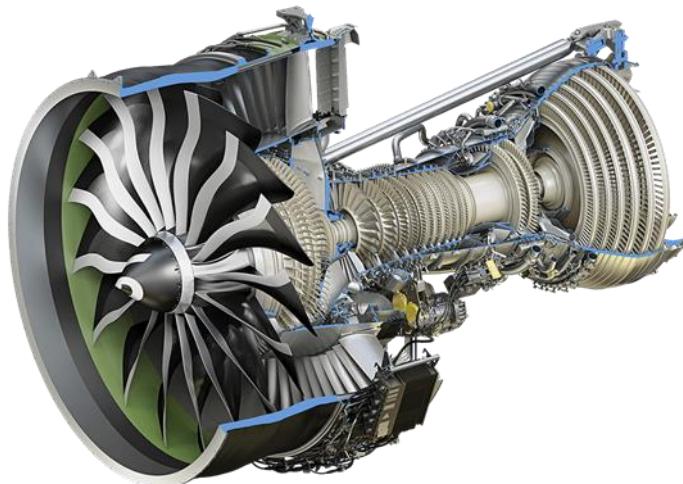




Contrôle non destructif de
pièces aéronautiques en CMC
par tomographie à rayons X

Olivier Rodriguez, président

Composites à matrice céramique



Moteur General Electrics GE9X du Boeing 777X
[Image credit: GE Aviation]

Remplacement des alliages métalliques :

- ✓ plus légers
- ✓ plus résistants à la chaleur
- plus efficaces
- durée de vie en opération plus longue

Composites à matrice céramique

Pièces internes moteur :

- Matrice fibreuse
- Propriétés de *transport et écoulement* de la phase non fibreuse
- Analyse automatique de *sensibilité aux paramètres* de segmentation



Anneau de turbine



Aube de turbine

Composites à matrice céramique



Anneau de turbine



Aube de turbine

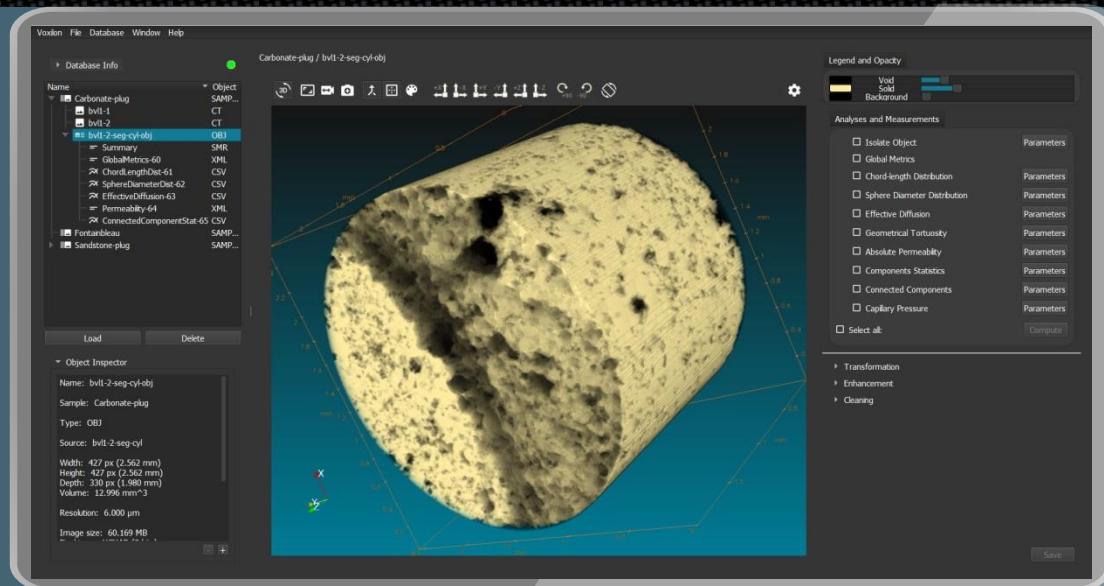
Pièces internes moteur :

- Matrice fibreuse
- Propriétés de *transport et écoulement* de la phase non fibreuse
- Analyse automatique de *sensibilité aux paramètres* de segmentation

Missions de Voxilon

Se rapprocher au plus près de l'analyse temps réel

- ✓ Orienté vers les résultats
- ✓ Simulations rapides et fiables
- ✓ Interface facile à maîtriser



Workflow Data-to-Results



Voxilon is



a 3D image database management system

Easily manage and access all your tomographic data and related files



a 3D image visualization and processing software

Visualization and image processing filters in an easy-to-tame interface

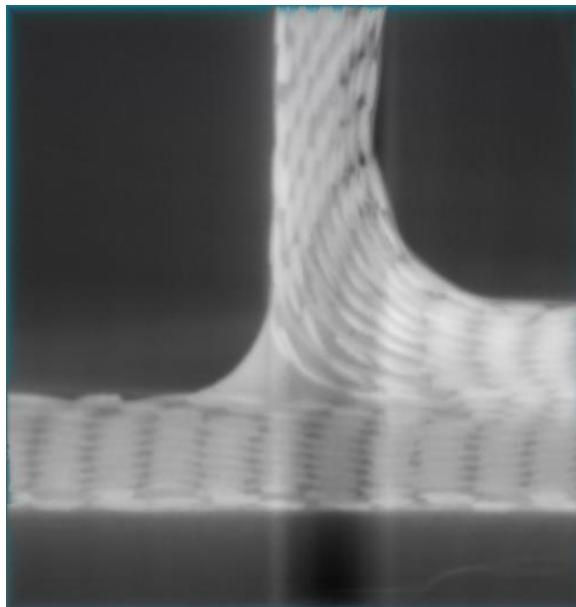


a numerical simulation platform

Simple yet powerful, Voxilon is easily extendable

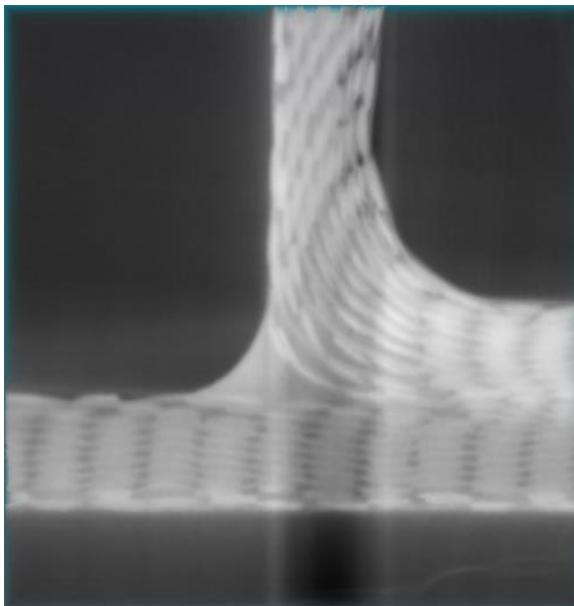
Voxilon is the integrated, workflow-driven numerical material analysis software.

