LA CHAÎNE NUMÉRIQUE DE LA COMPRÉHENSION À L’OPTIMISATION EN FABRICATION ADDITIVE

THIERRY THOMAS
VP SAFRAN ADDITIVE MANUFACTURING
DIGITAL THREAD FOR ADDITIVE MANUFACTURING: to understand and to optimize

SAFRAN

WHO ARE WE, KEY FIGURES, IMPORTANCE OF TECHNOLOGY AND INNOVATION FOR US;

CHALLENGES AND OPPORTUNITIES OF ADDITIVE MANUFACTURING

DIGITAL THREAD, A KEY FOR THE FUTURE OF MANUFACTURING

CONCLUSION
SAFRAN AT A GLANCE
OUR MISSIONS

BOOSTING AIR TRANSPORT PERFORMANCE

ENHANCING PROTECTION FOR CITIZENS

MAKING OUR LIVES SAFER AND EASIER

FACILITATING ACCESS TO SPACE
SAFRAN: TECHNOLOGY THAT BENEFITS OUR DAILY LIVES

1 SINGLE-AISLE COMMERCIAL JET TAKES OFF every 2 SECONDS, powered by our engines*

MORE THAN 40,000 LANDINGS a day using our equipment

MORE THAN 76 SUCCESSFUL ARIANE 5 LAUNCHES in a row**

3,000 MILITARY AIRCRAFT fitted with our inertial navigation systems

1 OUT OF EVERY 3 HELICOPTER TURBINE ENGINES sold worldwide

OVER 35,000 POWER TRANSMISSIONS totaling over 850 million flight-hours

17,300 NACELLE COMPONENTS in service

500 KM OF ELECTRICAL WIRING on an Airbus A380

2.8 BILLION ID DOCUMENTS delivered worldwide

*in partnership with GE, through CFM International
**in partnership with Airbus Group, through Airbus Safran Launchers
INNOVATION AT SAFRAN
(31/12/2016)

NEARLY 11% OF SALES INVESTED IN R&D*

21% OF EMPLOYEES INVOLVED IN R&D

1,000 EXPERTS IN THE GROUP

OVER 850 INITIAL PATENTS FILED IN 2016

€704 MILLION IN CAPITAL EXPENDITURES

Safran is ranked among the TOP 100 GLOBAL INNOVATORS by Thomson Reuters

*spending on Research and Development programs amounted to 1.7 billion euros in 2016
SAFRAN, IMPORTANCE OF R&D FOR US

Innovation is at the heart of SAFRAN Products

- Electrically-actuated A380/C919 thrust reverser
- Electrically-actuated carbon brake
- Multi-Biometric recognition
- 3D RTM fan blade
- CMC nozzle and combustor
- Complex simulations

→ R&D investment: **1,7 billion euros in 2016**, more than 11% of revenue

→ **70% of SAFRAN’s R&D budget is dedicated** to reducing the environmental impact of air transport
DIGITAL THREAD FOR ADDITIVE MANUFACTURING
A KEY SUCCESS FACTOR FOR AM DEVELOPMENT
3D AM ENABLES SAFRAN TO CREATE VALUE

- Production cycle down by 40% to 80%
- Tooling, Spares, prototypes → a lot of agility/pro-activity
- Development cycle reduced by 30% and Cost
- Less subassemblies / more complex parts
- Reduce weight up to 75%
- Innovative Repair solutions
3 SIMULTANEOUS PHASES FOR AN UNIQUE VISION, ENSURING AM DEVELOPMENT

**Appropriation: Iso Design**
Mature data and ability to certify parts
Mature Supply-chain
Maximise agility offered by AM technologies

**Optimisation:**
Design for AM, functions integration ...
Master the Digital Thread that must be deeply integrated
Process: Quality, process control, cost/productivity, post-fabrication and surface finish
Master powder: chemistry, recycling, productivity, cost

**Augmented/Intelligent Function:**
Systemic analysis of complex systems will drive our designs
Multi-material processes will enable complex functions
Integration of Electronic and electrical elements to be matured
ADDITIVE MANUFACTURING: A NEW PARADIGM

Material = Initial Chemistry + Process
As for composite, material is built with the part

