

11-6-2017

# High temperature composite overview in France

Marc Montaudon

*Eric Bouillon, Safran Ceramics, marc.montaudon@safrangroup.com*

Eric Bouillon

*Eric Bouillon, Safran Ceramics*

Follow this and additional works at: <http://dc.engconfintl.org/acmc>



Part of the [Engineering Commons](#)

---

## Recommended Citation

Marc Montaudon and Eric Bouillon, "High temperature composite overview in France" in "Advanced Ceramic Matrix Composites: Science and Technology of Materials, Design, Applications, Performance and Integration", Yutaka Kagawa, Tokyo University of Technology, Japan Dongming Zhu, NASA Glenn Research Center, USA Ram Darolia, GE Aviation (retired), USA Rishi Raj, University of Colorado, Boulder, USA Eds, ECI Symposium Series, (2017). <http://dc.engconfintl.org/acmc/59>

This Abstract and Presentation is brought to you for free and open access by the Proceedings at ECI Digital Archives. It has been accepted for inclusion in Advanced Ceramic Matrix Composites: Science and Technology of Materials, Design, Applications, Performance and Integration by an authorized administrator of ECI Digital Archives. For more information, please contact [franco@bepress.com](mailto:franco@bepress.com).

CERAMICS

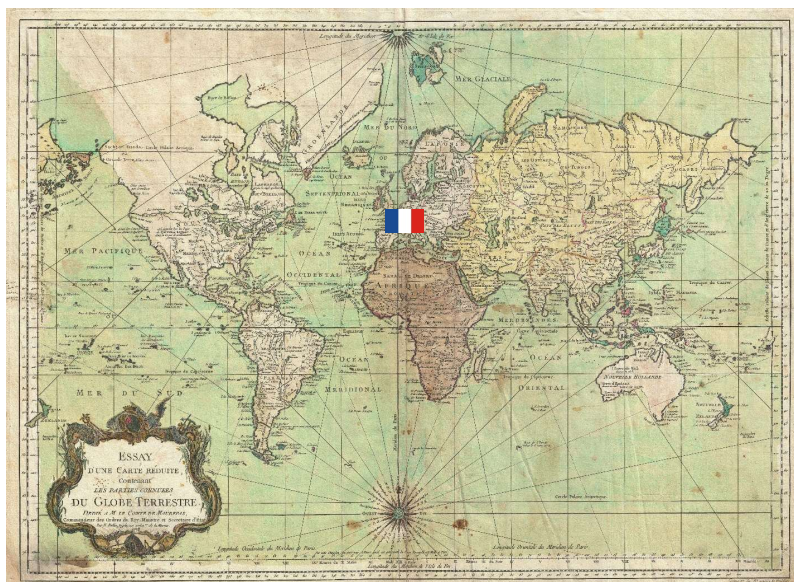
# Ceramic Matrix Composites In France: 40 Years Of Innovations

Santa Fe, November 5th, 2017

Marc MONTAUDON, COO, Safran Ceramics



This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran



2 Safran Ceramics – November 2017

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran



**SAFRAN**

**€15.8 BILLION**  
in sales #

**€2.4 BILLION**  
in adjusted recurring operating income #

**€1.7 BILLION**  
in R&D expenditures #

Over **850 INITIAL PATENTS** #

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

**MORE THAN 54,000 LANDINGS** a day using our equipment

**80 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

**18,400 NACELLE COMPONENTS** in service

**500 KM OF ELECTRICAL WIRING** on an Airbus A380

\*in partnership with GE, through CFM International  
\*\*in partnership with Airbus Group, through ArianeGroup

