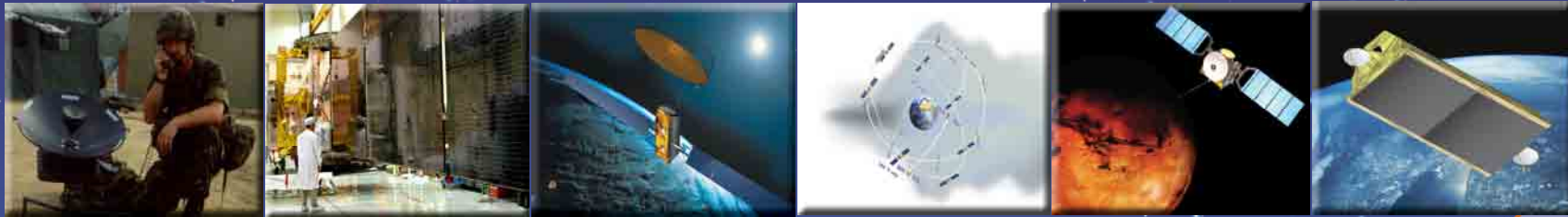


# SIMAGE

From rapid prototyping to end to end performance simulation for imaging payloads



*Umberto POLVERINI - Vivian LARRIEU*  
*Astrium Satellites // Modelling, Tools and Simulations*

*SESP08 09/10/08*

All the space you need



# SIMAGE

## ■ Introduction

- Image processing activities in Astrium: Why SIMAGE ?
- History of SIMAGE

- **SIMAGE V6**
- **SIMAGE applications**
- **Conclusions**

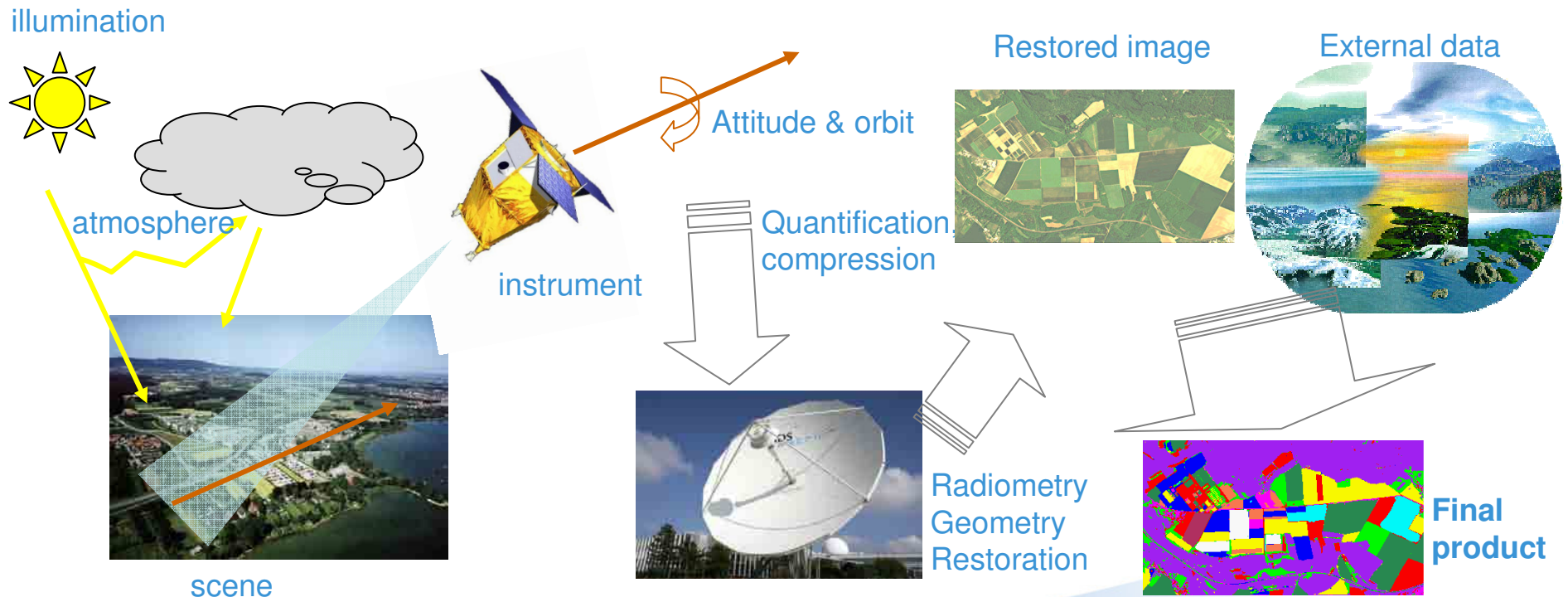
# SIMAGE an image toolbox

- From rapid prototyping to end to end performance simulation for imaging payloads
- An expertise necessary to support Prime activities
  - During phase **A B C D E** : Understanding of the final user's needs
    - show to the customer a final image product
    - capture the requirement
  - During phase **A B C D E**: Optimizing the design
    - relax instrument/satellite definition with processing techniques to improve the final image products
    - image quality performances budgets
    - derive instrument / AOCS / ground segment specification
  - During phase A B **C D** E: validating the development
    - Generation of images and products for system validation
  - During phase A B C D **E** : In orbit performance validation & monitoring