Beam hardening

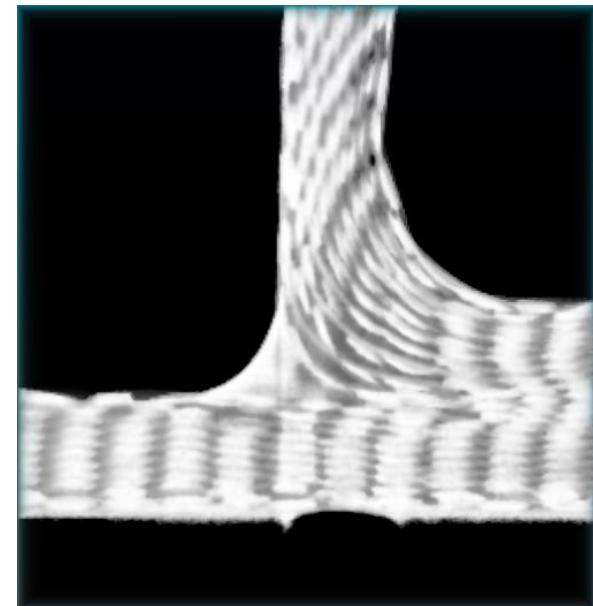


*Coupe d'une image tomographique
avant correction du beam hardening*

Beam hardening corrigé

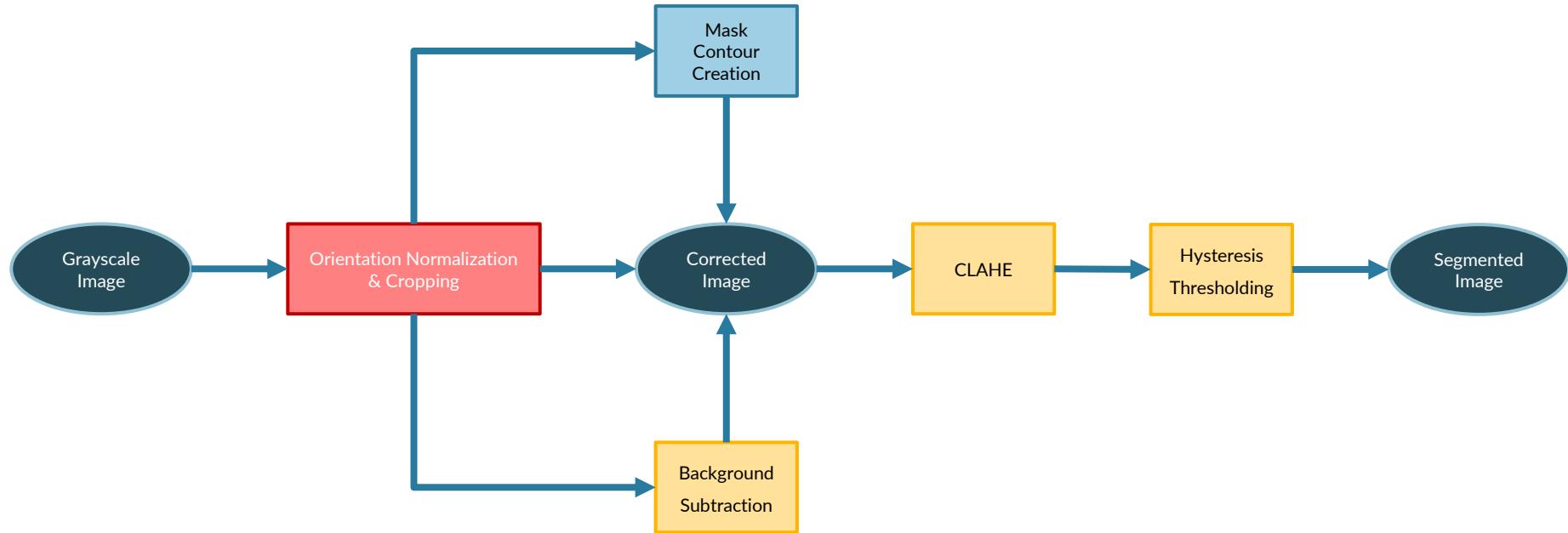


*Coupe d'une image tomographique
avant correction du beam hardening*

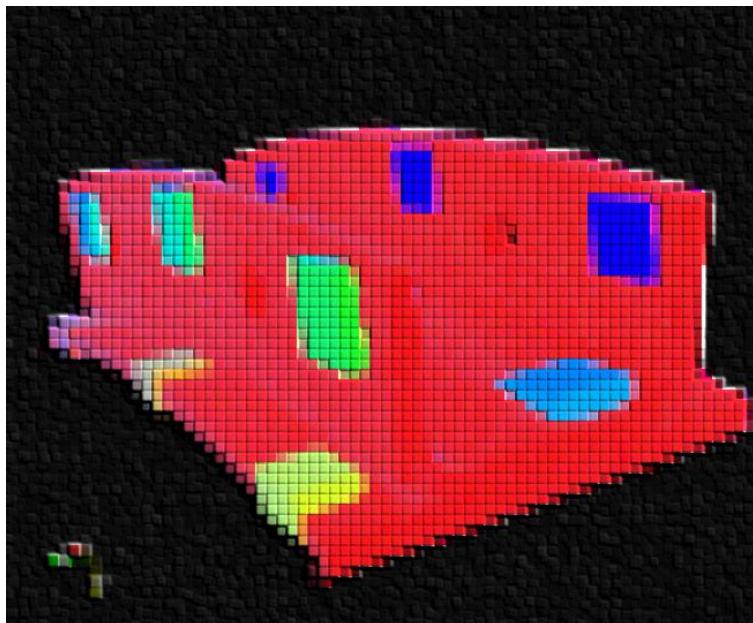


*Coupe d'une image tomographique
après correction du beam hardening*

Segmentation



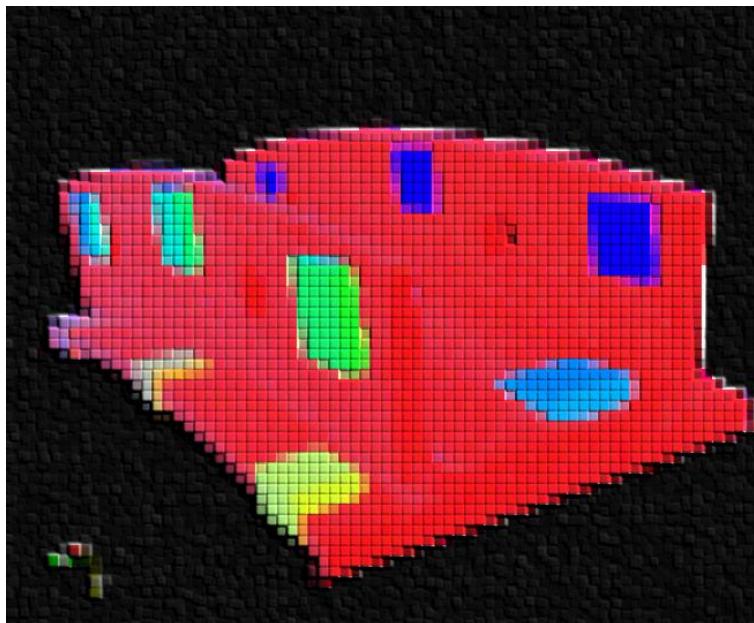
