

**COMPROME**  
EC funded research project  
FP 6 - Aeronautics & Space

**Monitoring, Optimisation and Control  
of Liquid Composites Moulding Processes**

*Presented by Dr. George Maistros  
INASCO Hellas & COMPROME Consortium*



AST3-CT-2003-502900:  
Monitoring, Optimisation and Control of Liquid  
Composite Moulding Processes



Aeronautics Days 2006  
Vienna, 19-21 June 06

# COMPROME Consortium

## Project partners:

1. INASCO Hellas (co-ordinator)
2. Technika Plastika SA
3. Polyworx vof
4. ISOJET Equipements
5. Israel Aircraft Industries Ltd.
6. INASMET Fundacion
7. KEMA Nederland b.v.
8. National Technical University of Athens
9. Bombardier UK
10. Kok & van Engelen Composite Structures b.v.
11. Laser Zentrum Hannover

- Complementarity of expertise
- Balanced research development and industrial application

- 7 countries
- 2 A/C manufacturers
- 5 SMEs
- 3 Research institutes
- 1 University

- Total budget: 3.26 MEuro
- Total funding: 1.82 MEuro



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# Current trends in manufacturing aerospace parts

Industry drivers for aerospace components production using Liquid Composite Moulding (LCM) techniques:

- Weight ↘
- Parts complexity and integration ↗
- Manufacturing costs ↘
- Quality ↗



**Integrated (flow and cure) Process Control (IPC)**

In LCM will serve needs and satisfy demands !



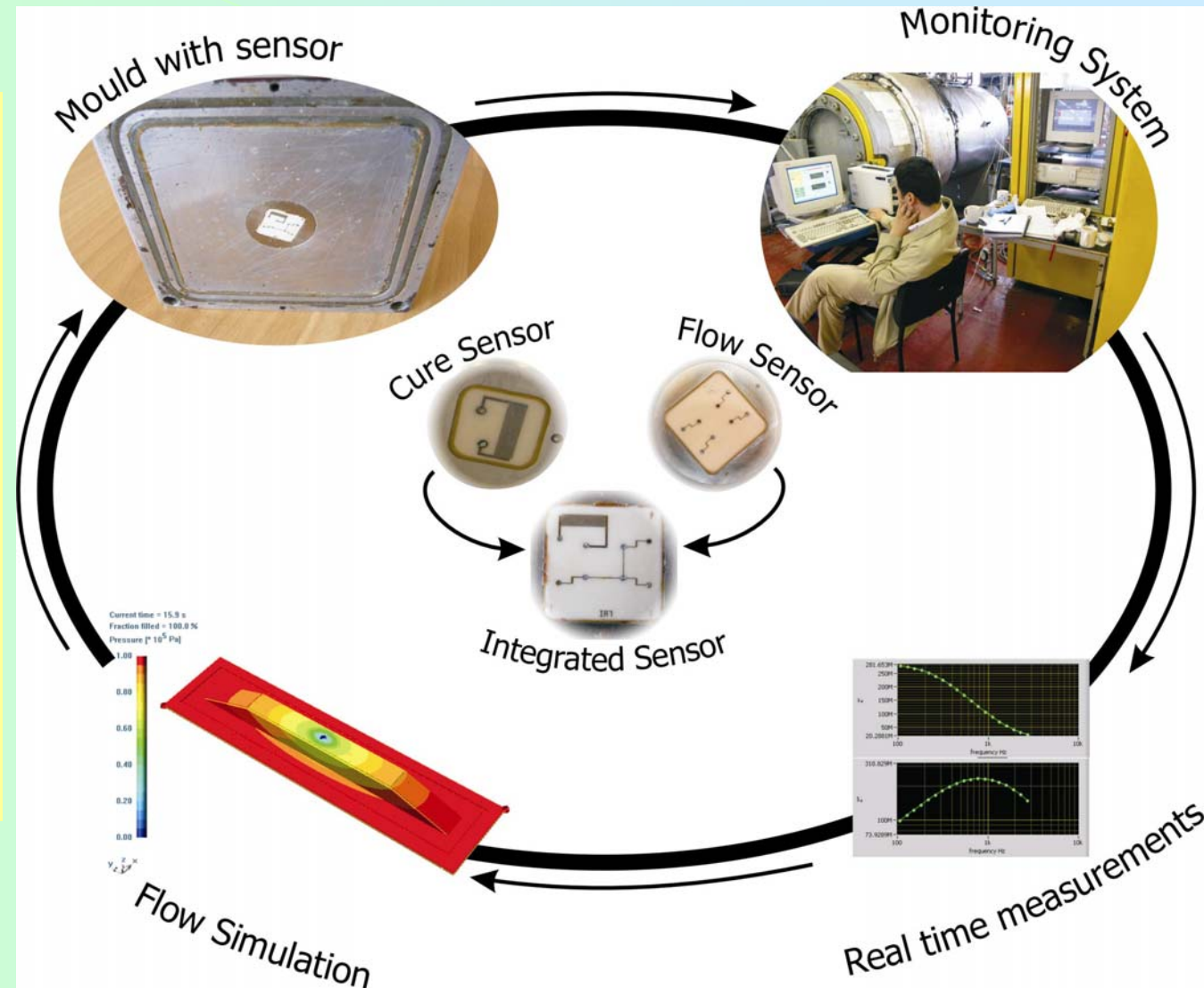
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# The elements of integrated process control

