

# The thermoplastic liner : a breakthrough in high pressure vessels technology

**Astrium Space Transportation**

*IAASS COPV Safety and Integrity Workshop  
October 20<sup>th</sup> & 21<sup>th</sup> 2008, Rome*

*Guillaume Rémy, Fabien Bénédic and Christian Le Floch  
Competence Centre  
guillaume.remy@astrium.eads.net  
fabien.benedic@astrium.eads.net  
christian.lefloch@astrium.eads.net*

All the space you need



## INTRODUCTION

- ASTRIUM Space Transportation has been involved in high pressure tanks design and development for more than 25 years in its Aquitaine plant.



- More than 800 HP tanks have been produced for both Satellites and Launchers and to this day, more than 90 satellites rely on ASTRIUM Space Transportation Tanks.

- ASTRIUM Space Transportation is still developing new technologies and products to provide the best solution in response to the evolution of the market in terms of performance, cost and cycle reductions.
- Last A5 programmatic constraints have led to develop a new **breakthrough** to strongly reduce both the cost and the cycle of the 300 L helium HP tank.



## The cost of the liner and the cycle of the liner are the two main tank drivers to achieve the following targets:

- the liner cost usually represents 40 to 50 % of the tank cost
- the liner production cycle usually represents 70 to 80 % of the tank cycle, mainly due to the raw material and rough forging supply

## What are the objectives for the 300 L A5 tanks ?

- to get a low cost liner concept to reduce the current cost by 30 %
- to get a low cycle liner concept to reduce the tank cycle by 60 %

## The solution :

- no real significant cheap process with metallic liners for such a A5 tank diameter :  $\Phi$  900 mm
- a new **breakthrough technology** is required with a thermoplastic liner to be able to fulfill the targets

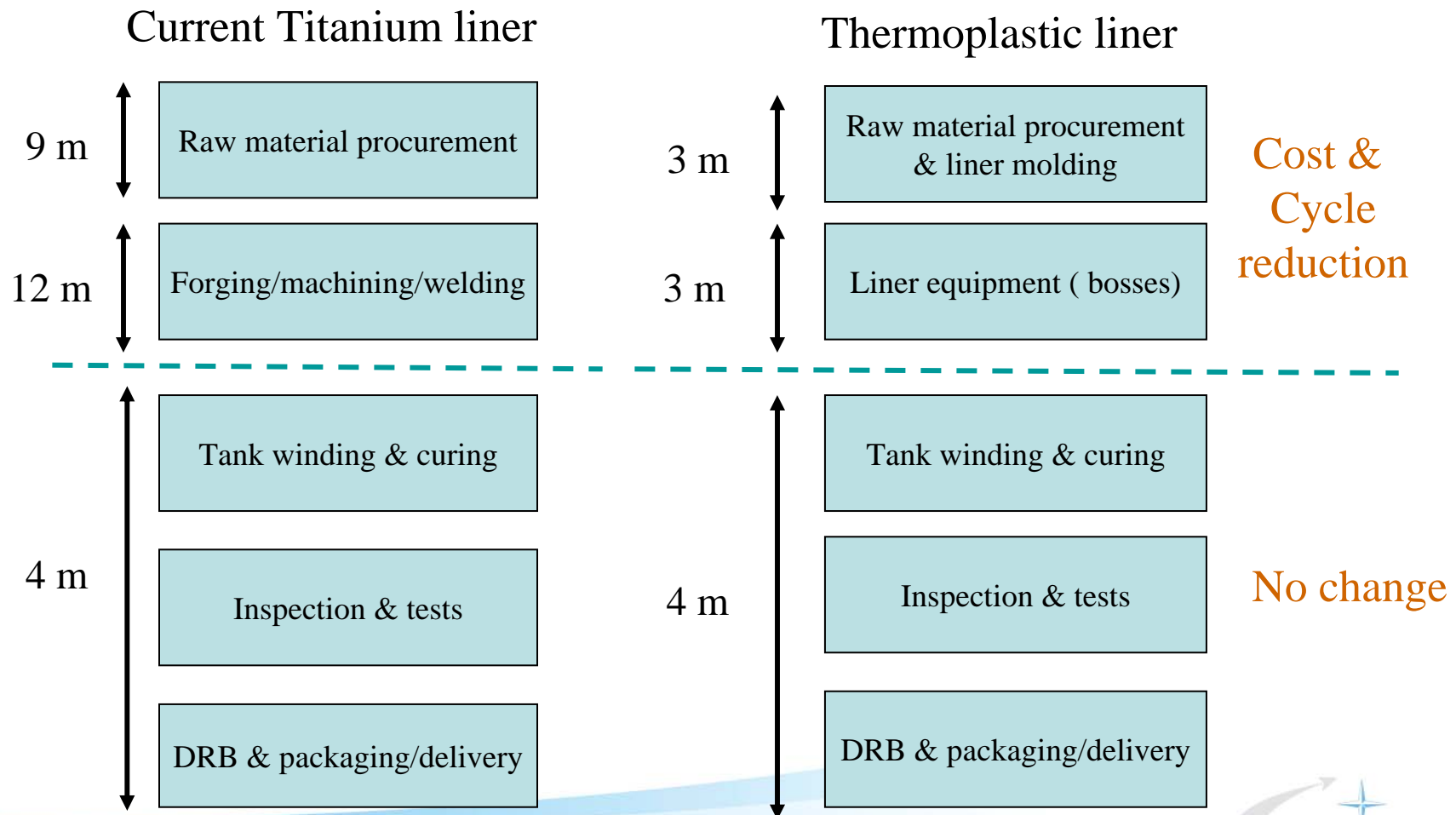
## New low-cost liner with Thermoplastic liner process

