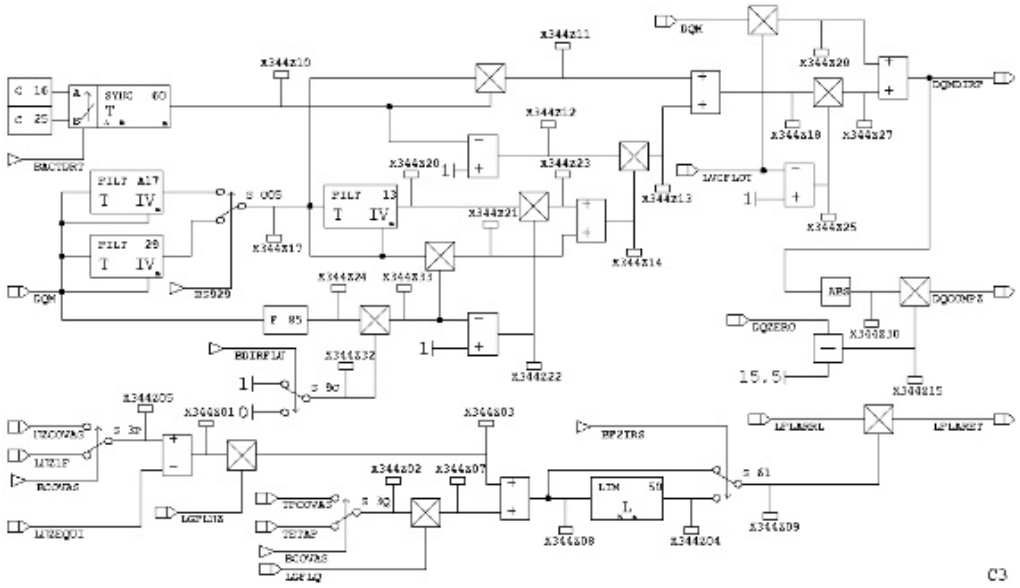

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formal software specification

Aérospatiale pioneering steps in the early eighties

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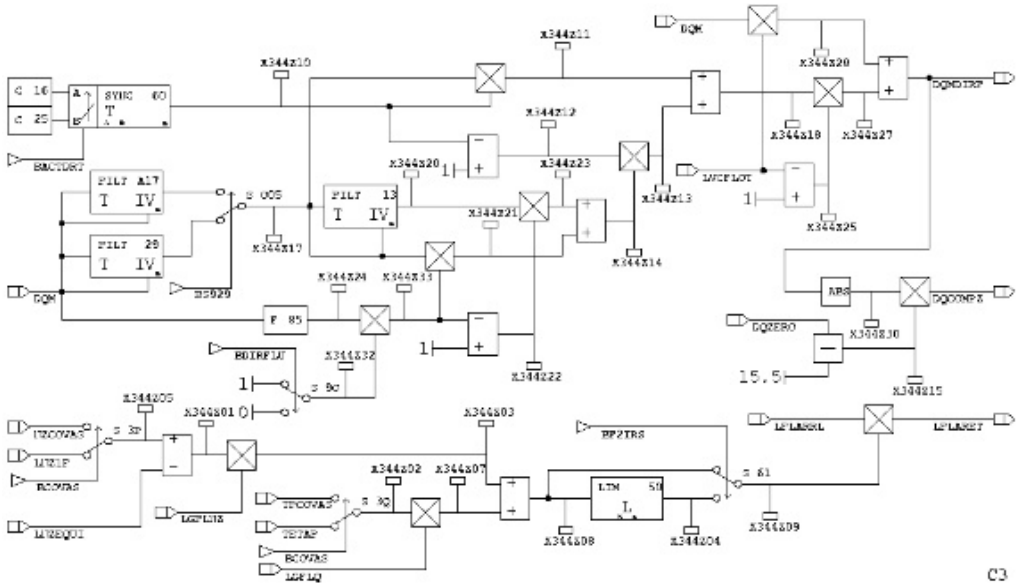

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formal software specification