*Real-time robust monitoring of material properties in Liquid Composite Moulding (LCM) processes by means of tool mounted sensors and linked process simulation tools*



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# Benefits to aerospace industry

**IPC**

*Continuous and robust monitoring of material properties in Liquid Composite Moulding (LCM) processes by means of permanently attached in-mould sensors and linked process simulation tools*

## **Improved Quality**

- Composite materials with 'process signature'
- Secured closed mould filling procedures
- Increased production reliability

## **Cost effectiveness**

- Reduction of scrap
- Shorter process cycles
- Efficient process development
- Elimination of post-process testing



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# COMPROME Project Objectives

## Main target

Develop a revolutionary control system applicable to the production of composite materials through a wide range of LCM methods

## Development plan

1. an integrated, durable and tool-mounted dielectric sensor
2. modular monitoring system with embedded knowledge
3. process control strategy interacting with simulation tool and actuators
4. global integrated process control (IPC) system
5. the manufacturing aerospace components with cost-effectiveness and improved quality



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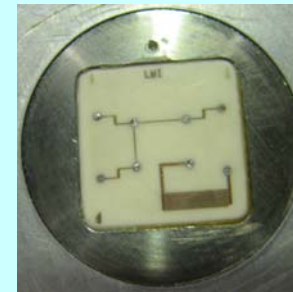


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# COMPROME Innovative Character

## Main innovations

- integrated, durable and tool-mounted dielectric sensor cluster
- multi-sensor real-time monitoring system
- interfacing composites process simulation tools with actuators and the monitoring system
- intelligent guidance of the manufacturing stage at a predefined path of global process conditions towards given final state



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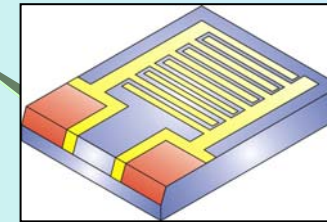
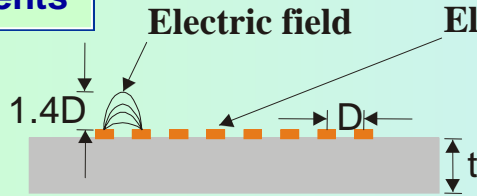
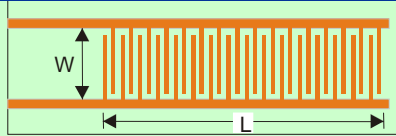


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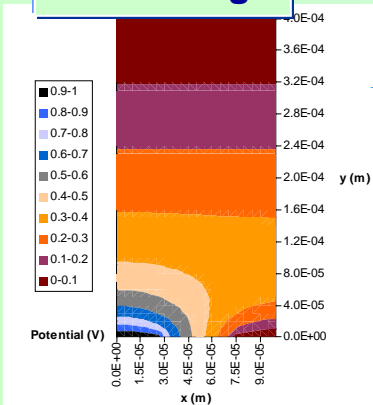
# COMPROME Technologies