Analyses



Définition de propriétés locales :

- 15 ROI par image
 $200 \times 200 \times 100$ voxels
- 200 translations par ROI
- 12 images
- 36 000 ROI à analyser

Analyses



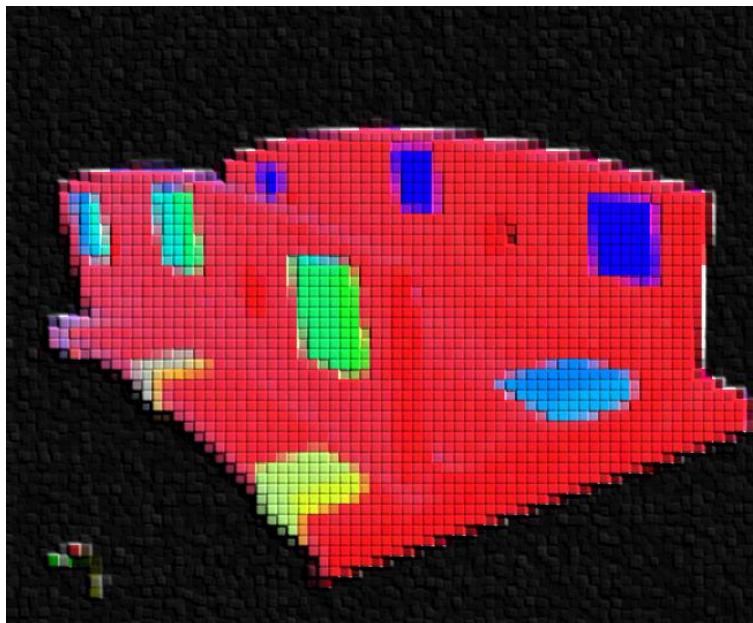
Sur toute la pièce :

- ✓ Porosité globale
- ✓ Porosité locale

Sur chaque ROI :

- ✓ Tortuosité géométrique
- ✓ Perméabilité
- ✓ Distribution de pores et gorges
- ✓ Diffusion effective