Nearly **58,000 EMPLOYEES** in nearly **30 COUNTRIES** #

# 2016

**SAFRAN**

3

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran

# Chapter 1

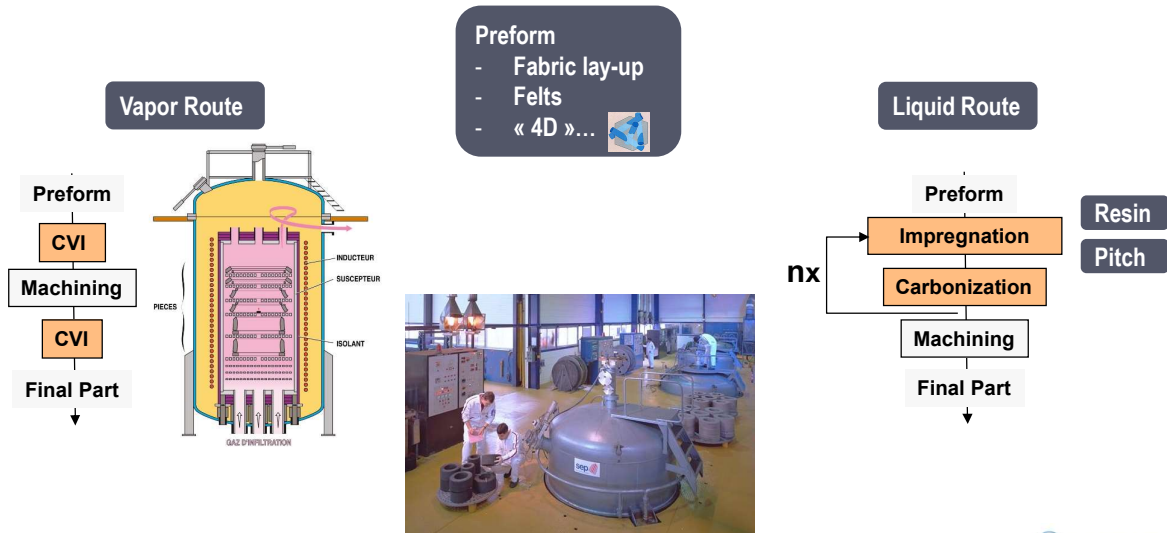
## The Tale of Carbon - Carbon

4 Safran Ceramics – November 2017

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran

**SAFRAN**

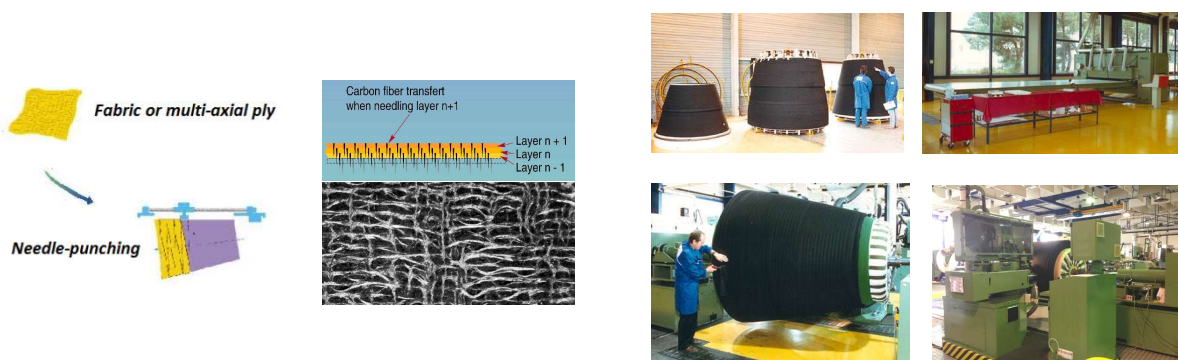
## 1) 1969-1979: acquire, taste and improve a processes toolbox



This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran



## 2) 1982: invent a technological/economical rupture, Novoltex® texture



- **Automative process**
  - **Various shapes (thin plates, parallelepipedic blocks, cylinders, cones, etc.)**
  - **Homogeneous pores network w/o bottlenecks**
  - **Handlable & self-supporting w/o toolings**
- perfectly adapted to any densification route, particularly CVI!*

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran



### 3) >1985: Develop a material range and extend the scope

**Carbon-Carbon**  
Sepcarb®

MISSILES

SPACE

AERONAUTICS

INDUSTRY

Cost per kg : ÷ 500 depending on volume and specifications

2016 Deliveries ~7500 parts + 1,100 tons of brakes

(1) Through our ArianeGroup subsidiary  
(2) Through our Safran Landing Systems subsidiary

arianeGROUP + SAFRAN

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran

### CFRC Nozzle: a World Monopoly based on a 40 Years Experience

Maximum diameter (mm)