### Target cost reduction : - 70 % at liner level

The thermoplastic liner is a technological breakthrough within the two following major areas :


- **For Cost** : This technology breakthrough is the only way to meet the target cost reduction of Arianespace: - 30% at tank level
- **For Industrial Cycle** : The TP liner also offers a significant cycle reduction : 10 months instead of 25 months from the raw material procurement up to the tank delivery.

## Current titanium lined & future thermoplastic lined tank flow chart



This document is the property of Astrium. It shall not be communicated to third parties without prior written agreement. Its content shall not be disclosed.


## Feasibility Works for a 300 litres Helium Thermoplastic Lined Tank


- to demonstrate the feasibility of a thermoplastic liner at a full 300 L scale 

- to demonstrate the winding feasibility on a very flexible liner

- to perform a close to 300 L breadboard tank to demonstrate :



- the design of a thermoplastic lined tank to replace the current A5 titanium lined tank 

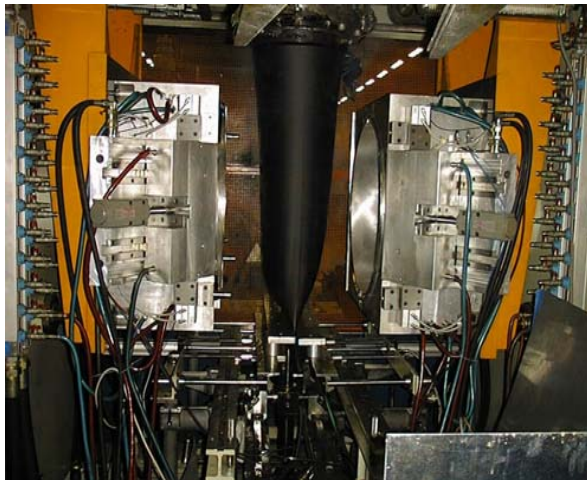
- the capability to withstand proof test, the tightness at MEOP pressure (40 MPa), 

- the capability to withstand the pressure loads and to demonstrate the safety margin 

