Meeting the Challenge of Environmental Regulations in Europe and North America

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ASETSDefense 2011: Sustainable Surface Engineering for Aerospace and Defense Workshop, February 7 - 10, 2011, New Orleans, LA. Sponsored by SERDP/ESTCP.
• THE SAFRAN GROUP
• AERONAUTIC DRIVERS
• CADMIUM REPLACEMENT
• CHROMIUM VI REPLACEMENT
• MAGNESIUM PROTECTIONS
• ReaCH
Key figures

2008 revenues by branch

- **Aerospace Propulsion**: €5,803 million (56%)
- **Defence Security**: €1,646 million (16%)
- **Aircraft Equipment**: €2,856 million (28%)

**Revenues:** 10,329 million euros

**Operating income:** 798 million euros

**Net income – Group share:** 256 million euros
AEROSPACE ENGINES (1)

Civil aircraft

Military aircraft

Futur civil engines

Helicopter
AEROSPACE ENGINES (2)

**HM7B™**
Thrust: 22,000 lb

**Vulcain®2**
Thrust: 297,000 lb

**Vinci®**
(Under development)

**Ariane 5**

**HTE**
AEROSPACE EQUIPMENTS and PARTS
Fan blades, booster and Fadec on GEnx engine
- Landing gear
- Wheels and carbon brakes
- Electric brake actuation controller (EBAC)
- Wiring
- Integrated landing and braking system
- Main landing gear
- Wheels and carbon brakes
- Fuselage and engine pylon wiring
- Components for onboard information system and flight control system
Launch vehicle

**ARIANE**

- Vulcain main stage engine
- HM7B upper stage engine
- Solid booster motors, via Europropulsion
Research & environment

INNOVATION: AT THE HEART OF THE GROUP’S PRODUCTS

Technologies - architectures - processes

- Electrically-actuated A380 thrust reverser
- Electrically-actuated carbon brake
- A380 ventilation
- Hemispherical resonating gyro
- Thermal imager
- 3D RTM fan blade
- Félin integrated equipment suite
- Mica missile seeker
- CMC nozzle and combustor
- 3D composite strut for B787 landing gear
- Complex simulations
- Biometric recognition

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R&D investment: **1.2 billion euros in 2008**, equal to 12% of revenues, with about 60% self-financed by the Group

**R&D calls on about 20% of the Group’s workforce:** 450 doctoral scientists and over 100 doctoral candidates work at Safran

> **400 patents filed per year**, on average: **1th** highest in Aerospace in France (source: INPI 2009)
DRIVERS (1) FLEET GROWTH

Needs 2006-2026

AIRCRAFTS

Capacity (seats)

- Twin aisle: 7170 units
- Single aisle: 14430 units
- Regional jet: 6530 units
- Regional turbo: 1520 units

20-year demand for 24,951 aircraft

- 16,977 single aisles
- 6,245 twin aisles
- 1,729 very large aircraft

Market value of $3.1 trillion

AIRCRAFTS

2006-2026
DRIVERS (2) CUSTOMER PROJECTS
DRIVERS (2) EUR

REACH

REGISTRATION, EVALUATION and AUTORISATION of CHEMICALS

RoHS

RESTRICTION OF USE on HAZARDOUS SUBSTANCES (electronic and electrical equipments)
• THE SAFRAN GROUP
• AERONAUTIC DRIVERS
• CADMIUM REPLACEMENT
• CHROMIUM VI REPLACEMENT
• MAGNESIUM PROTECTIONS
• ReaCH
**CADMIUM REPLACEMENT Requirements**

<table>
<thead>
<tr>
<th>E(V)/ENH</th>
<th>Pt/Pt²⁺</th>
<th>Cu/Cu²⁺</th>
<th>H₂/H⁺</th>
<th>Ni/Ni²⁺</th>
<th>Fe/Fe²⁺</th>
<th>Zn/Zn²⁺</th>
<th>Al/Al³⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+ 1.20</td>
<td>+ 0.34</td>
<td>0</td>
<td>- 0.25</td>
<td>- 0.44</td>
<td>- 0.76</td>
<td>- 1.67</td>
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</table>