## Dielectric sensors for LCM manufacturing

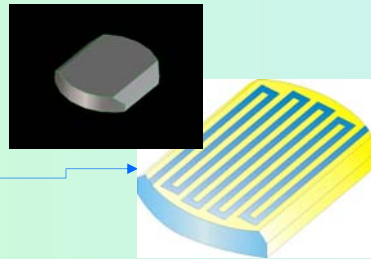
interdigital sensing elements



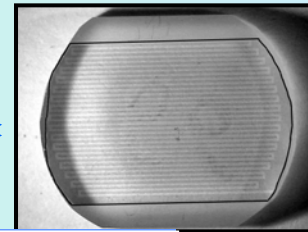
electric field modelling



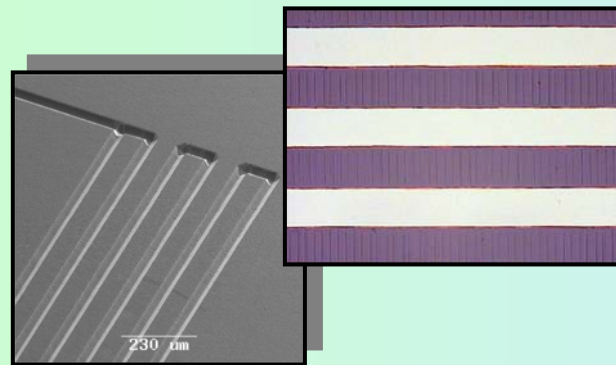
Sensor design tool



durable sensors



robust tool mounting



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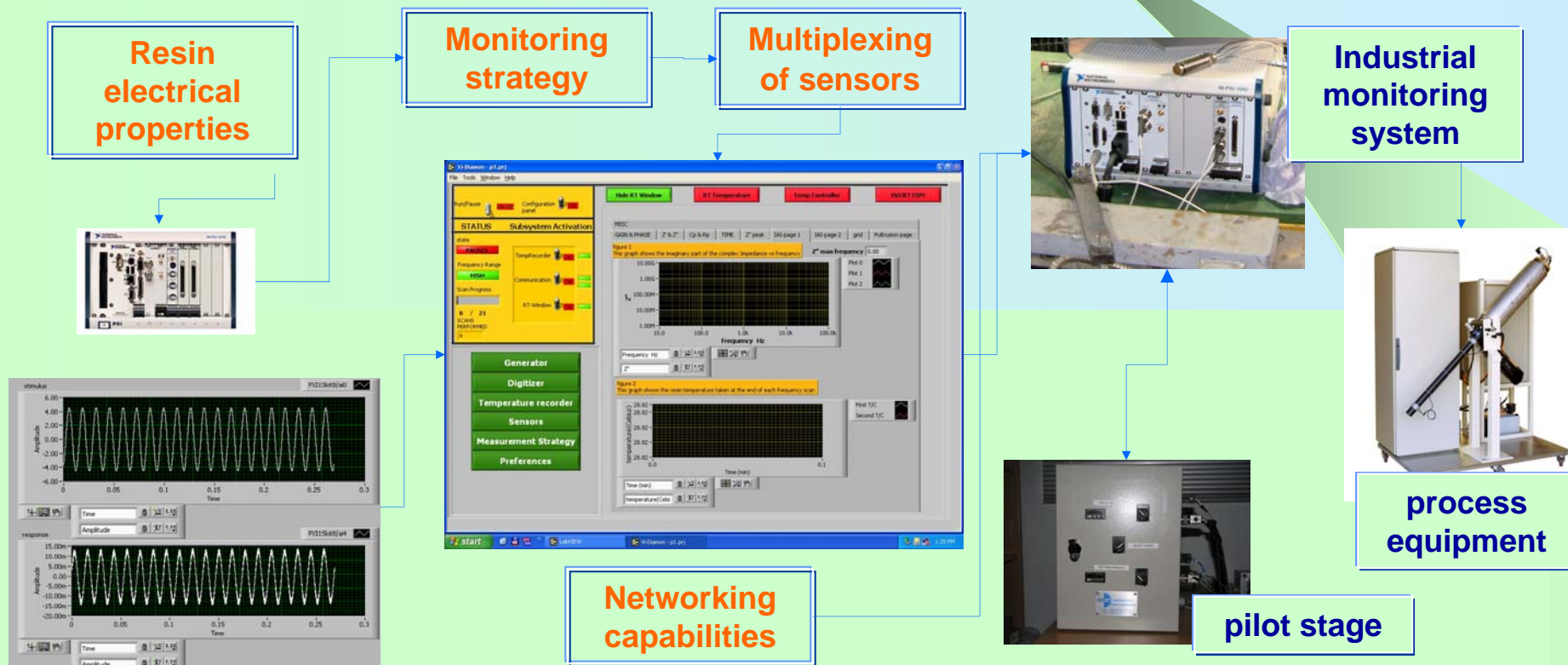