The thermoplastic liner : a breakthrough in high pressure vessels technology

## A low-cost thermoplastic liner (close to 300 L) to replace the current titanium A5 liner

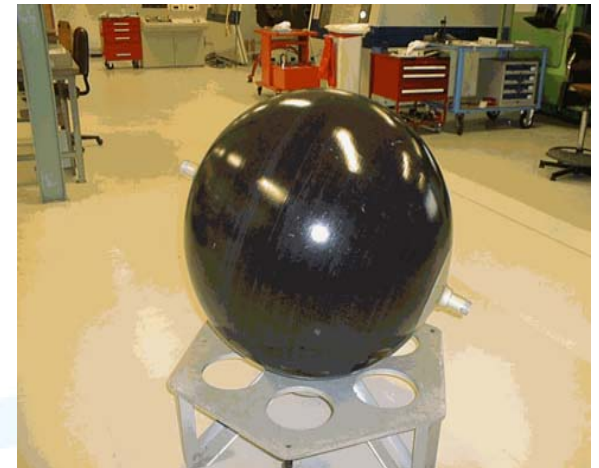
### Moulding and injection machine



### First set of plastic liners



### Thermoplastic equipped liner ready for overwrapping



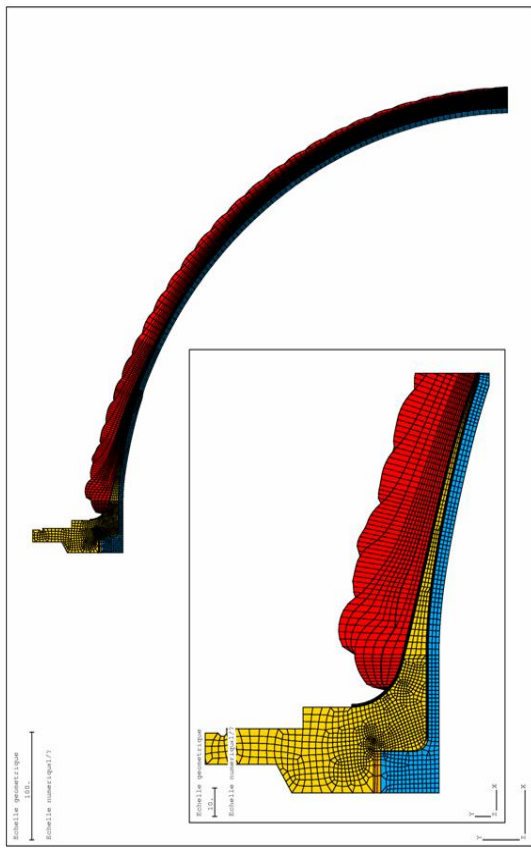
**Thermoplastic liner obtained in one operation  
No weld**

This document is the property of Astrium. It shall not be communicated to third parties without prior written agreement. Its content shall not be disclosed.

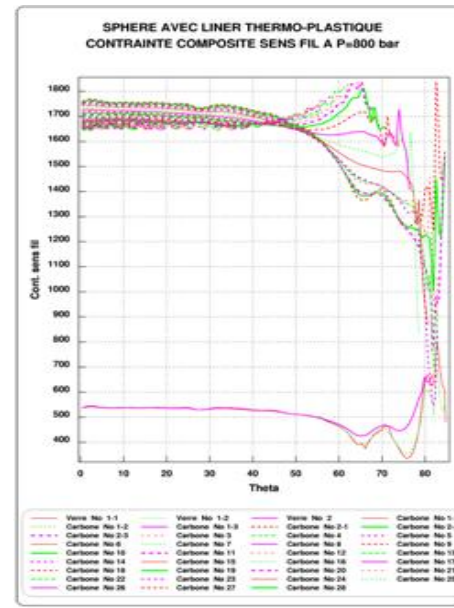
The thermoplastic liner : a breakthrough in high pressure vessels technology