Rapid prototyping

End to End perfo

# SIMAGE E2E imaging payload simulation



# E2E simulation impact on design

A: Small instrument  
MTF = 0.10

Blurred

B: Large instrument  
MTF = 0.30

sharp

A instrument +  
ground restoration

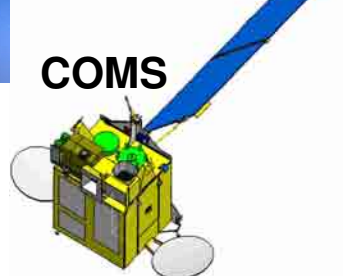
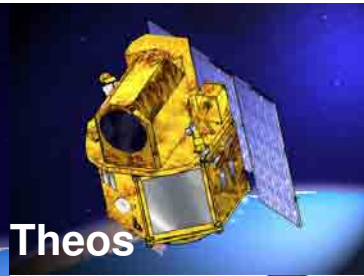
sharp

Preferred  
Design

# SIMAGE is used for many EO programs



Export



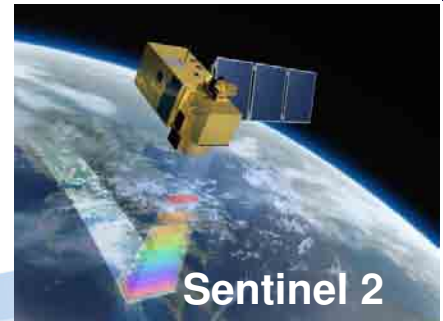
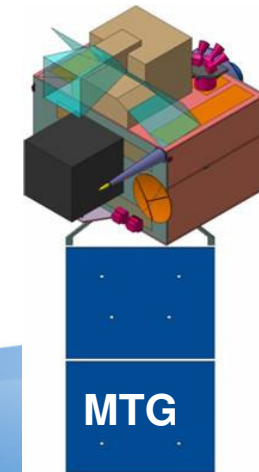
EADS



France

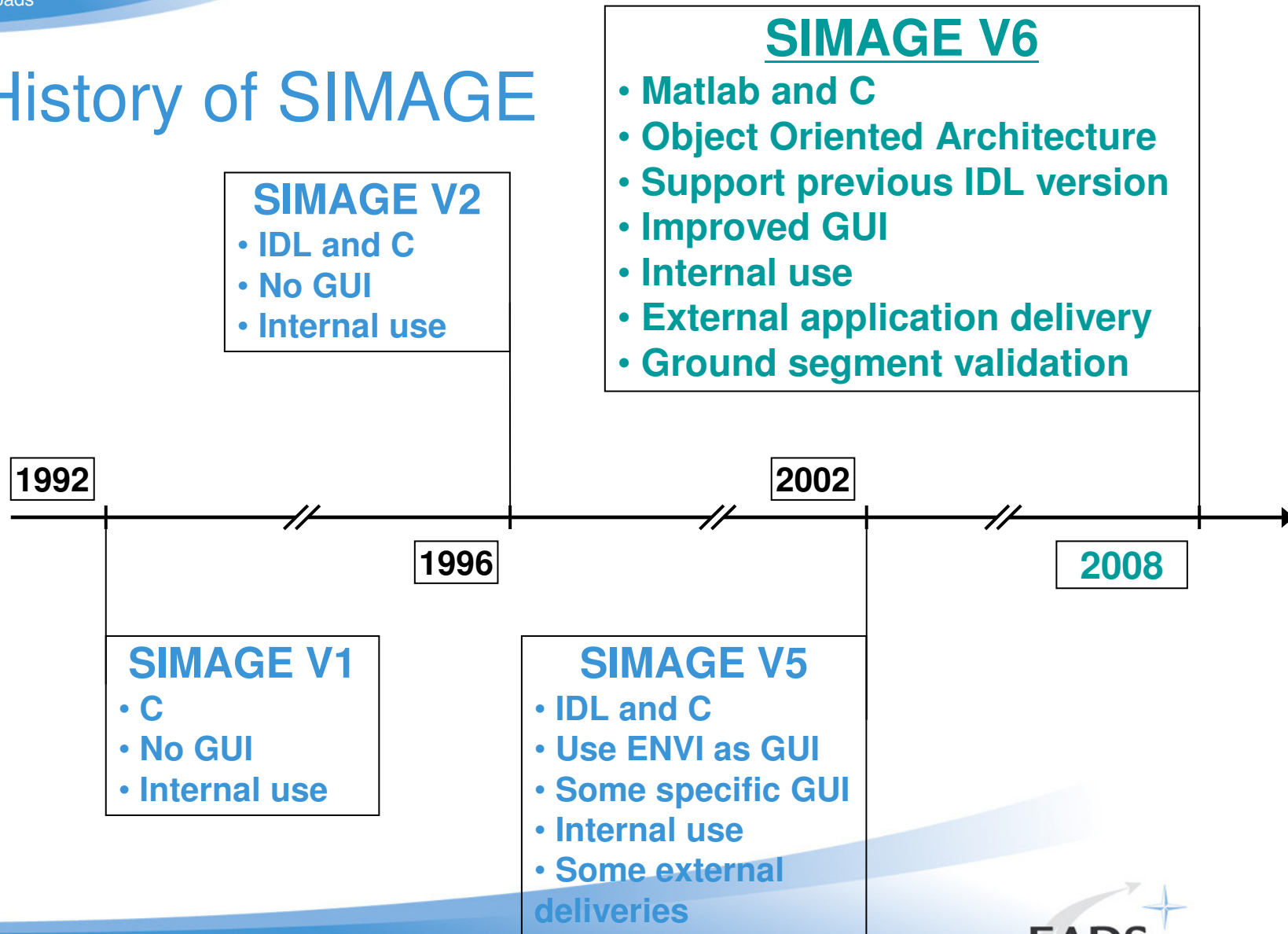


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# History of SIMAGE



## ■ Introduction

### ■ SIMAGE V6

- Main characteristics
- Capitalization process
- GUIs

### ■ SIMAGE applications

### ■ Conclusions





# SIMAGE

## SIMAGE V6

- SIMAGE V6 is a major upgrade
- A new design
  - Fully Matlab
  - An integrated Matlab SIMAGE ToolBox
  - An Object Oriented Architecture
  - Support of industry standard (GeoTiff, ENVI file, XML file, Shape file)
  - A robust framework (with trace, log file, etc.)
- A capitalization process
  - Supporting the whole R&D prototype to operational software transition
  - An interactive help system & a WIKI based documentation
- New GUIs
  - A customizable simulation control GUI
  - An image viewer