↓

automatic code generation

↓

Software

Aérospatiale pioneering steps in the early eighties

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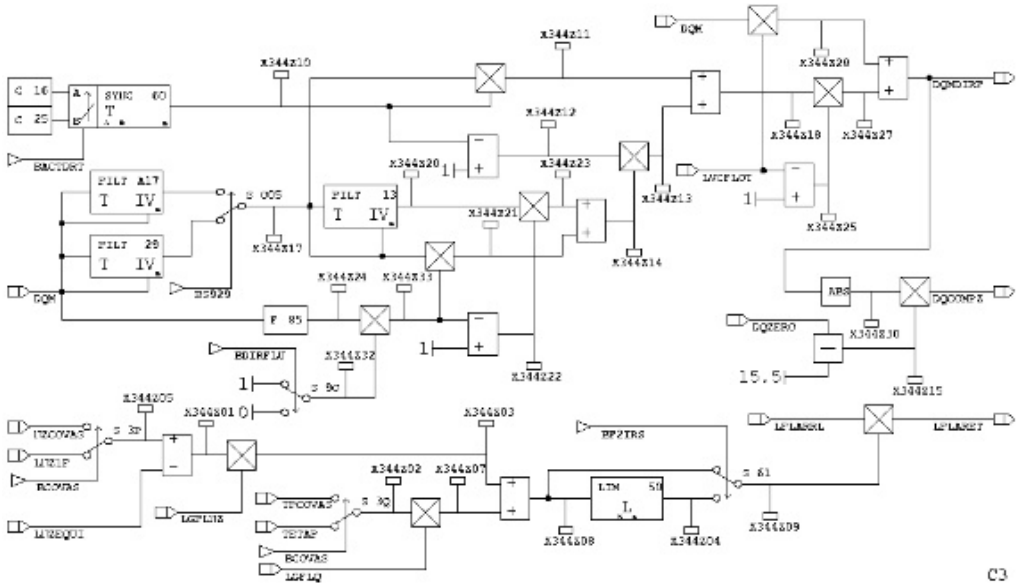

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formal software specification

↓

automatic code generation

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Software

“Spécification Assistée par Ordinateur”(SAO)

“Computer Aided Specification”

Interest of SAO

Twofold :

- **Automatic code generation from high-level control models:**

  easier and earlier debugging

- **Graphic language close to the cultural background of avionic engineers, test pilots, suppliers, certification authorities, . . . :**

  allows easier communication within the entreprise

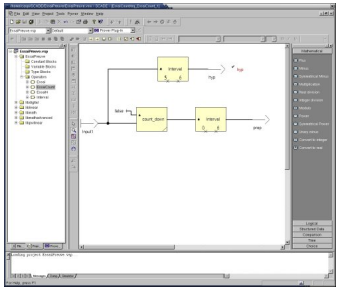
  preserves the know-how and makes easier the technology transfer

SAO participates to the success of A320

From then on…

Powerful model-based development tools:

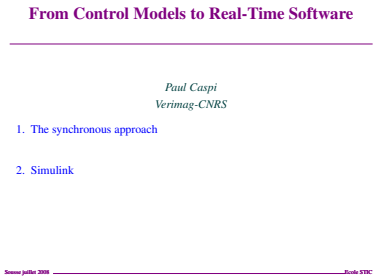
- **SAO replaced by SCADE**



commercial product partially based on  synchronous technology

Do178B level A qualified automatic code generator

- **Simulink/Stateflow**



continuous/discrete time simulation toolbox

the defacto standard in control modelling

- **Formal methods: automatic mathematical proofs for dynamic systems**

PROVER TECHNOLOGY

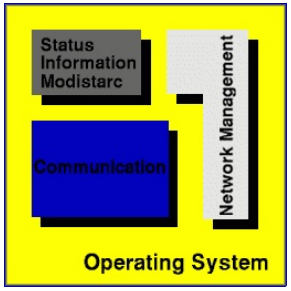
PolySpace TECHNOLOGIES Delivering safe code - faster

…

From then on...