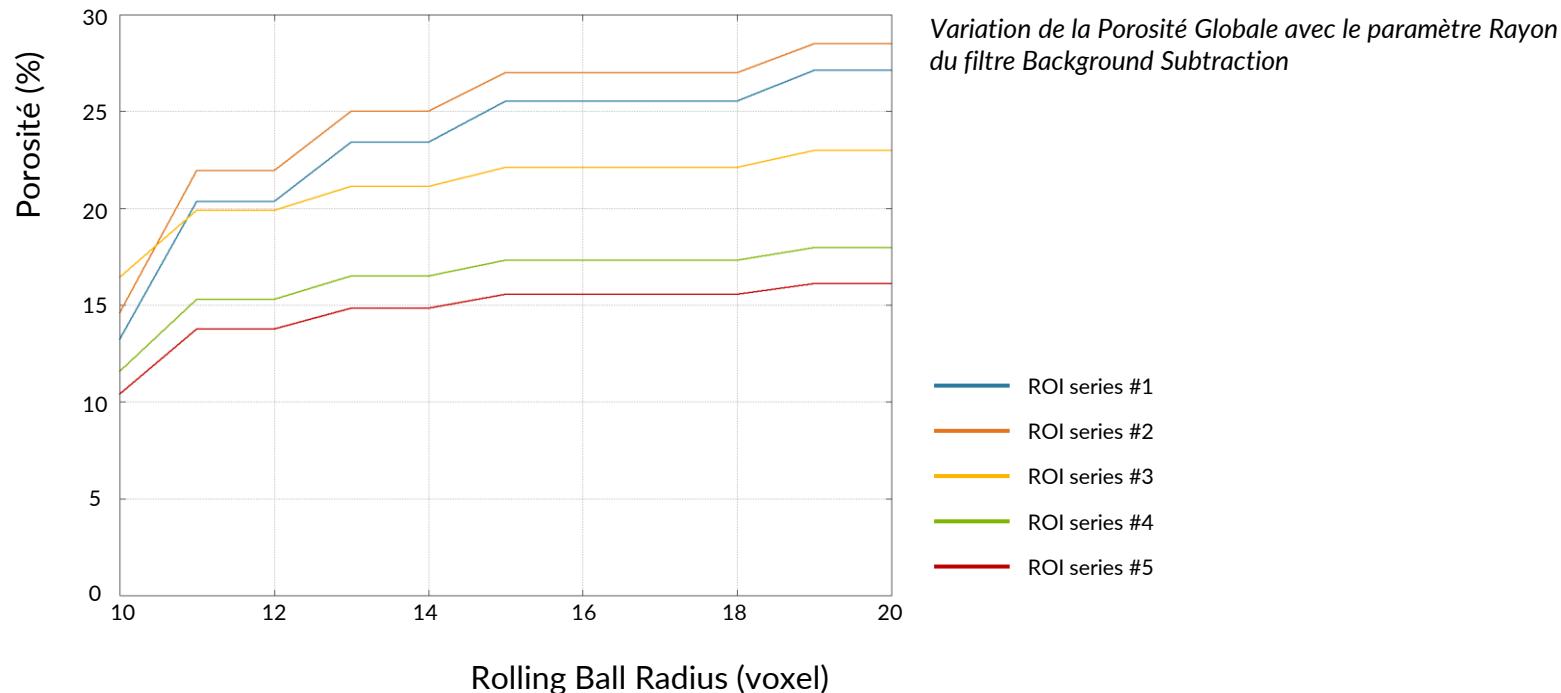
Analyses



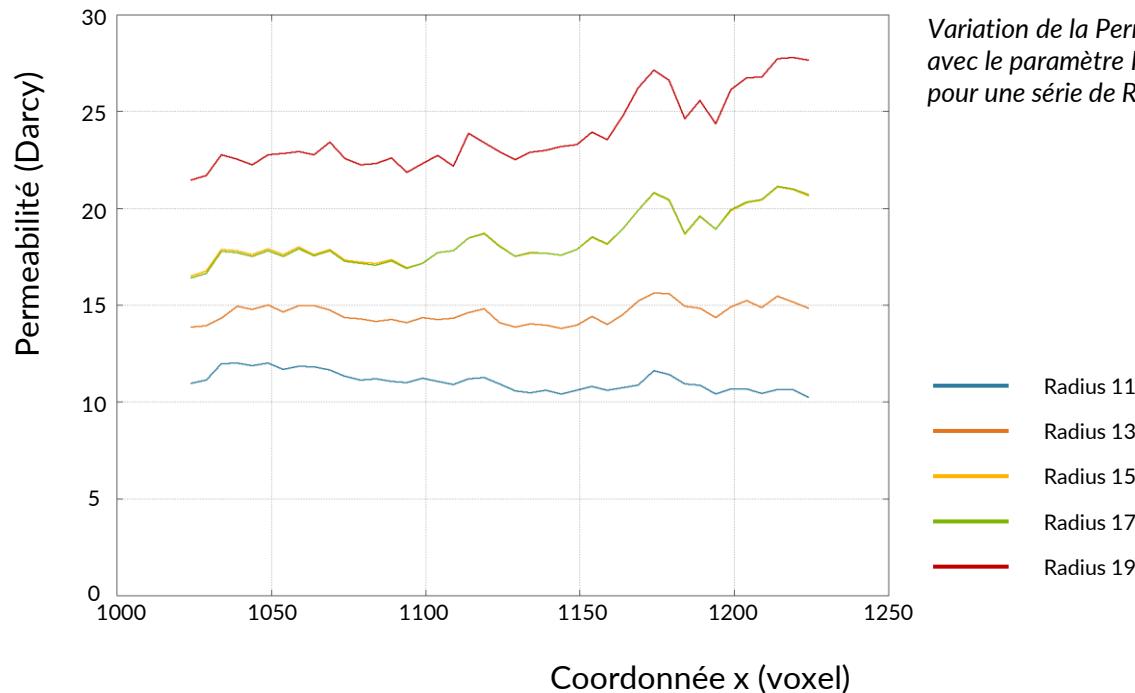
<i>Propriété locale</i>	<i>Durée moyenne</i>
Porosité	21 s
Perméabilité	38 min
Diffusion Effective	21 min
Tortuosité Hydraulique	22 min
Diamètres de pores & gorges	09 s

Temps de calcul pour une série de 200 ROI avec Voxilon

Etude de sensibilité (ex. 1)



Etude de sensibilité (ex. 2)



Variation de la Perméabilité Absolue dans la direction x avec le paramètre Rayon du filtre Background Subtraction pour une série de ROIs

Conclusion



Rapidité

Vitesse des calculs



Flexibilité

Scripting

Calculs asynchrones



Organisation

Gestion d'une base de données

Contact



rodriguez@voxaya.com



+33 6 32 02 74 22

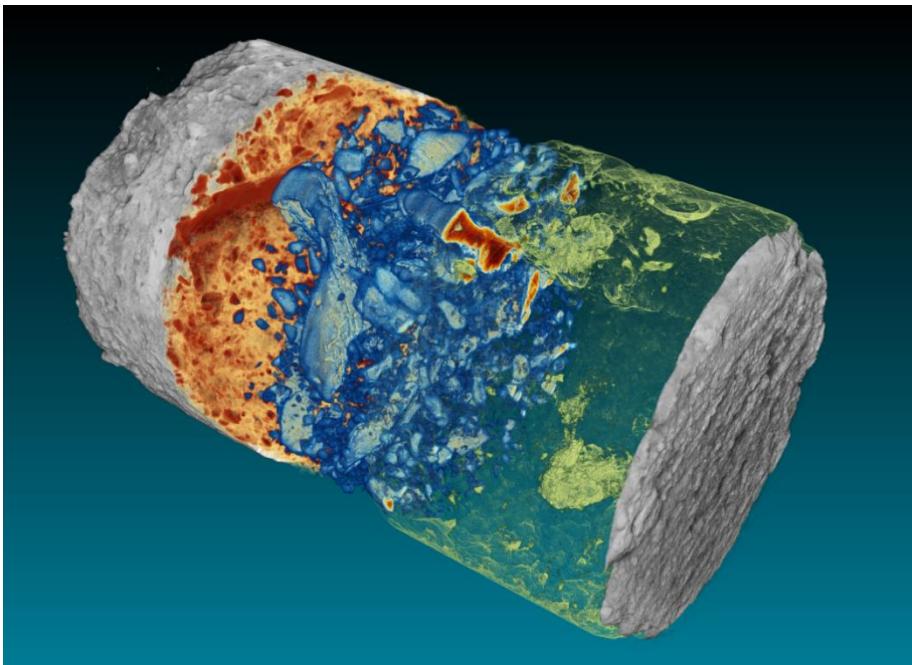


www.voxaya.com



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FRANCE

Digital Material Analysis Flaws



Voxilon is



a 3D image database management system

Easily manage and access all your tomographic data and related files



a 3D image visualization and processing software

Visualization and image processing filters in an easy-to-tame interface



a numerical simulation platform

Simple yet powerful, Voxilon is easily extendable

Voxilon is the integrated, workflow-driven numerical material analysis software.