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Solution Potential (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Zn</td>
<td>-1.10</td>
</tr>
<tr>
<td>2. Zn-Co</td>
<td>-1.026</td>
</tr>
<tr>
<td>3. AA 5083</td>
<td>-0.87</td>
</tr>
<tr>
<td>4. Cd</td>
<td>-0.82</td>
</tr>
<tr>
<td>5. Zn-Ni</td>
<td>-0.80</td>
</tr>
<tr>
<td>6. Mild Steel</td>
<td>-0.58</td>
</tr>
<tr>
<td>7. Sn</td>
<td>-0.49</td>
</tr>
<tr>
<td>8. Ni</td>
<td>-0.07</td>
</tr>
</tbody>
</table>

- **Galvanic properties**
- **Thicknesses**
- **Corrosion resistance**
- **Hydrogen embrittlement**
- **Torque**
- **Fricition**

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CADMIUM REPLACEMENT (1) A wide range of parts

Of some mm to few meters length
CADMIUM REPLACEMENT (1) Zinc Nickel

- **Atotech**: Reflectalloy ZNA (listed on BAC 5680) + Cr$^{3+}$ passivation
- **Mecaprotec**: « home-made » process (12-15%) + Cr$^{3+}$ passivation
- **Coventya**: Performa 280.5 + Cr$^{3+}$ passivation
- **SurTec**: SurTec 716 and 717 + Cr$^{3+}$ passivation
- **McDermid**: Enviralloy Ni 12-15% + Cr$^{3+}$ passivation
- **Enthone OMI**: Zincroyte KCL-Ni III + Cr$^{3+}$ passivation
- **Glomax**: Glovel 800 + Cr$^{3+}$ or Cr-free (Zec-Coat 888) passivation

(TRL 9) Ratier Figeac
CADMIUM REPLACEMENT(2) – Al coatings

Ion Vapour Deposition
(TRL 9)

Electrolytic Al coating

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ASETSADEFENSE2011
CADMIUM REPLACEMENT (3) - MCAC

(TRL 9)
CADMIUM REPLACEMENT (4) – Lamellar zinc

(TRL 9)
CADMIUM REPLACEMENT(5) - New technologies

Electrolyte: [EMIm]Cl/AlCl₃
Electrolyte preparation in a glove box
Electrolysis under argon

Al electrolysis with film (room atmosphere)
Bright Al coating on steel

Zn/Sn alloy (20%Zn)
Electrolyte: ChCl + EG + Zn and Sn chlorides + EDTA

- Sol Gel
- Ionic liquid processes  Zn/Sn or AL

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ASETS DEFENSE  2011
CHROMIC ACID ANODIZING REPLACEMENT (1)

- SULFOCHROMIC ETCHING REPLACEMENT (TRL 9)
  - Sulfo fluoro nitro ferric
  - Phospho sulfonic
  - Alkaline

- DICHROMATE SEALING (TRL 1 - 4)
  - Molybdates salts
  - Electrolytic
  - Trivalent chromium
  - Rare earth salts
  - Sol Gel
CHROMIC ACID ANODIZING REPLACEMENT (2)

• SAA (TRL9)
Sulfuric acid anodizing
H₂SO₄ 160 to 240g/l
Low thickness applications

• DSAA (TRL3)
Diluted sulfuric acid anodizing
H₂SO₄ > 50 g/l

• SBAA (TRL4)
Sulfo boric acid anodizing
>30 g/l

• TSA (TRL4)
Sulfo tartaric acid anodizing
> 34 g/l
TRIVALENT CHROMIUM

- SUITABLE ONLY TO 1000, 3000, 5000 and 6000 ALLOYS SERIES

+ • Electrical conductivity, painting adhesion, fatigue
- • Poor Corrosion on rich copper alloying aluminium alloys
  • Color less
  • Very Sensitive to Surface Preparation