More powerful execution platforms:

- **multi-tasking**



WIND RIVER

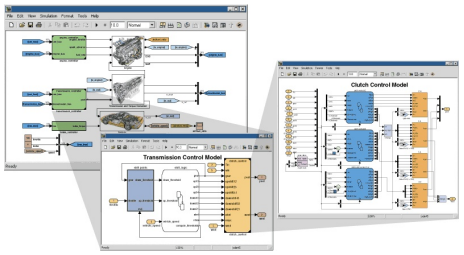
- **distributed and multi-processor**

TTTech

FlexRay™

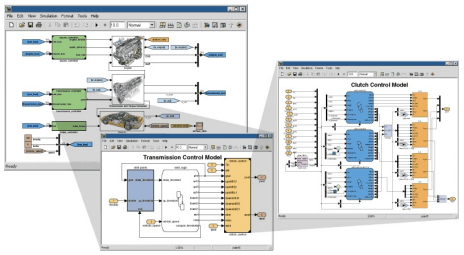
State of the Art

modelling

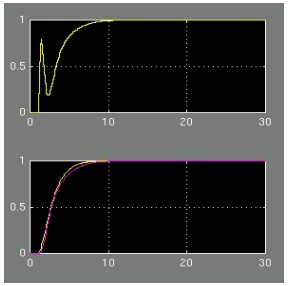


State of the Art

modelling



simulation
debugging



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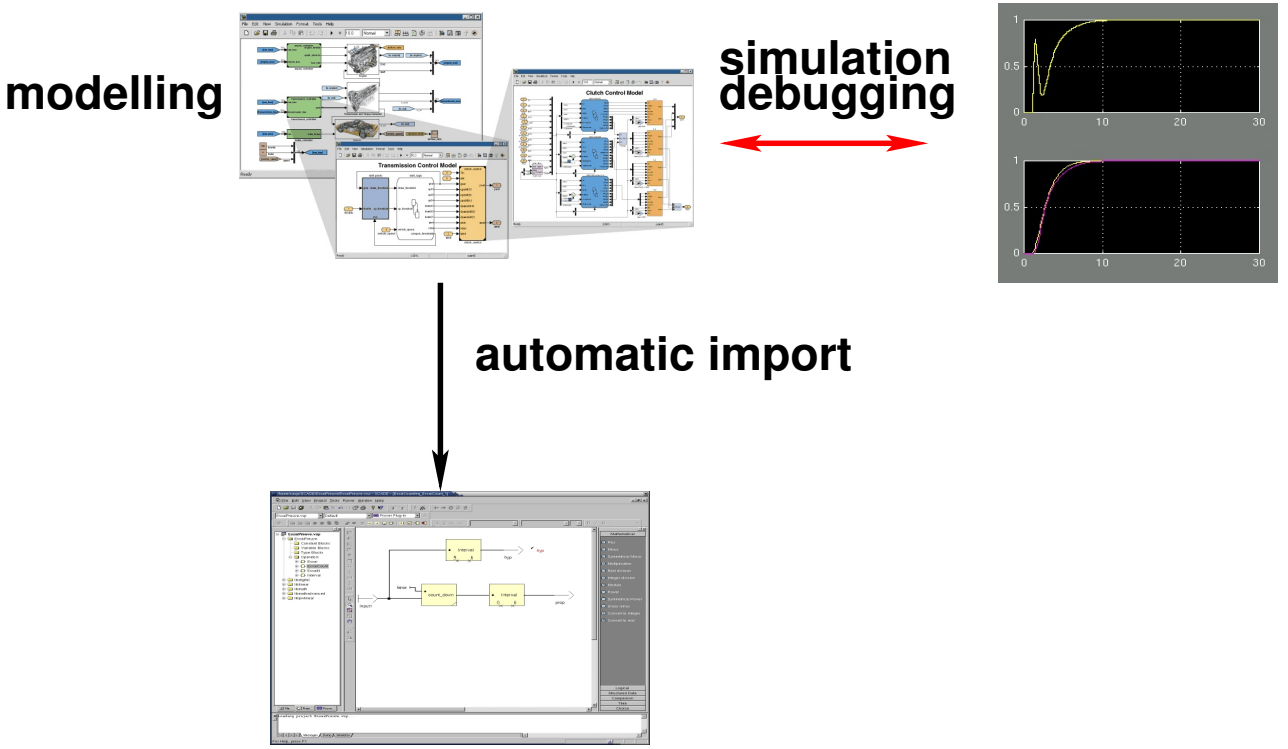