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# COMPROME Technologies

## Monitoring system for LCM manufacturing

- modular architecture, multi-functional operation
- connectivity to industrial equipment

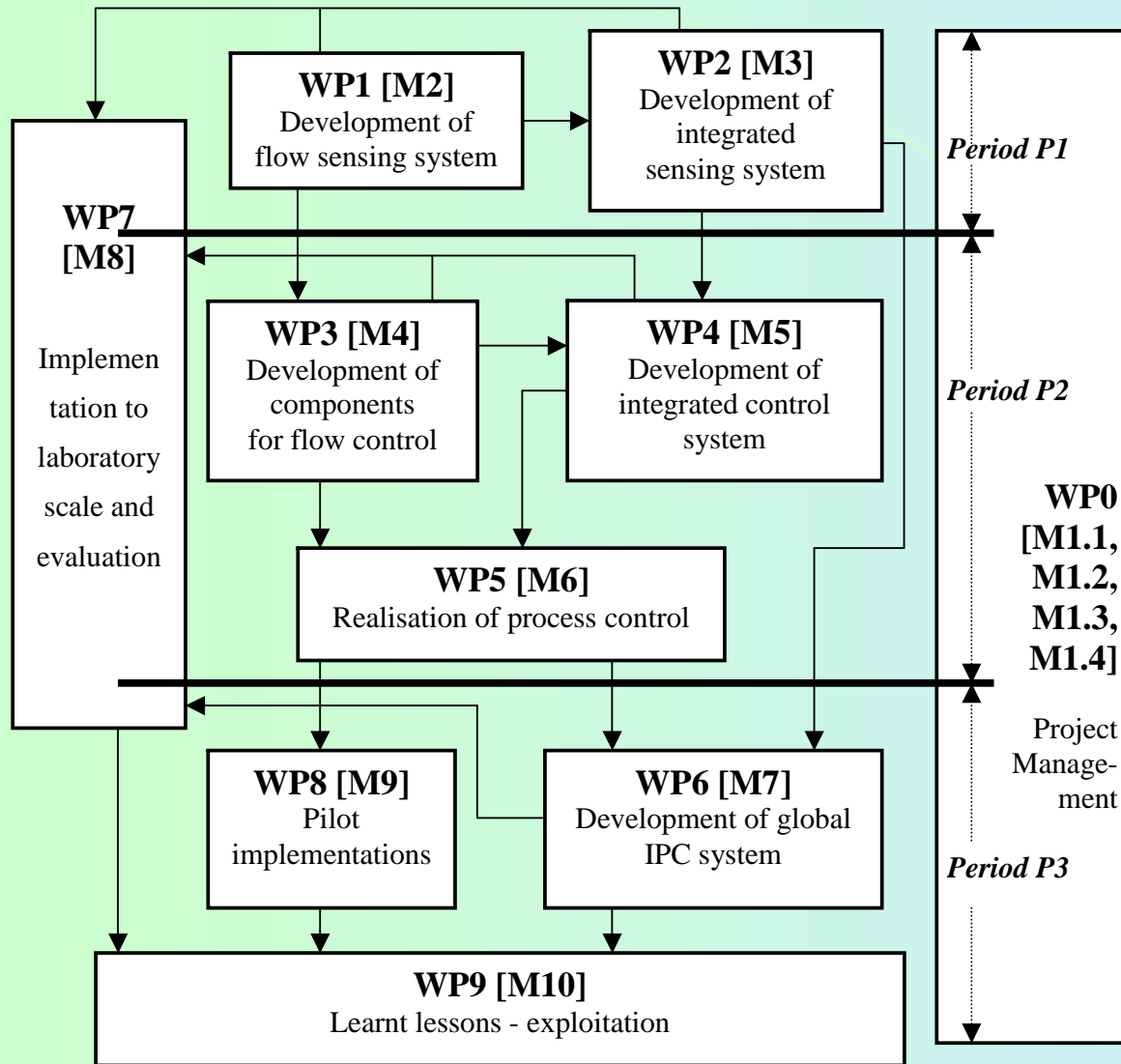


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# COMPROME Project Structure



Each workpackage deals with a single item in the development plan