Key Benefits



Fast

Swiftly get representative data
from your high resolution 3D
images
with Voxilon's tailored algorithms



Flexible

Never get stuck again

Keep on working while your most
demanding computations are running,
thanks to Voxilon's modular architecture.



Organized

Organize your projects

Instantly access your images and data
from your own secured database,
within Voxilon's easy-to-tame interface.

Key Benefits



Fast

Swiftly get representative data

from your high resolution 3D
images

with Voxilon's tailored algorithms

State-of-the-art algorithms

15 years of research from our founding team in Geosciences Montpellier (CNRS / University of Montpellier).

	Permeability (mD)	Computation time
OpenFOAM	586	27 hours <small>DELL R820 rack server 96 cores / 1TB RAM</small>
IFPEN lab	569-886	3 to 4 hours
IFPEN algorithm	433	~1 hour
Voxilon	552	38 seconds

*Computations made on a Berea sandstone image provided by IFPEN (269_Ftb_GW3)
Hardware setup: HP Z840 workstation 32 cores / 256 GB RAM*

Key Benefits



Fast

Swiftly get representative data
from your high resolution 3D
images
with Voxilon's tailored algorithms

State-of-the-art algorithms

15 years of research from our founding team in Geosciences Montpellier (CNRS / University of Montpellier).

HPC expertise

Our R&D team includes experts in scientific code optimization.

Academic partnerships

Our key partners include IFPEN and DMEX (University of Pau / Carnot ISIFoR).

Key Benefits

Possible configurations



Flexible

Never get stuck again

Keep on working while your most demanding computations are running, thanks to Voxilon's modular architecture.



Single Laptop

Key Benefits

Possible configurations



Flexible

Never get stuck again

Keep on working while your most demanding computations are running, thanks to Voxilon's modular architecture.



Single Workstation

Key Benefits

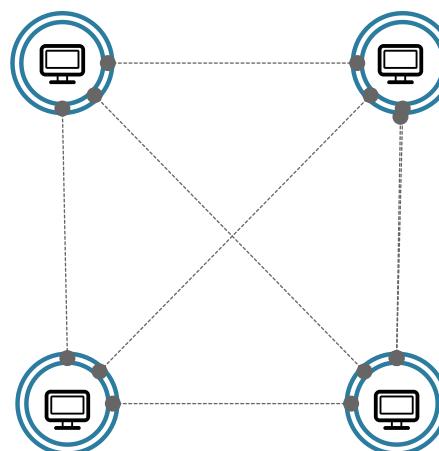


Flexible

Never get stuck again

Keep on working while your most demanding computations are running, thanks to Voxilon's modular architecture.

Possible configurations



Local Network

Key Benefits

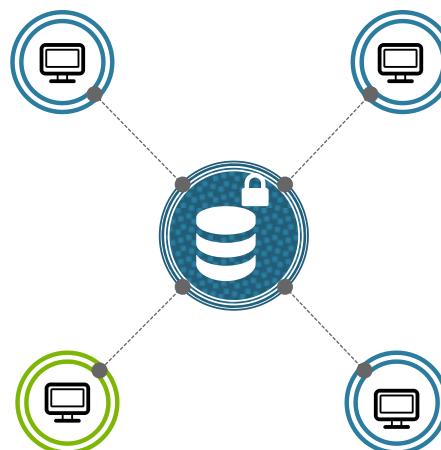


Flexible

Never get stuck again

Keep on working while your most demanding computations are running, thanks to Voxilon's modular architecture.

Possible configurations



**Local Network
with File Server**

Key Benefits

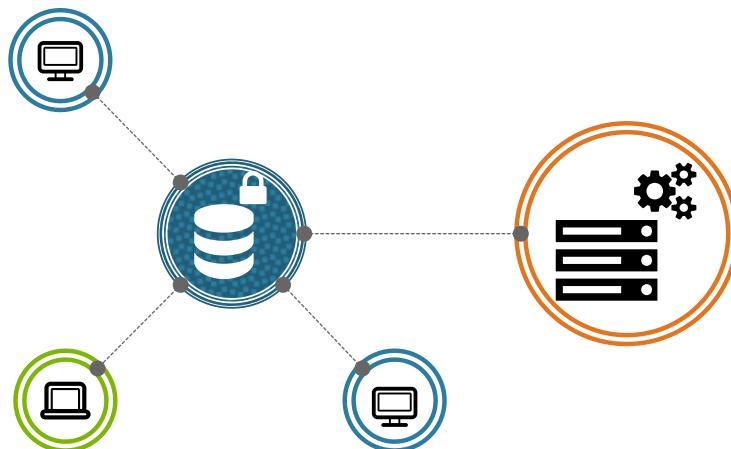


Flexible

Never get stuck again

Keep on working while your most demanding computations are running, thanks to Voxilon's modular architecture.

Possible configurations



**Local Network
with HPC Cluster**

Key Benefits

Coming Soon



Flexible

Never get stuck again

Keep on working while your most demanding computations are running, thanks to Voxilon's modular architecture.

Job scheduler

Easily sort and prioritize your simulations.

Scripting

Add your own simulation codes to the platform.

Key Benefits



Organized

Organize your projects

Instantly access your images and data
from your own secured database,
within Voxilon's easy-to-tame interface.

Hierarchical organization

Samples, raw and processed images, results, metadata: everything in the same place.

Secured access

Access several databases over your local network.
Create collections to organize your projects.

Process tracking

Voxilon keeps track of the sources, parameters, timestamps, etc. for every single process and verifies the integrity of all your files.

Key Benefits

Coming Soon



Organized

Organize your projects

Instantly access your images and data
from your own secured database,
within Voxilon's easy-to-tame interface.

Cross-data analysis

Analyze results from different samples
in a given project.

Workflow automation

Deep learning allows to ease image processing
and segmentation.