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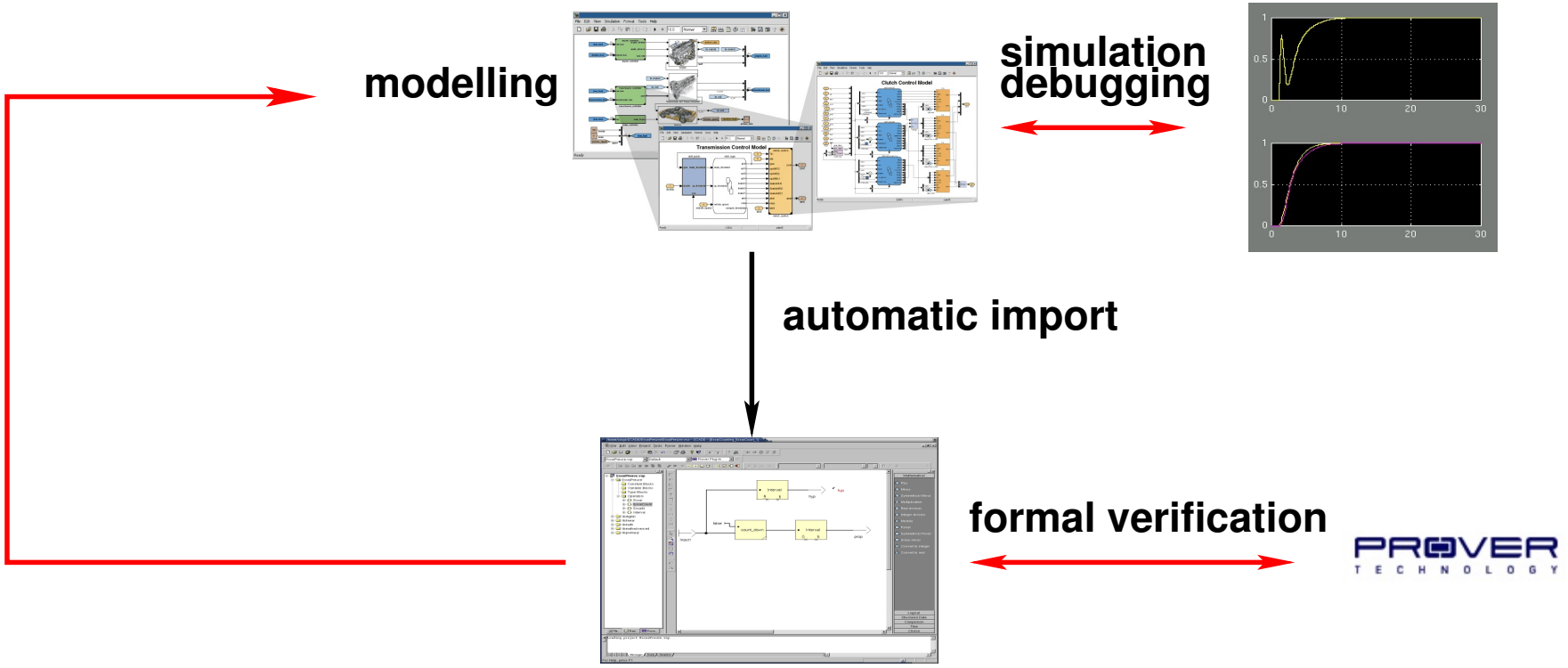