⇒ Final version for **end of 2008**

## Why Matlab ?

- A large collection of functions
  - Matlab toolboxes / File Exchange / Large Internet library
  - ⇒ 80% of common processing are into Matlab
  - ⇒ Need to implement “only” state-of-the-art algorithms and space-specific algorithms
- A large user community
- Allows fast prototyping (interactive shell)
- Easy to use IDE (Shell, Editor, Debug tools)
- State-of-the-art language
  - High level, Objects, ...
  - Java I/F, C I/F, ...
- Used in Astrium from R&D to operational SW

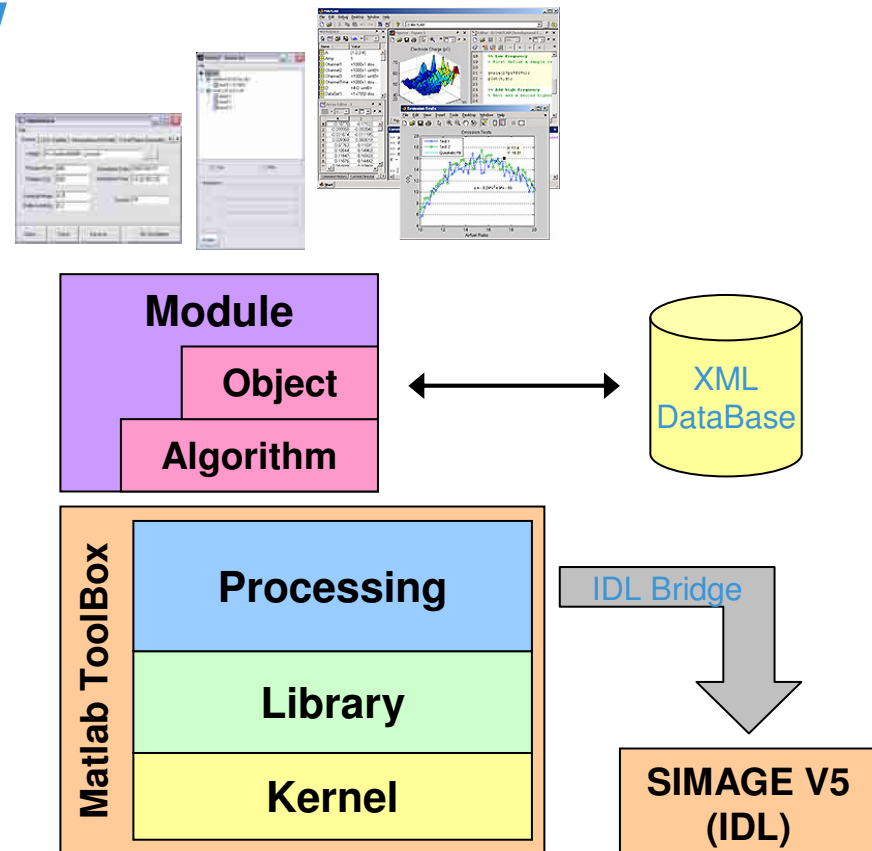
# SIMAGE V6 Overview

## ■ Module level

- **Algorithm:** Processing sequences
- **Object:** High level models
- **Module:** Interface with other applications