Data-to-Results Workflow

Georessources

Exploration & production

Petrophysical
characterization of
geomaterials

Sequestration &
underground storage

Evaluation of storage and
disposal capacities

Geothermal

Fracture monitoring
Estimated production
potential

Synthetic materials

Conception

Exploring 3D morphology
Evaluation of their properties

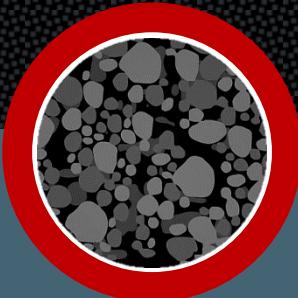
Development

Real 3D model construction
for simulation

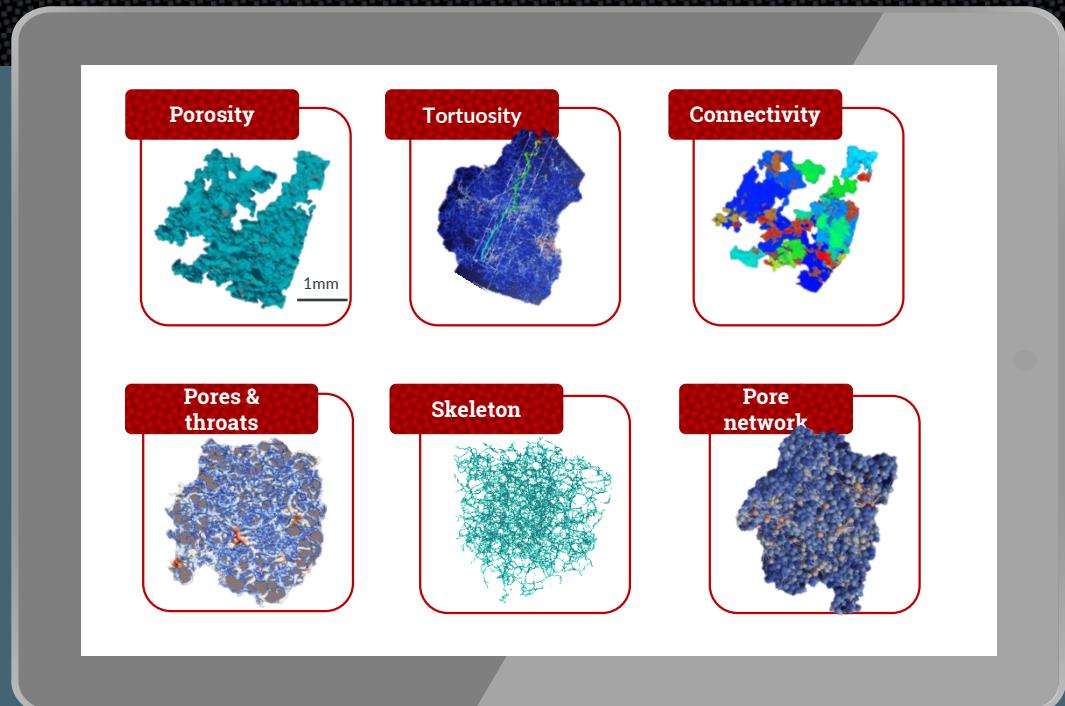
Control

Monitoring morphological
evolution

Structural Properties



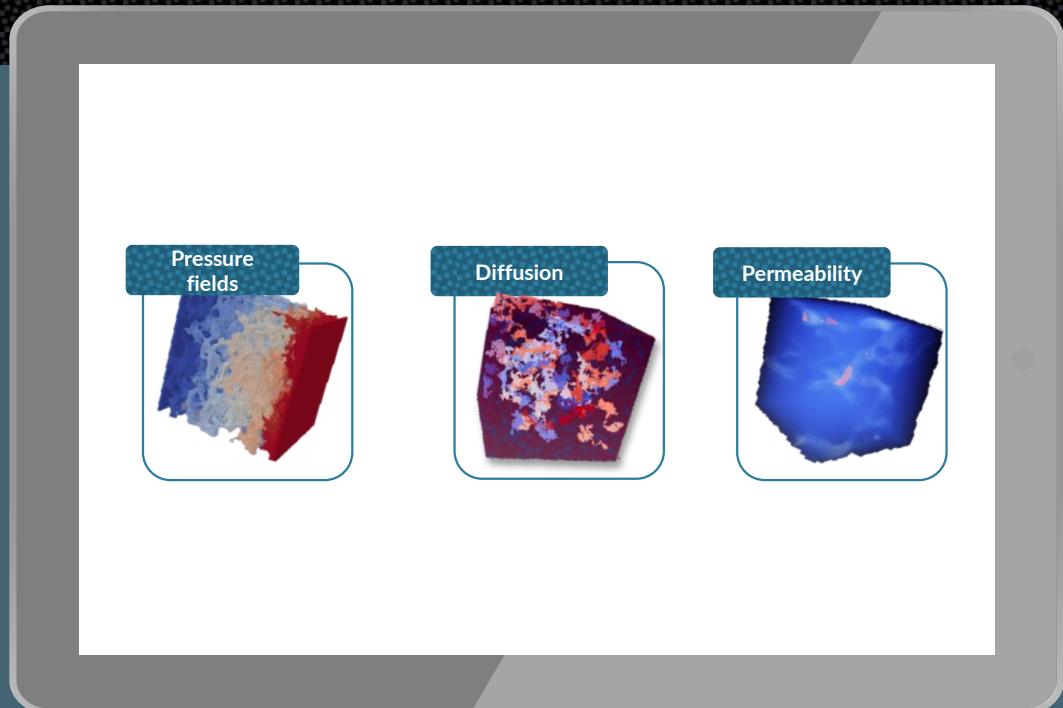
- Porosities
- Connectivity
- Geometrical statistics
- Element size distribution
- Geometrical tortuosity
- Formation factor



Dynamical Properties



- Diffusive tortuosity
- Effective diffusion
- Capillary pressure
- Absolute permeability



Voxilon Analyses

Morphological characteristics

- Effective, Accessible porosities
- Chord-length distribution
- Sphere diameter distribution
- Geometrical tortuosity
- Formation factor

Dynamical properties

- Effective diffusion
- Diffusive tortuosity
- Absolute permeability (K_x , K_y , K_z)
- Capillary pressure

DRP measurements	Results	Computation time
Effective porosity	15.8%	5 sec
D _p -max (chord-length)	91 µm	2 sec
D _p -main (maximum-balls)	38 µm	11 sec
Geometrical tortuosity	1.58	190 sec
Connected pore components	3947 networks	3 sec
Diffusivity-tortuosity	5.2	136 sec
Absolute permeability	927 mD	280 sec
Pore entry diameter from P _c curve	17 µm	448 sec

Total time: 18 min

Computations made on a Fontainebleau sandstone image -500³ voxels (125 Mo)
Hardware setup: Dell XP 13 laptop 4 cores/8 GB RAM