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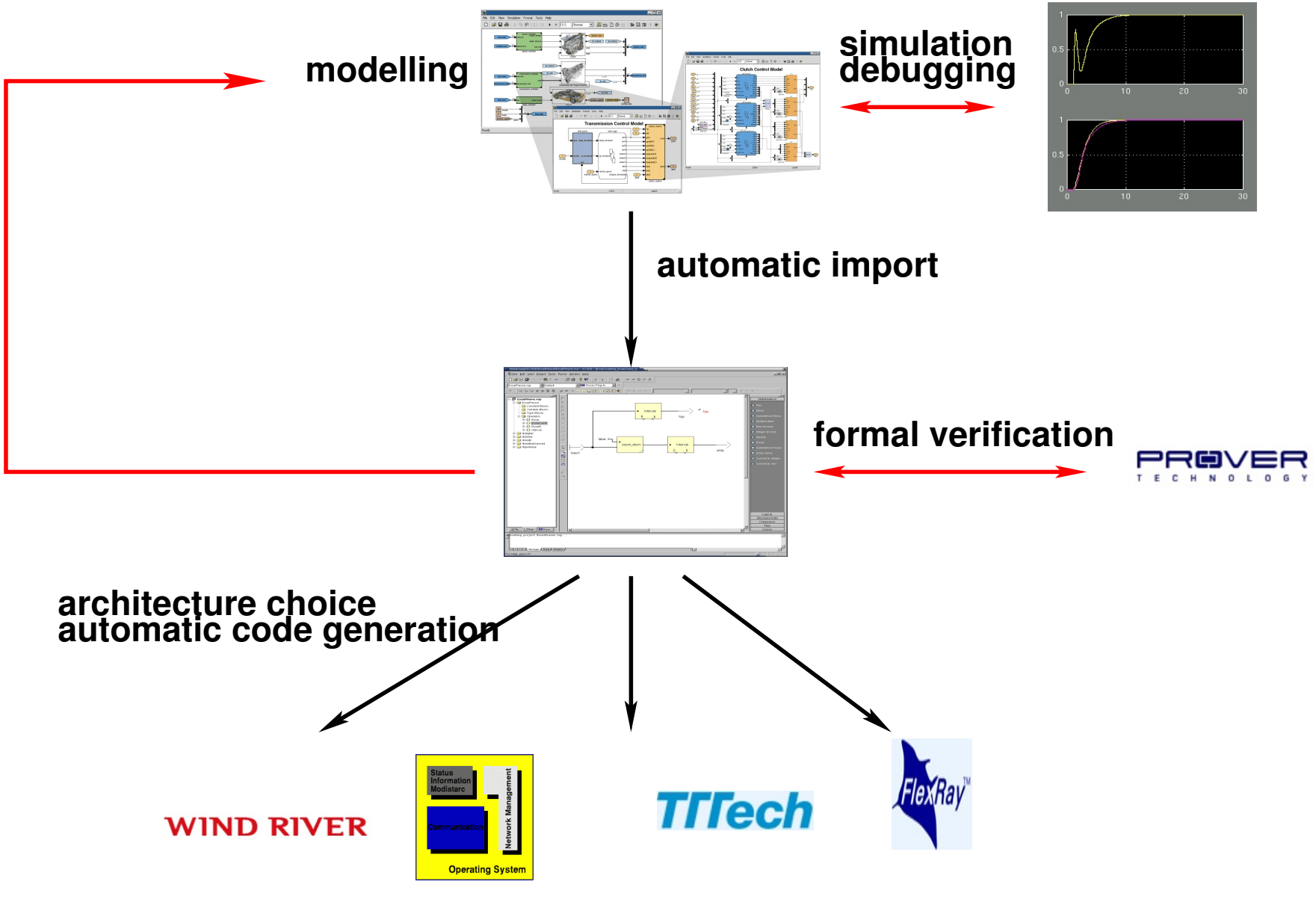