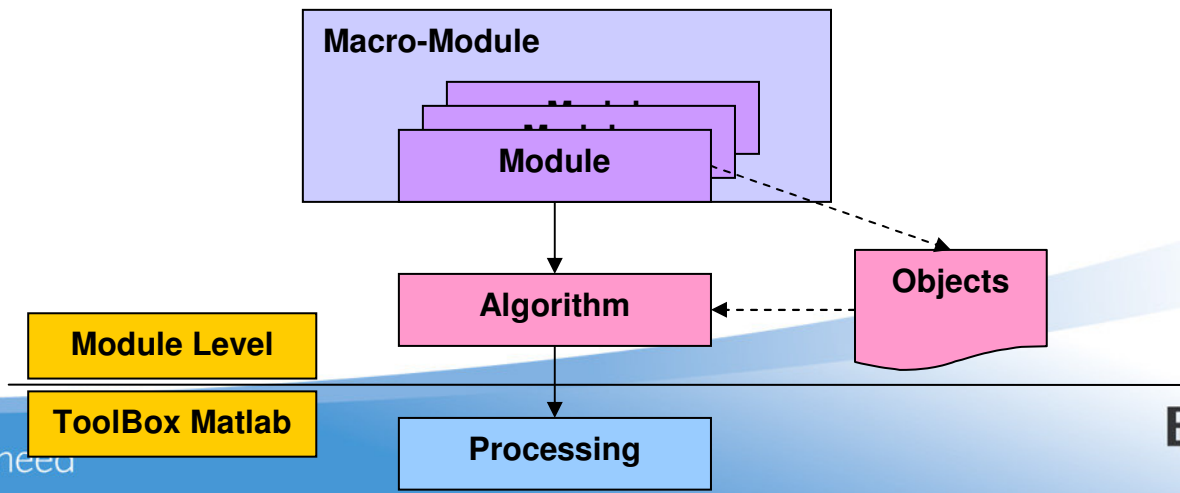
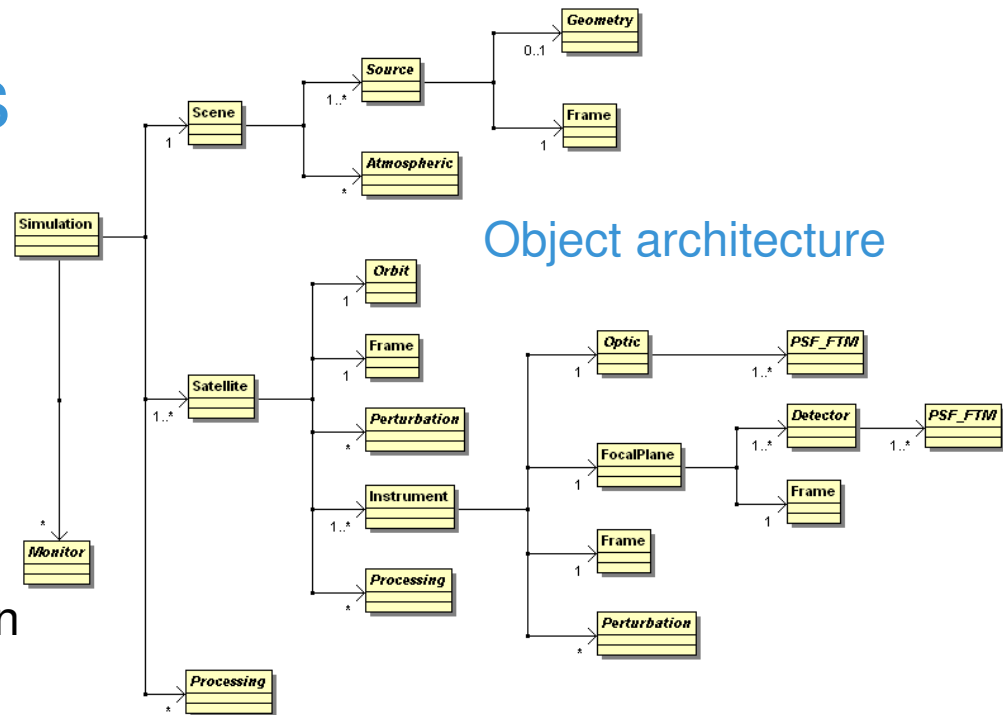
## ■ « Matlab ToolBox » level

- **Kernel:** Low level functions
- **Library:** Mathematic functions
- **Processing:** Image processing