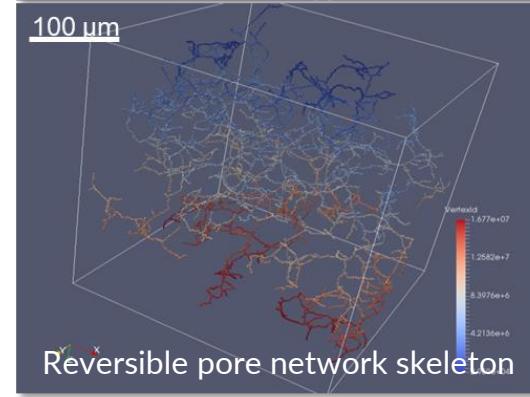
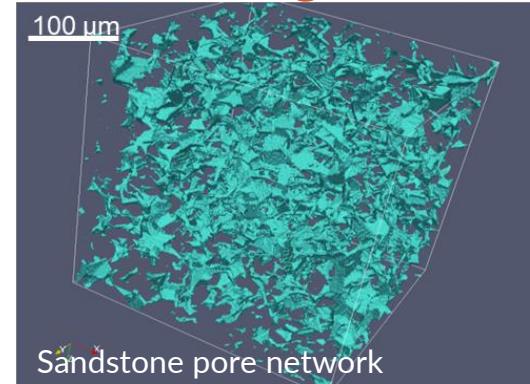
Focus on Absolute permeability

Characteristics

- Skeleton-based method
- Similar method to Pore Network Modeling
- Parallel computation

Rocks	Image size	Permeability	Computation time
Mallorca	1 Gb	14 mD	276 sec
Berea	2,5 Gb	104 mD	11 min
GD15	6 Gb	100 mD	39 min
Bentheimer	21 Gb	2270 mD	1h 45 min

Hardware setup: HP Z840 workstation 32 cores / 256 GB RAM



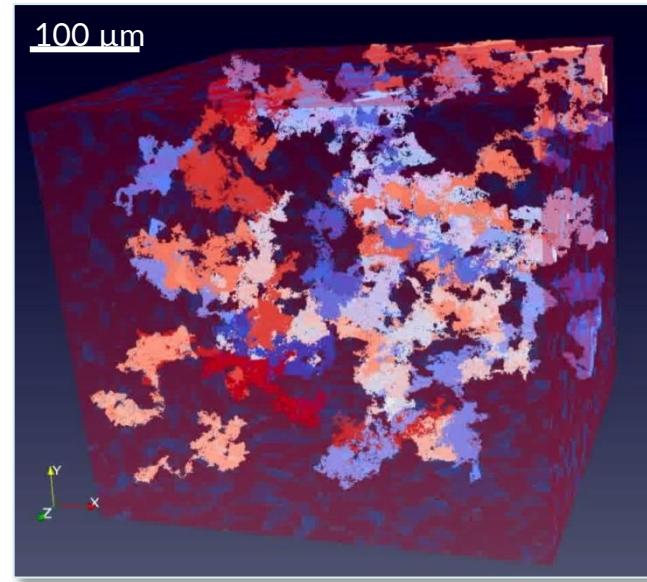
Focus on Effective diffusion

Characteristics

- TDRW-based method
(Dentz, Russian, Dweik, Gouze et al.)
- Parallel algorithm
- Automated post-processing

Rocks	Image size	Diffusive tortuosity	Computation time
Mallorca	1 Gb	9	10 sec
Berea	2,5 Gb	7	10 sec
GD15	6 Gb	30	500 sec
Bentheimer	21 Gb	5	295 sec

Hardware setup: HP Z840 workstation 32 cores / 256 GB RAM

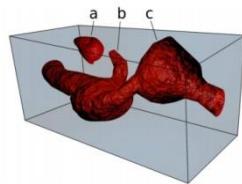


Diffusion process in a sandstone pore network

Focus on Capillary pressure

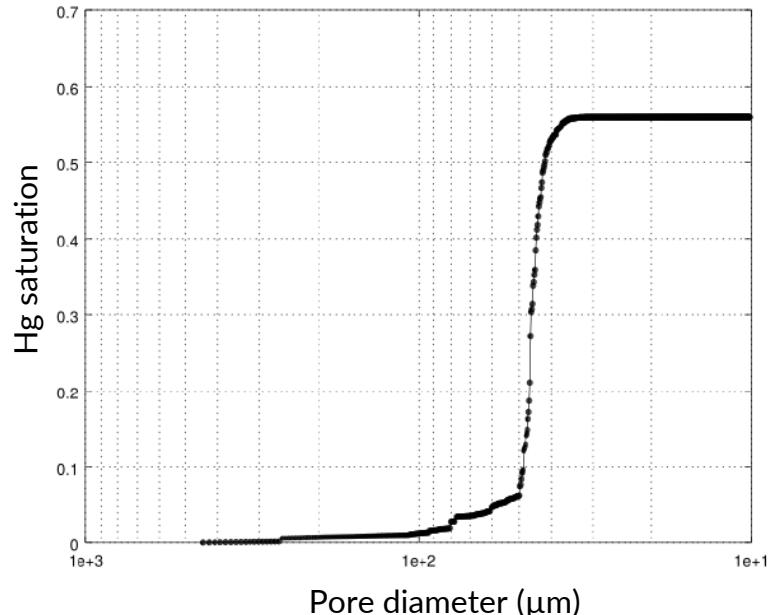
Characteristics

- Drainage process modelization
- Skeleton-based method
- Non-wetting phase
- Trapping possibility



Rocks	Image size	Pore entry diameter	Computation time
Mallorca	1 Gb	7 µm	296 sec
Berea	2,5 Gb	4 µm	13 min
GD15	6 Gb	5 µm	42 min
Bentheimer	21 Gb	3 µm	1h 48 min