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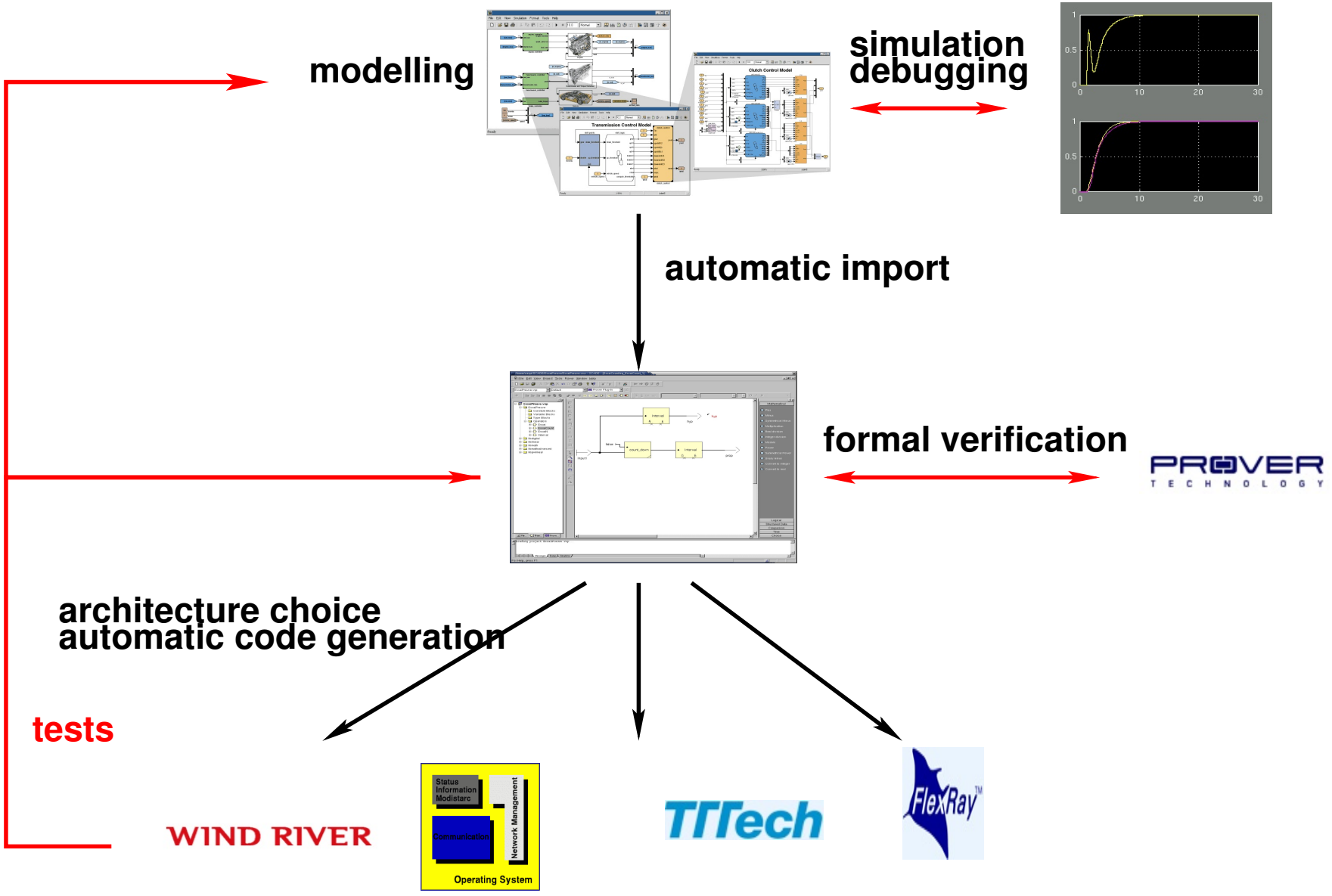
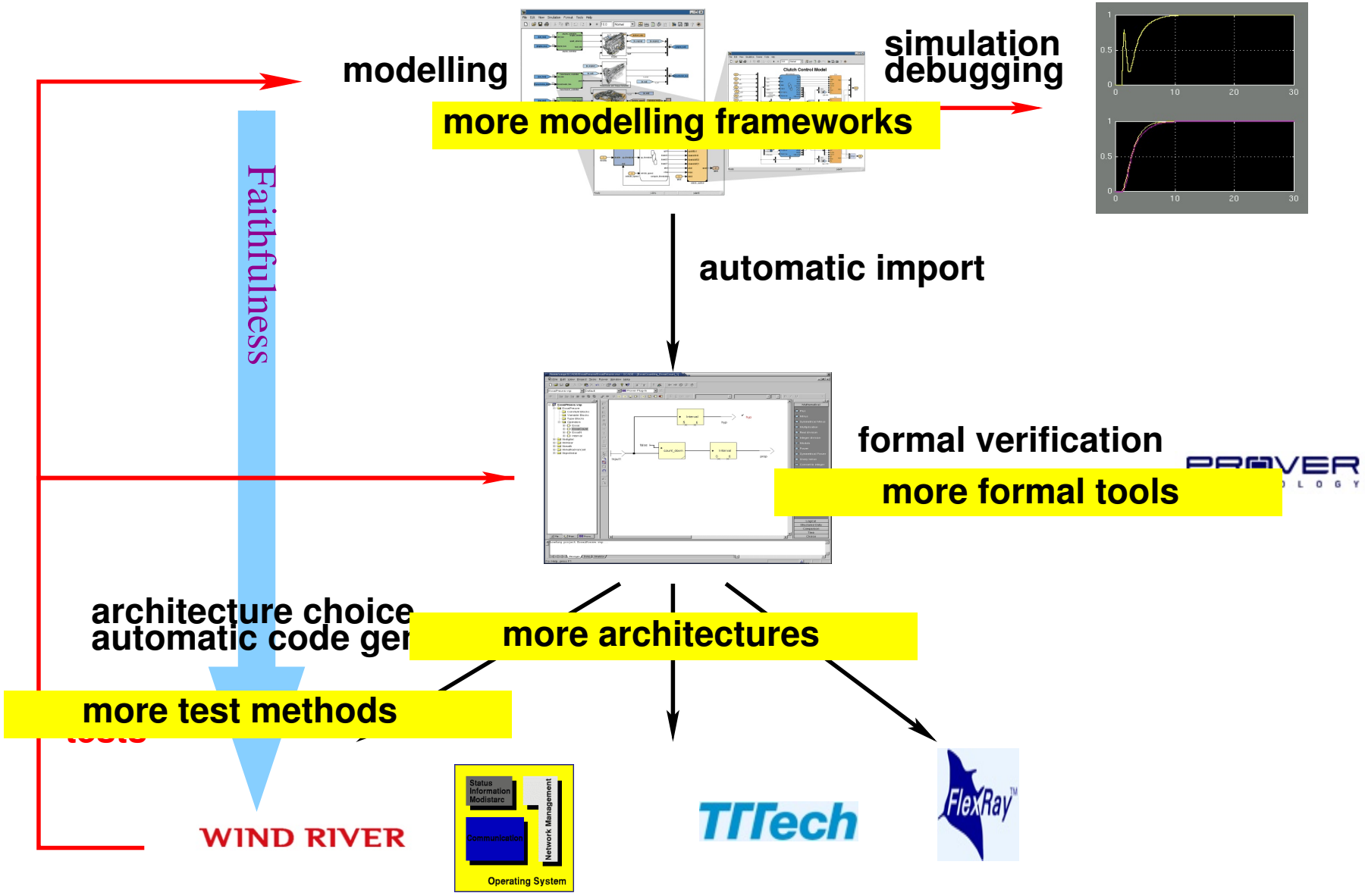