2500

2000

1500

1000

500

0

75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07

Year

Ground test

Flight

Extendible Nozzle

MAGE 2

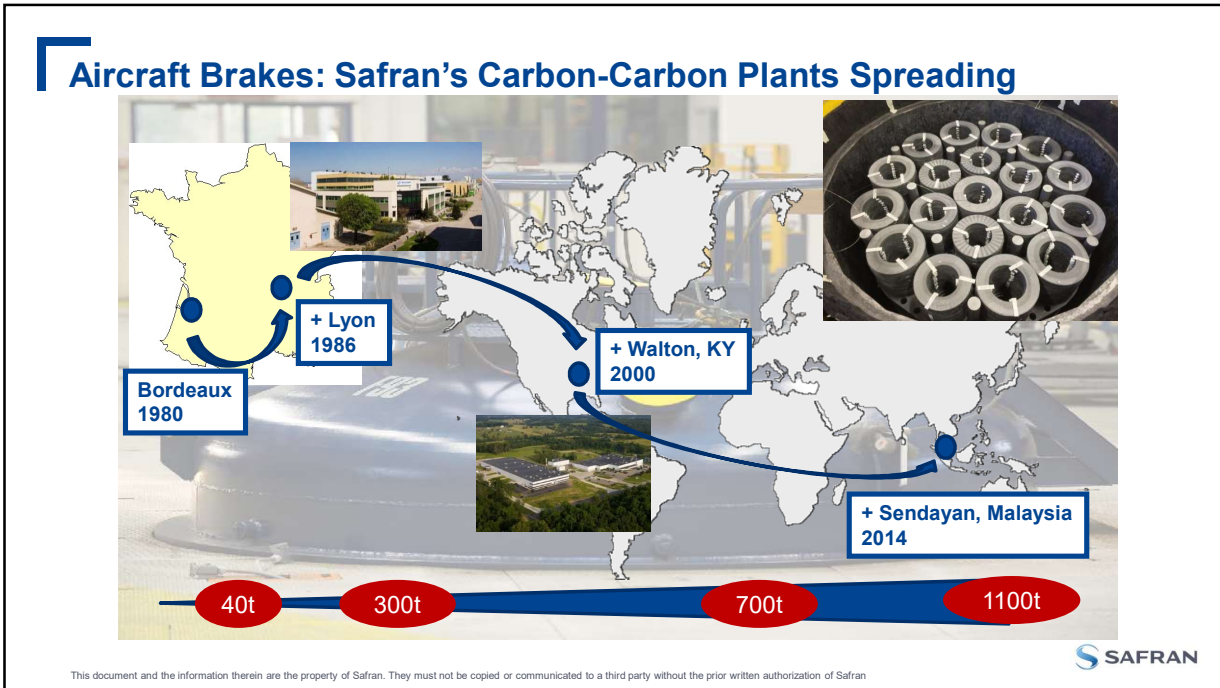
HM7

RL 10 B-2

Ariane 6 VINCI

arianeGROUP + SAFRAN

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran



## Chapter 2

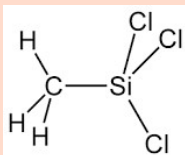
# The Tale of Ceramic Matrix Composites

10

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran

## 1977: First Ceramic Matrix Composite

- Densification of a carbon preform
- Chemical Vapor Infiltration from methyltrichlorosilane