# Design & Justification feasibility of the thermoplastic 300 L lined Tank

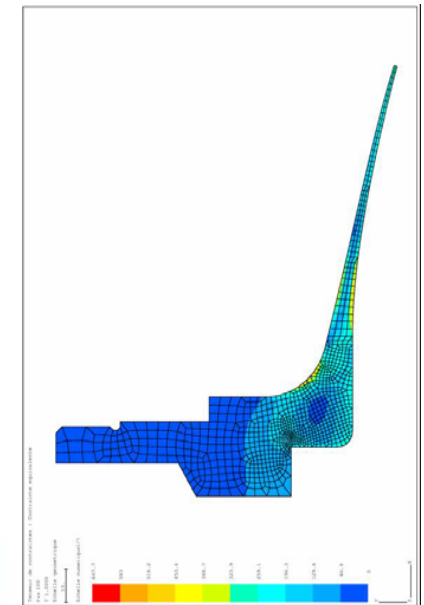
## Tank mesh model



Carbon  
layers  
stresses



Titanium interfaces  
bosses stresses



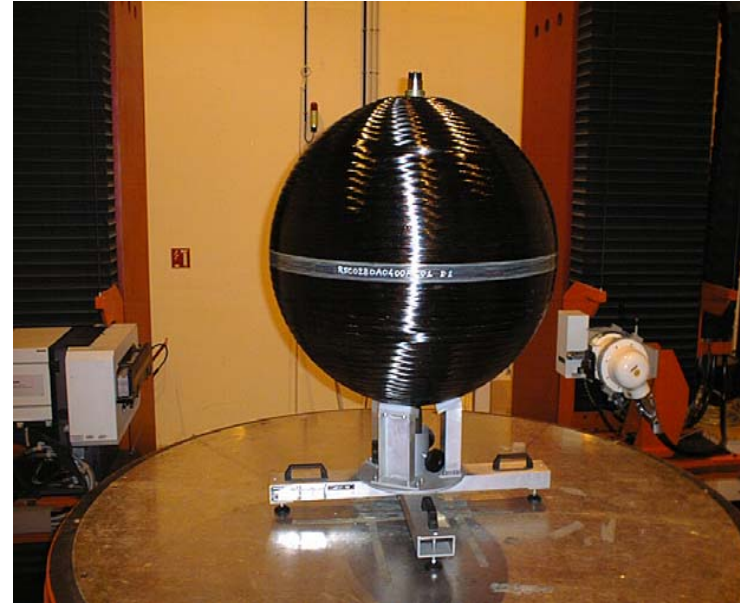
This document is the property of Astrium. It shall not be communicated to third parties without prior written agreement. Its content shall not be disclosed.

## Controls on the thermoplastic lined tank

Proof Pressure test 60 MPa ( 5' )  
with acoustic emission survey



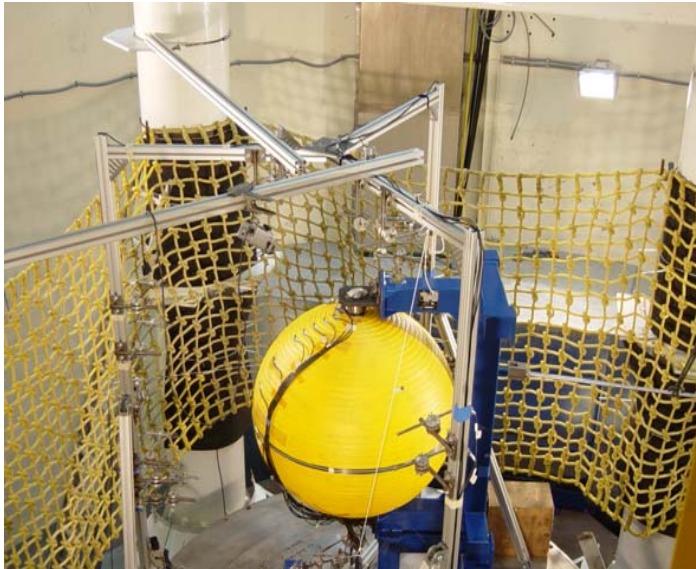
RX control : tomography checking  
of the thermoplastic lined tank



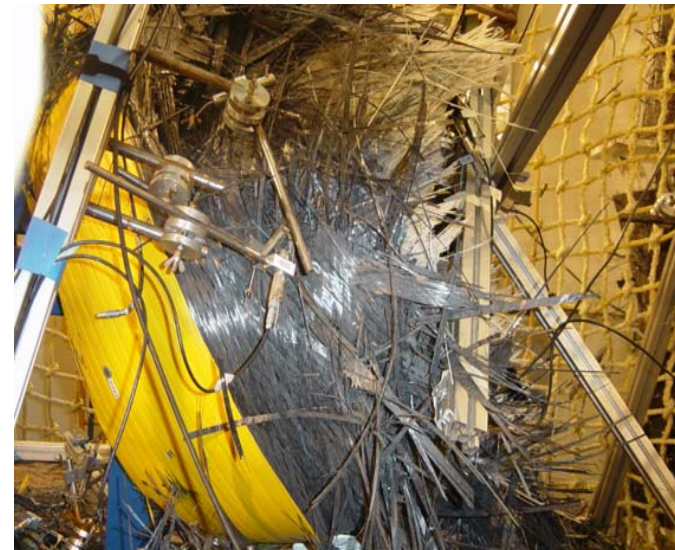
**All the controls : proof pressure test - Xray - ultrasonic inspection  
leak test to helium gas at MEOP = 40 MPa have given a very healthy  
behaviour of the tank**