Perspectives



Perspectives

- more modelling frameworks:

  networks, telecommunications, ...

- more powerful formal methods

- more execution platforms

  CAN, Ethernet, Internet, ...

- more test methods

A Key Issue: Faithfulness

What you { *model* / *simulate* / *prove* } **is what you** { *implement* / *execute* }

Implantation sûre de systèmes contrôle/commande _

Implantation sûre de systèmes contrôle/commande _

- **”sûre” ?**

  Étudier et expérimenter les méthodes qui permettent de garantir que l’implémentation respecte de *bonnes* propriétés :

  - **temps-réel : notion relative, beaucoup de paramètres (matériel/logiciel)**
  - **déterminisme : essentiellement liée au logiciel, à l’exécutif (OS).**

- **N.B. nécessaire/requis pour les systèmes critiques (on parle de ”hard real-time”).**

Implantation sûre de systèmes contrôle/commande (suite)

But du cours

- Voir les méthodes classiques de conception/implantation sûres :
  - synchrone ”pur” : systèmes échantillonés, mono-tâche, sans exécufif (i.e. sans OS)
  - relachement du synchronisme, multi-tâches déterministe
- Expérimenter sur la brique Lego :
  - pas vraiment ”critique”, mais ...
  - suffisemment simple et représentatif pour illustrer les principes.