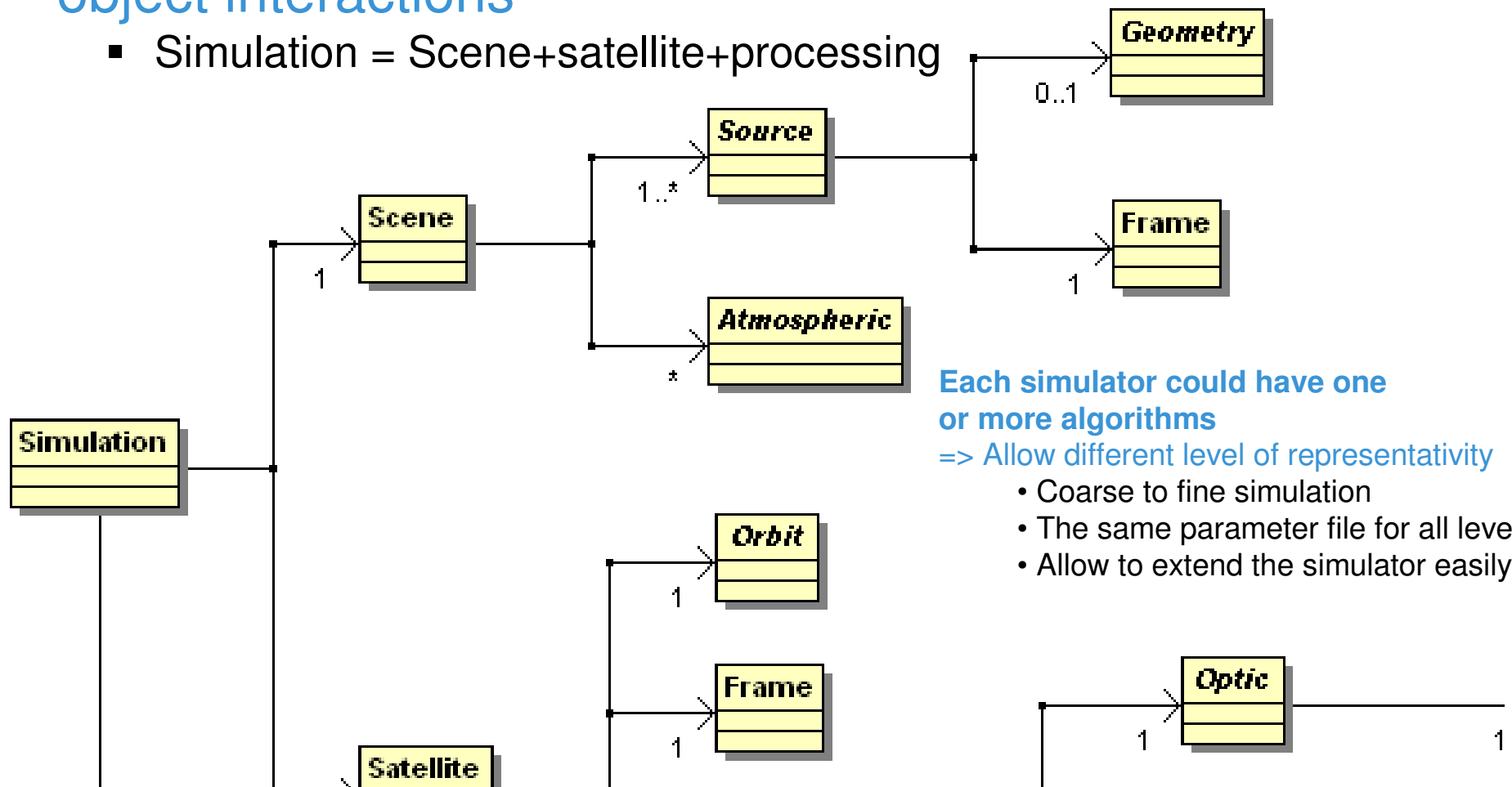
# Modules - Principles

- High level functions
  - Image simulators
  - Registration tool
  - Ground processing tool
- Organisation
  - Objects to define models
  - Algorithms to define skeleton (processing sequence)



# Object oriented architecture

- A Simage simulator is a “Module”, built through object interactions
  - Simulation = Scene+satellite+processing



Each simulator could have one or more algorithms

=> Allow different level of representativity

- Coarse to fine simulation
- The same parameter file for all level
- Allow to extend the simulator easily

## Validation & versions

### ■ Use of MUnit for automatic test

- Validation plan automation
- Non regression
- Used for each module/algorithm/processing

<http://xtargets.com/cms/index.php>

### ■ Use of a coverage tool

- Build on Matlab 'profile' tool
- Integrated into our validation framework
- Allow to test branch coverage
- Automatic report of non-covered line of code

### ■ Versions: V6.x.y

- y changes: patch and bug corrections without impact on I/F
- x changes: new functionalities or I/F modification

# SIMAGE: A capitalization process

- Supporting the whole R&D prototype to operational software transition

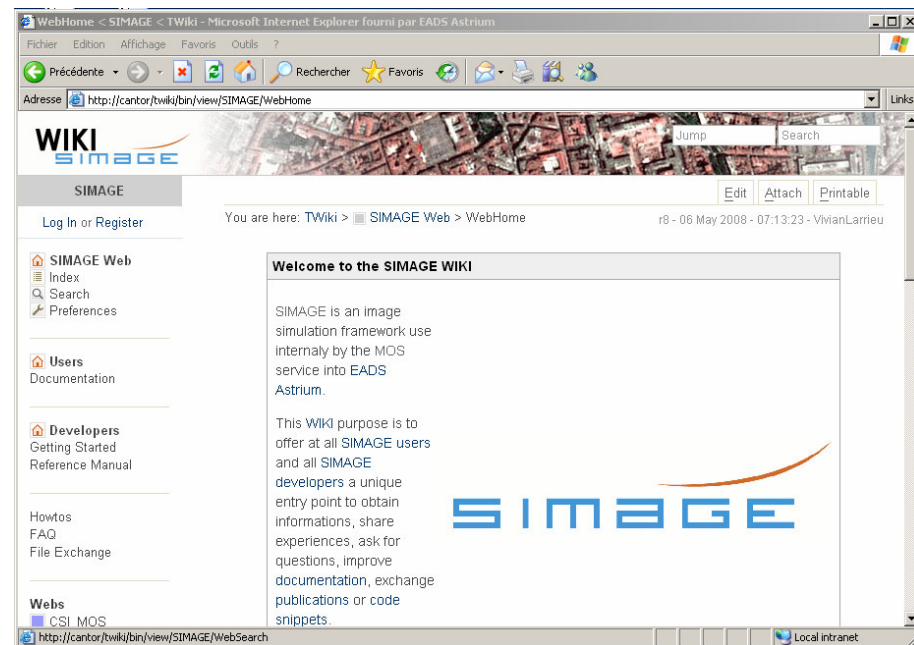
## Incremental approach

- Level 1: prototype “as is” with a technical note description
  - Rapid prototyping using Simage without constraint
  - Inform others that the function exist
- Level 2: level 1 + code cleaned for sharing
  - Involve some robustness and error handling effort, I/F control, ...
  - The code can be used by others in R&D
- Level 3: level 2 + code adaptation, integration and validation
  - Full implementation of Simage standard (rules for comments, coding, automated testing, large image/tiling implementation, documentation), supported/done by SIMAGE maintenance team
  - The code is validated and operational

# SIMAGE: A capitalization process

An interactive help system & a WIKI based documentation

- Fast access to information for rapid prototyping
  - One of Matlab strength is the interactive help system
- A Wiki support the incremental capitalization
  - a unique entry point to obtain informations, share experiences, ask for questions, improve documentation, exchange publications or code snippets.