J. Laser Appl., Vol. 26, No. 1, February 2014

Building Direction

Energy - Material interaction

Strategical Manufacturing

Material

Design

Powder or wire
5 BUILDINGS BLOCKS TO BE MASTERED for AM process

**Powder**
- Cost – quality management
- Supply-Chain Qualification
- Dedicated AM nuances (MFAM)

**Energy-material Interaction**
- Defect library
- Thermal field modeling/steering
- New energy sources

**Process control**
- Defect library
- Key process parameters
- In situ process control
- Sanction & Control loop process
- Performant NDT

**DFAM (Design for AM)**
- Optimisation Topologic and Parametric
- Design to manufacturing and to cost
- Function Integration
- Pyramid tests & Certification

**Simulation**
- Process Simulation & Optimisation
- Multi-scale & Multi-physics simulation
- Part simulation
NUMERICAL SIMULATION FOR ADDITIVE MANUFACTURING

To understand the material creation complexity, at all pertinent scales, in order to optimize parts and process, we need powerful numerical tools.

Numerical Simulation Objectives:

- Design and optimise Complex Functions
- Predict part ‘printability » as well as part final state and its constitutive material characteristics
- Define process parameters including powder design
- Develop process deviation treatment tools: NCR first then real time
DIGITAL THREAD ADDITIVE MANUFACTURING AND TOPOLOGICAL & GEOMETRIC OPTIMISATION

- Lifetime calculation
- Operating Constraints
- Design functions

**Virtual prototype**
- Proto V1.0
- Proto V2.0
- Proto V3.0

**Material Manufacturing**
- Manufactured material
- Optimized material

**Parametric Manufacturing Optimization**
- Part Design (mainly manual today)

**Processes simulation**
- Interesting outputs
- Operating parameters

**Heat treatment**
- Stresses
- Grains size
- Anisotropy

**Manufacturing Optimization**
- Modes REDUITS / EXP + NUM
- « CAM »
- Progressive introduction of AM constraints

**Modeles Reduits / Exp + Num**
- Powder metallurgy
- Meltpool
- Hatch
- Multi-Layer

**Scale**
- Slices
- Operating parameters
ROAD MAP ORGANISED IN 3 CHAPTERS
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<tr>
<td>Develop tools to support raw materials design for AM applications (powder, wires, …)</td>
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<td>Develop tools that embed AM specificity</td>
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**ADDITIVE FACTORY HUB (ex FAPS) will be an important enabler to support this.**

- **Comparison num./exp.**
  - Develop in situ instrumentation
  - Develop Open loop machine control → Close loop
  - Develop database and use of big data tools
  - Connexion simulation / machines / CAM tools

**SAFRAN ROADMAP FOR DIGITAL THREAD IN ADDITIVE MANUFACTURING**

Develop database and use of big data tools
INNOVATIVE TECHNOLOGIES

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<thead>
<tr>
<th>Year</th>
<th>2016</th>
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<td>Functions Optimisation</td>
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<td>New powders and new function concepts</td>
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<td>Multi-physics Intégration in codes</td>
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<td>Multi-materials/ lattice design &amp; process</td>
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<td>Integration/ function/ Systems</td>
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<td>IOT (Health monitoring, embedded intelligence)</td>
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Technology is important, but this is key to guide/accompany our engineers on the AM journey. Digital tools will be mandatory to support this.
NO DOUBT, Additive Manufacturing will be part of the big transformation of tomorrow industrial jobs and plants. A strong integrated digital thread will be a Must to optimize AM use within The Factory of the Future.
CONCLUSION

- Additive Manufacturing is in an irreversible phase of development. These technologies will be more and more part of the tools set available to complete classical manufacturing tools as they open:
  - New ways of optimizing and/or integrating functions in one part,
  - New materials: chemistry, microstructure, meso structure, multimaterials, …
  - New system concepts, more integrated: fusion of AM and IoT
  - New services to support our customers

- The Digital Thread, that is already important for today processes, is going to play a KEY role to maximize Additive Manufacturing use and benefits.

- Parametric optimization, in addition to topological, process simulation and multi-physics simulation … must be at the heart of our developments and need a particular attention.
POWERED BY TRUST

THANK YOU