(TRL 4)
Other followed tracks

- TRIVALENT CHROMIUM + TOP COAT

- TRIVALENT CHROMIUM + INHIBITORS

- OTHER CHEMISTRY BASED

- SOL GEL
NEW TECHNOLOGIES (5)

Plasma Electrolytic Oxydation on Aluminum alloys

Ceratronic (F)

(TRL 9) LIEBHERR AEROSPACE

MESSIER-BUGATTI
Airbus 320

LIEBHERR-AEROSPACE Toulouse 2004
Airbus A380
HARD CHROMIUM REPLACEMENT
HARD CHROMIUM REPLACEMENT (1)

H.V.O.F.

TRIBALLOY 28.17.3 or 28.6.2
CERMETS WCCoCr 86.10.4
CERMETS Cr3C2 / 20NiCr
HARD CHROMIUM REPLACEMENT (2)

Nano Cobalt phosphorus coating

Electroless Ni + (…)

Trivalent Chromium Process

Ionic liquids

Ecole Nationale Supérieure des Mines
SAINT-ETIENNE

Electrolyte: choline chloride + Cr III chloride + 20% water

Electrolysis:
25°C, 5A.dm⁻² (up)
40°C, 20A.dm⁻² (down)
HARD CHROMIUM REPLACEMENT (3)

Based on Martensitic CRES
MLX 17 /19 (Aubert&Duval)
Custom 465 (Carpenter)

Non chromate passivated processes

- Ionic implantation
- DLC coating
- Triboslide WS2 coating
MAGNESIUM SURFACE TREATMENTS (1)

Chromic Conversion Coating

Mordançage (F) / DOW 17 (US)
HAE Coating (Harry A. Evangelides patented 1952)
POTASSIUM PERMANGANATE, TRISODIUM PHOSPHATE, POTASSIUM AND ALUMINIUM HYDROXYDE

MAGOXID (G) –

Ceratronic Process (F)
MAGNESIUM SURFACE TREATMENTS (3)

Touch Up Process
MAGNESIUM SURFACE TREATMENTS (4)

• Alodine 160/161

• Anaphoretic coating (E-coating)

- What is and will be low VOC???

- “Lower” VOC products have been in use since early 90’s.

- All new programs require “lower” VOC.

• Water based / Cr6 free paints

• Cold Spray
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REACH: SCHEDULE and MILESTONES

Entry into effect of REACh

Pre-registration

Registration times

Restrictions

Annex XIV

Authorizations

Communication of the substances of very high concern in the articles

Notification of the substances of very high concern in the articles
Definition of Substances of Very High Concern (SVHC)

Step 1 was closed End of 2008
150,000 substances

Phase 1 by December 2010
About 10,000 substances

Authorisation

Customers and EU to be notified

>0.1% weight

Technical file +
Chemicals Safety Report

REACH Process (Registration, Evaluation, Authorization of Chemicals)
SAFRAN Identified risks

SAFRAN put a Specific Group Project in place to manage the following Risks:

- **Risk 1 - Very short term obsolescences**
  - Due to the end of each step of the Registration processes

- **Risk 2 - Restriction of use**
  - Due to yearly release of SVHC

- **Risk 3: Chemicals traceability in articles**

- **Risk 4 : Monitoring the evolution of REACH Regulation**
EXAMPLE SAFRAN BUSINESS UNIT: REACH PROJECT

**Objective 1**
Ensure Registration

- Identification of short-term obsolescences

**Objective 2**
Manage Authorisations

- Identification of middle-term obsolescences

**Objective 3**
Substitution

- Chemical products:
  - Paint schemes
  - Mastics/Sealing Pdt
  - Alodine/Alochrom
  - ...

- R&T Programs:
  - CADFREE
  - Nano-HVOF
  - Aluminium Surf. Treat.
  - ...

**Objective 4**
Define Chemicals Traceability tool for MD articles

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Collaboration

European REACH regulation shows us a path, we experience as you and we need to understand and to respect it.

Safran is interested in pursuing more partnerships ……