Laboratoire de Chimie du Solide (now LCTS)  
University of Bordeaux



Pr. Roger NASLAIN

## 1979: First Industrial Furnace



SEP (now Safran), Bordeaux



This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran

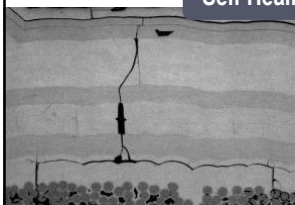
## The Process Toolbox



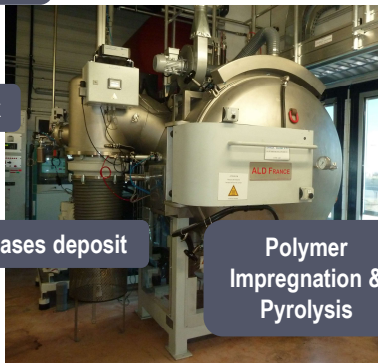
SiC Chemical Vapor Infiltration

**Preform**

- Novoltex<sup>®</sup>
- 2D tows or fabrics
- 3D Weaving



Self Healing Matrix



Interphases deposit

Polymer Impregnation & Pyrolysis



Slurry Incorporation

Melt Infiltration of Silicon

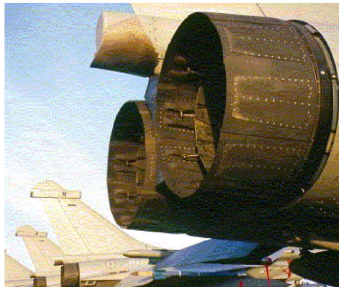
Oxide sintering




This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran

**Carbon-Carbon**  
Sepcarb®

**Carbon-Ceramic**  
Sepcarbinox®



French Fighter Rafale's nozzles since 1990



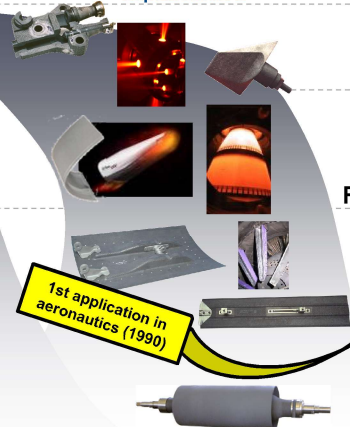
also successfully ground (>11,000 TACs) and flight tested (>1,000h) on F-15, F-16

MISSILES

SPACE

AERONAUTICS


INDUSTRY



1st application in aeronautics (1990)

2016 Deliveries


~5000 parts




This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran


**Hot Gas Valves Experience**

**Military serial application**





80s






90s






00s



X

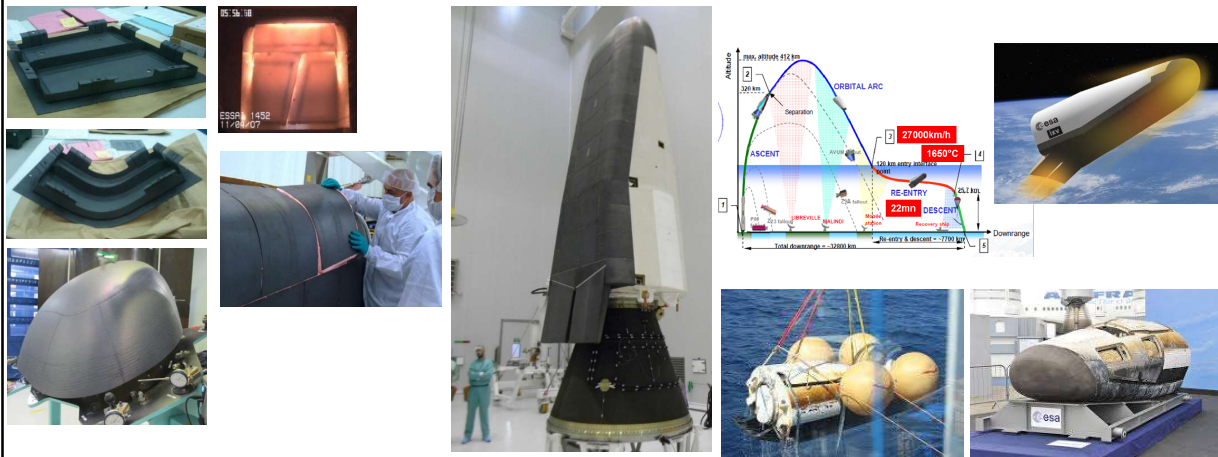
10s

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran





# ESA's IXV Atmospheric Re-Entry Demo: TRL6 for a re-usable CMC Nose and Thermal Protection System (Feb 2015)



This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran



## Carbon-Carbon Sepcarb®      Carbon-Ceramic Sepcarbinox®

MISSILES

SPACE

AERONAUTICS

INDUSTRY

1st application in aeronautics (1990)

2016 Deliveries

~5000 parts



This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran





## Then came the Silicon Carbide Fibers...



Courtesy of Nippon Carbon K.K. (now NGS Advanced Fibers, K.K.)

17

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran



**Carbon-Carbon**  
Sepcarb®

**Carbon-Ceramic**  
Sepcarbinox®

**Ceramic-Ceramic**  
Cerasep®

MISSILES

SPACE

AERONAUTICS

INDUSTRY



This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran