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# COMPROME Results

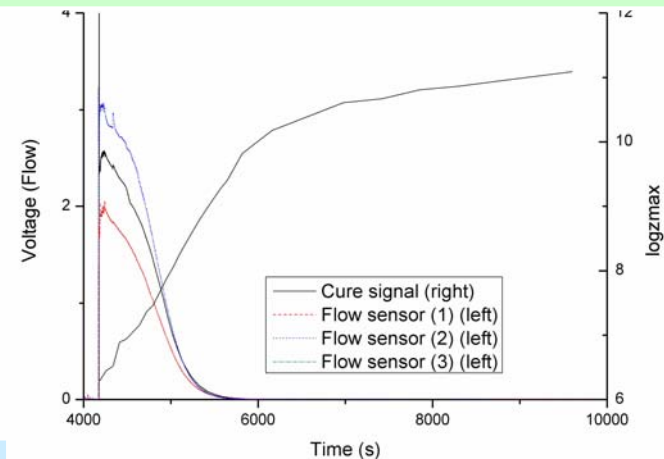
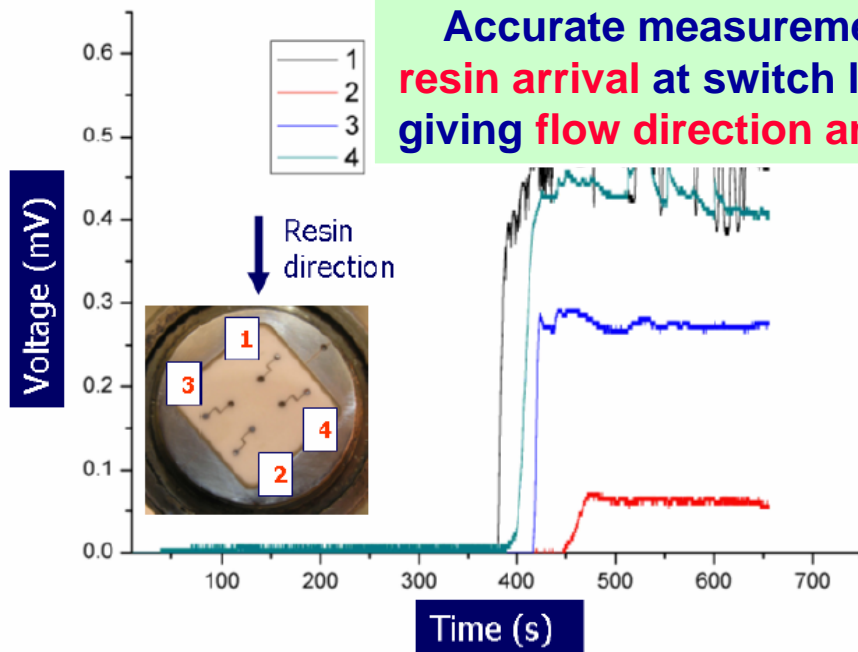
## Dielectric integrated sensors in RTM

RTM flow & cure monitoring result

Mould filling and resin cure effects

Accurate measurements of resin arrival at switch locations giving flow direction and speed