Hardware setup: HP Z840 workstation 32 cores / 256 GB RAM



About Voxaya

257 k€

AxLR SATT project

340 k€

Equity fundraising



190 k€

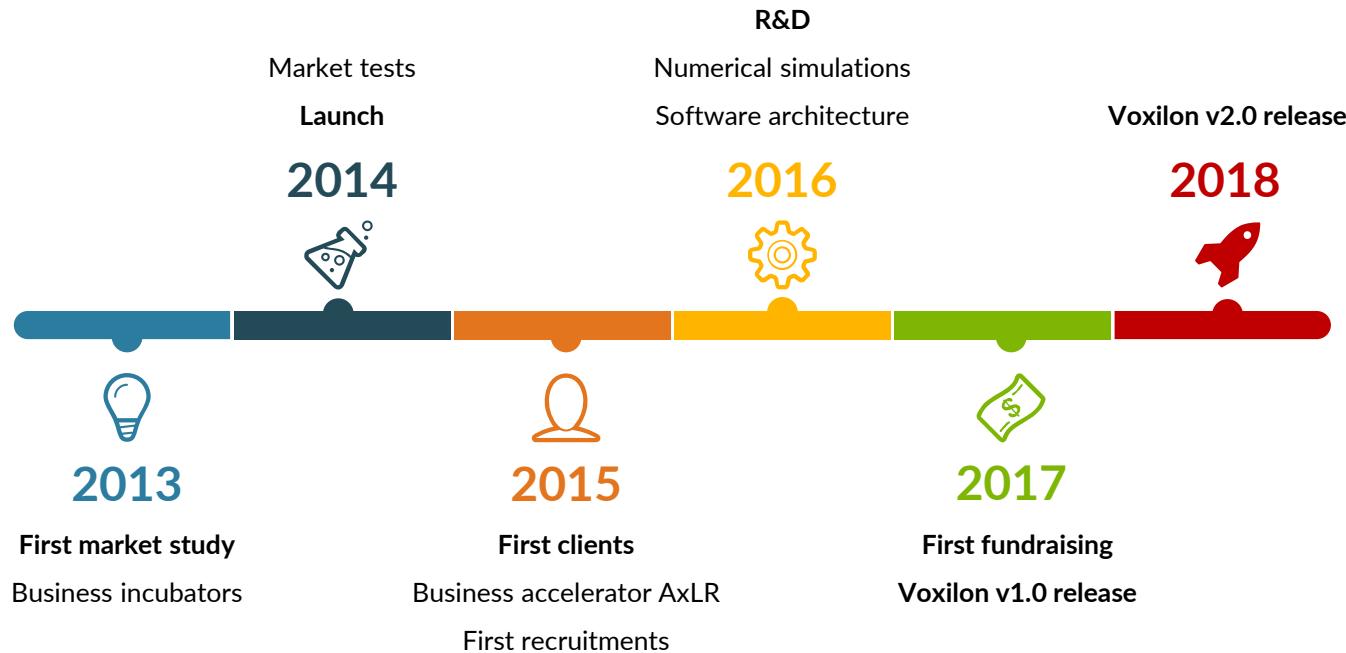
Subsidies

100 k€

Income

Voxaya is a spin-off from the Geosciences Montpellier laboratory, founded in 2014 and located in Montpellier, South of France.

Brief History



Current Team



Olivier Rodriguez
CEO, PhD



Vanessa Hébert
General Manager, PhD



Philippe Gouze
Scientific Advisor, PhD



Thierry Porcher
CTO



Valentin Planes
R&D engineer



Thomas Izard
R&D engineer, PhD



Loren Marc--Fahmy
Marketing & Communication



Marie Léger
R&D engineer



*Oseo Startup Competition
Montpellier (France), 2012*



*i-Lab Startup Competition Final
Montpellier (France), 2015*



*France Tech Transfer Invest
Paris (France), 2017*



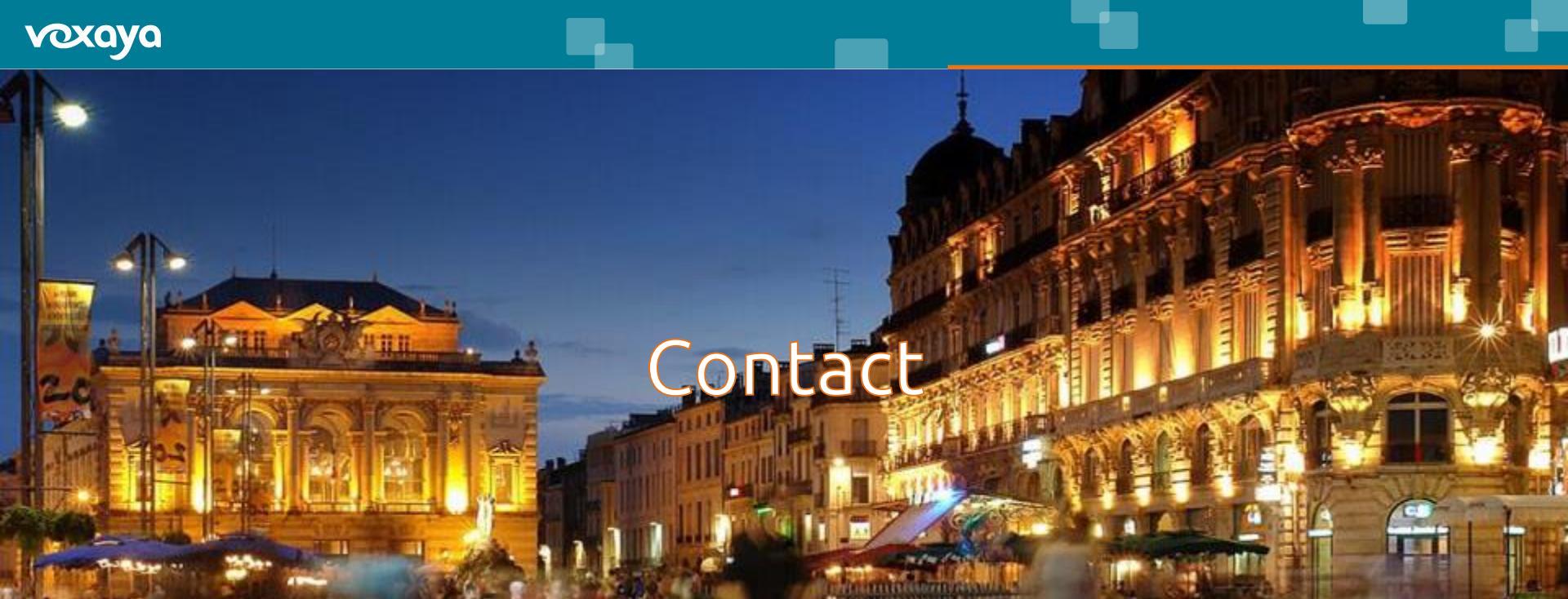
*NETVA Competition Final
Boston (MA, USA), Jul. 2017*



*SPE ATCE Startup Competition Final
San Antonio (TX, USA), Oct. 2017*



*European Venture Contest Final
Düsseldorf (Germany), Dec. 2017*



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