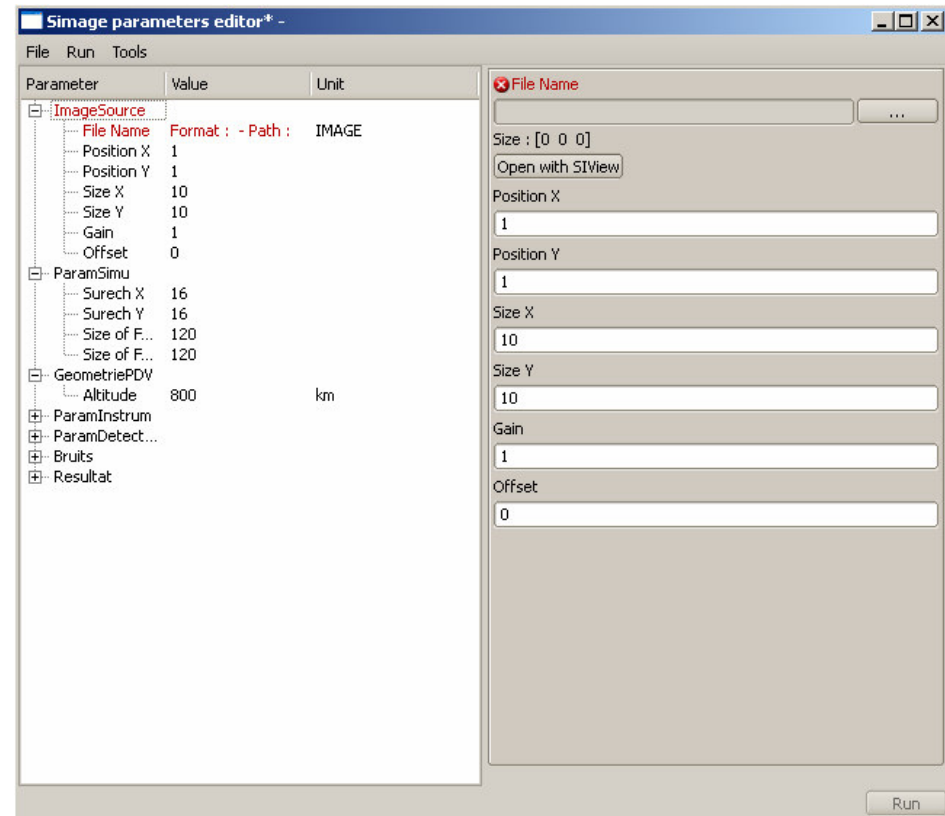
## Customizable GUI

- Used to parameterize simulation
- Based on



## libraries

- QT/C++
  - Use an XML definition to describe content
  - Provide Control / conditions / help facilities
- Handle context values & overload
    - Possibilities to make loops or Monte-Carlo



# Image viewer

- Based on Matlab
- Three windows
  - Overview
    - Display entire image
    - Draggable view area
  - View
    - Display view area
    - Resolution 1:1
    - Draggable zoom area
  - Zoom
    - Display zoom area
    - Custom zoom factor
    - Target mode
    - Pixel information
    - Spectrum viewer



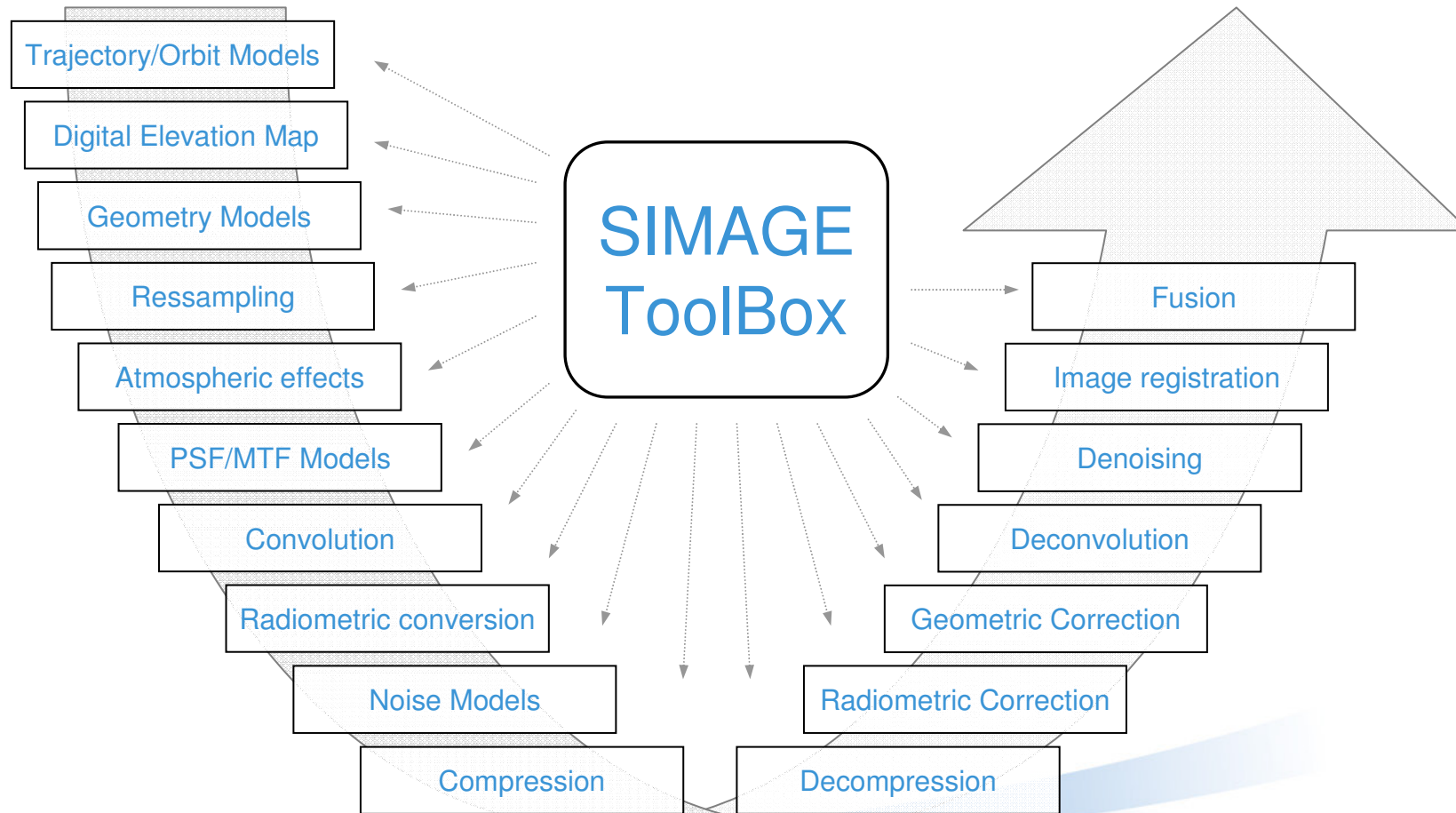
- **Introduction**
- **SIMAGE V6**
- **Handling large images**

- **SIMAGE applications**

- Image processing themes
- Example of ground processing

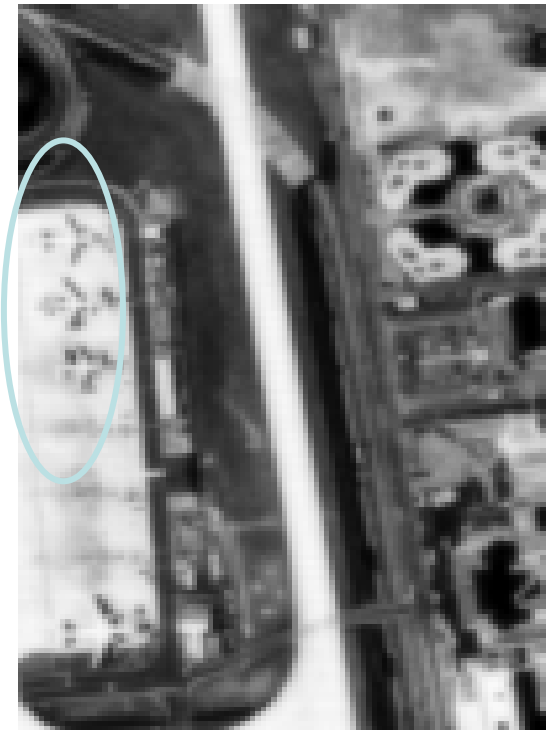
- **Conclusions**

# Image processing themes

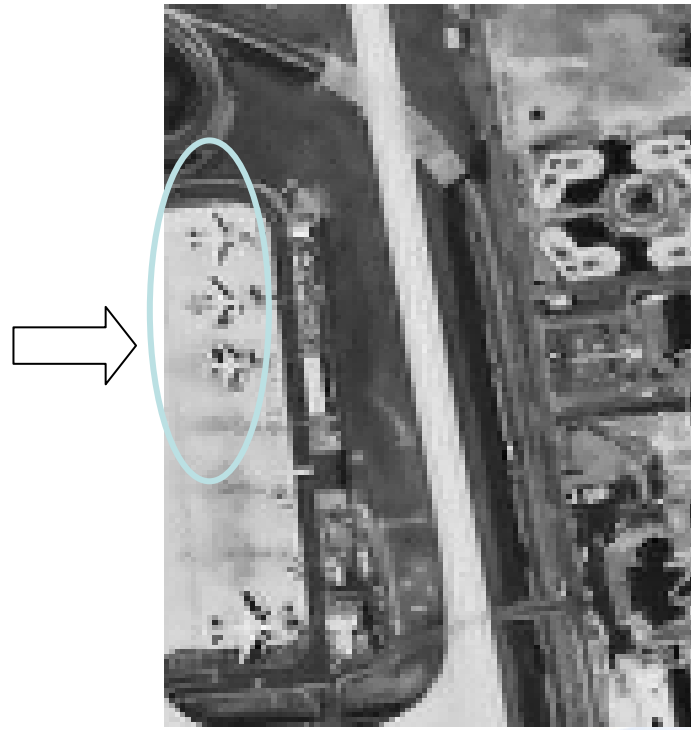


## Example: Image restoration

Blurred raw image



Restored image



Wavelet denoising  
+ deconvolution

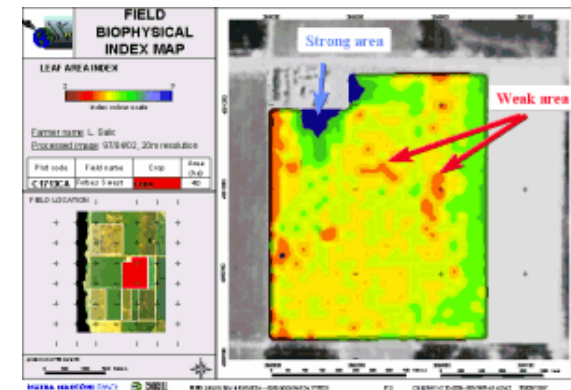
# Registration

## ■ Methods

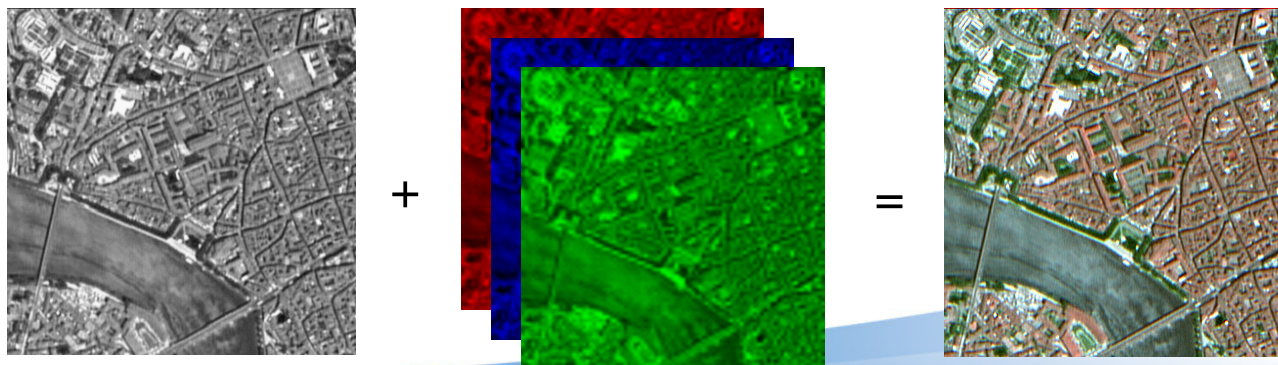
- Correlation, differentiation, Entropy
- Hierarchical approaches
- Spline based optimisation

## ■ Applications

- Image enhancement (Super resolution)