Correlation between DC resistance and resin viscosity



Proved benefits: in situ resin flow measurement



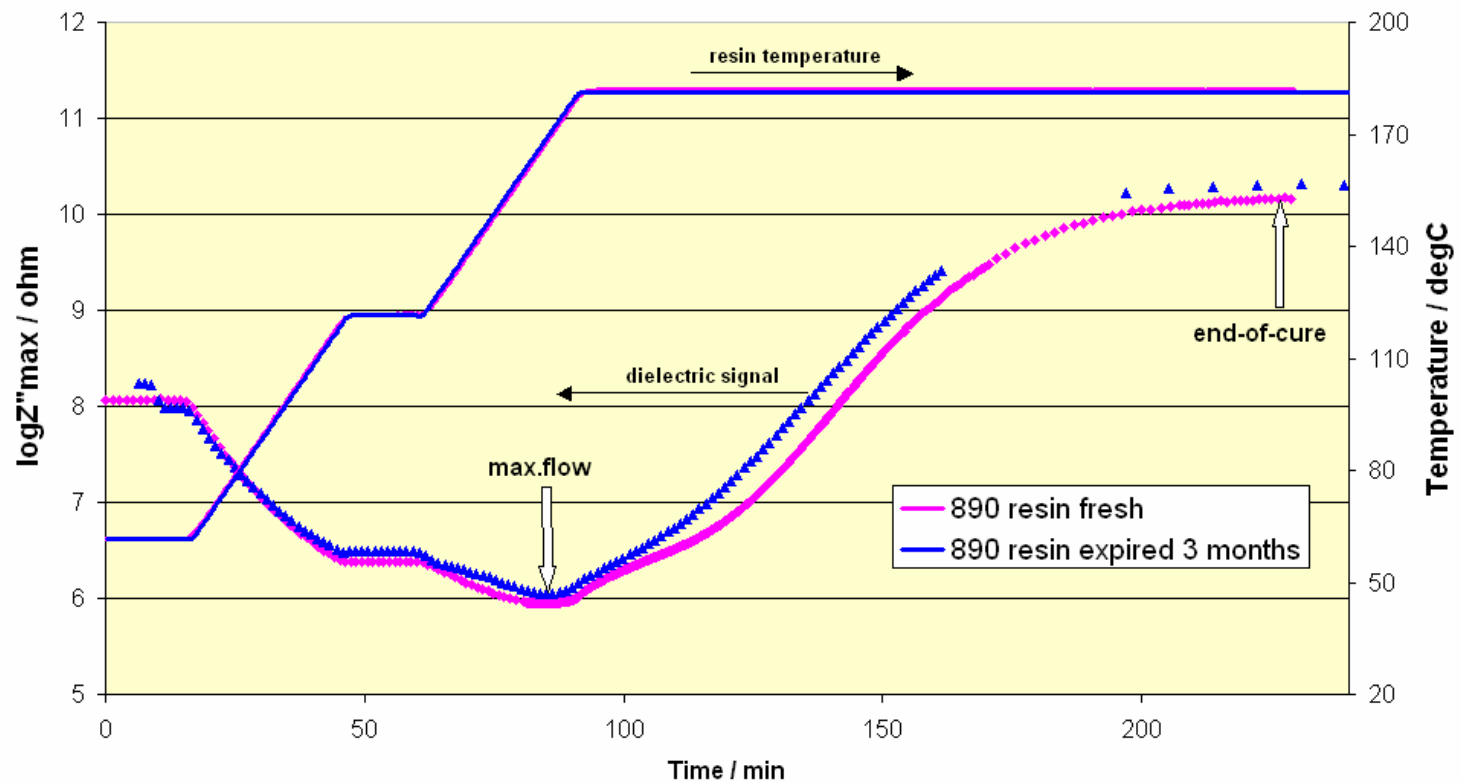
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# COMPROME Results

## Dielectric cure sensors in RTI installation



Sensor installed  
in autoclave

- study of aging effect on cure progress
- resin arrival and cure progress leading to shorter process cycle



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# COMPROME – Next steps

- Dielectric sensors for flow and cure measurements are tested for durability and robustness in RTM moulds, vacuum infusion and resin transfer infusion (RTI) processes
- The aerospace resin systems proposed by the A/C manufacturers will be modelled to produce the material state translator
- The required tools for flow and cure control are under construction
- The lab scale RTM implementation is scaled up with integrated control technology
- The system installation at the end user pilot cases is about to start based on the proposed fabrication applications



# Thank you for your attention

Current project outcomes are displayed  
at the COMPROME stand  
next to Gate 1 conference room



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