The thermoplastic liner : a breakthrough in high pressure vessels technology

## Burst test of the thermoplastic lined tank



Preparation of the thermoplastic lined tank  
for burst test



Burst test result  
90.5 MPa for 80 MPa minimum expected



Feasibility phase for thermoplastic liner successfully achieved

## Main Technical Characteristics of the 300 L A5 Thermoplastic lined tank

- **Main characteristics :**
  - dry mass of the tank: 95Kg
  - outer diameter: <903mm @ Patm
  - MEOP: 40 MPa
  - minimum burst pressure: 80 MPa
  - temperature range: -20°C up to +50°C in operating
  - external leakage :  $5 \times 10^{-3}$  scc/sec @ GHe MEOP
- **Design**
  - thermoplastic lined tank overwrapped with T800 carbon composite
  - polar mounting with bearings
  - interface with propulsion system: a single port available (stub tube of 13mm inner diameter)



## Safety aspects

### Major interrests of the thermoplastic liner concept wrt safety aspects:

- No contribution of the liner to the mechanical strength:
  - In case of liner failure, **no sudden stress rise** is expected in the overwrapped composite
- Consequence of a leak:
  - The **liner is still in compression** at MEOP ( $\neq$  metallic liner)
    - this will prevent crack/defect propagation (validation to be checked by test)
  - Astrium experience in similar carbon overwrapped vessel shows that a leak at MEOP do not cause a carbon damage : demonstration LBB (Leak Before Burst) done on the 70L vessel

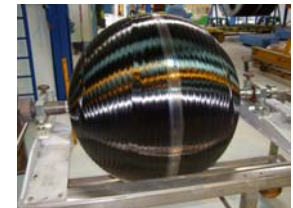
**This thermoplastic liner technology offers advantages regarding to the safety**

## The thermoplastic liner : a breakthrough in high pressure vessels technology

# CONCLUSION (1/2)

### Development phase

Demonstration of reliability of liner process: 20 liners manufactured  
Thermal cycling and leak test on 1st breadboard



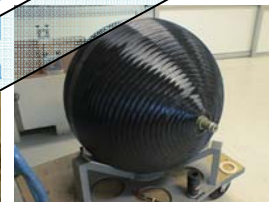
To follow :  
Vibration test & rapid depressurization test



Feasibility of the winding and curing processes  
1st breadboard  
1st leak test at 5 MPa



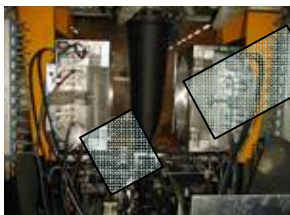
Demonstrator tank for test  
Leak test at 40 MPa  
burst at 90,5 MPa (min 80 MPa)



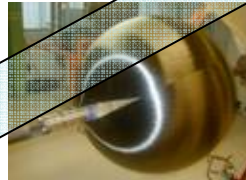
Processes validation  
manufacturing of a 2nd breadboard

Maturity level

Full scale injection moulding tool for the TP liner manufacturing



Liner technology feasibility: 1st batch of TP liners closed to A5 size (280L)



A5 HP vessel with thermoplastic liner main results

## CONCLUSION (2/2)

ASTRIUM Space Transportation has demonstrated the economical interest of the thermoplastic liner on a close to 300 L A5 tank by reducing the recurring price by 30 % at tank level and the tank cycle (10 months instead of 25) :

- ⇒ Advantages wrt safety aspects
- ⇒ Ready for a complete qualification and a development phase to replace the current A5 titanium lined tank
- ⇒ These results also open a new way for helium satellite tanks