- Data fusion, multi spectral analysis, pan sharpening

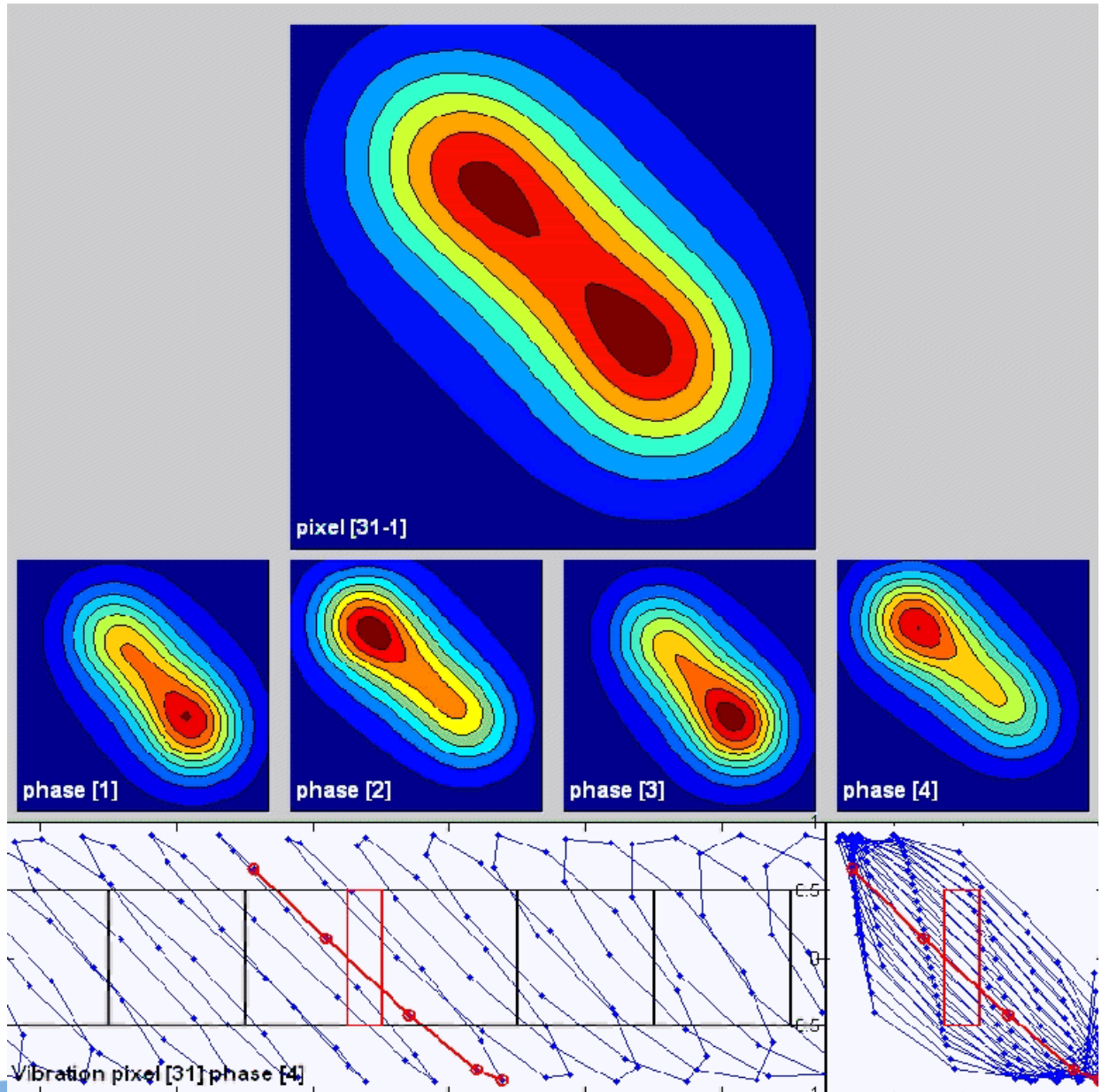
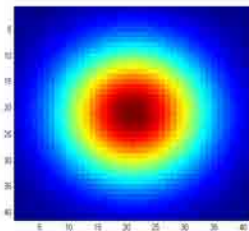


Multi-Super Spectral image analysis



# $\mu$ vibration Blurring effect

- PSF degradation
  - high frequency  $\mu$ vibration for 4 stage TDI (Time Delay Integration) detector



- Introduction
- SIMAGE V6
- Handling large images
- SIMAGE applications

- Conclusions



# Conclusions

## ■ New SIMAGE version

- Allows fast prototyping
- Allows E2E simulation
- Strong modularity
- Reusable & validated component
- Allows to create deliverable application
- Provide a capitalization process