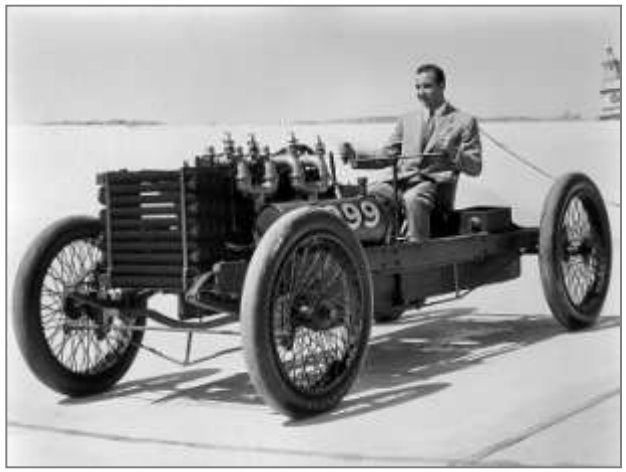
SPEED AND SAFETY:

COMPOSITE MATERIALS IN MOTORSPORT

Luca Pignacca
Chief Designer and EU Racing Business Leader

TECHNOLOGY: THE CONNECTION BETWEEN SPEED AND SAFETY



Low speed - High risk

High speed - Low risk

"It is all about probabilities. You can never make it safe. F1 is not safe but you can do a lot of work to reduce the probability of somebody getting hurt."

Max Mosley
Former FIA President

Safety in F1 from the early days until today

1950s : no thoughts for safety : cars, tracks , public , drivers , mechanics , etc

1960s : the first safety features : rear roll bar , seat belts , helmets and overalls, fire protections for fuel tanks

1970s : the begininnings of modern Formula One. Jackie Stewarts leads the safety crusade : drivers must be extracted in less than 5 secs, safety bladders for fuel tanks, head rest, safety structures around dashboard and pedals , front roll bar

1980 : survival cell extended to the front of the drivers' feet

1985 : frontal crash test

1988 : drivers's feet behind the front wheel axle, mandatory static homologations tests

1991 : more stringent testing of survival cell, including seat belts, fuel tank and roll bar

1994 : minimum headrest thickness of 75 mm

1995 : longer cockpit opening, rear and side impact test , higher speed in frontal crash

1998 : front roll bar test

1999 : tethered wheels, higher frontal impact test speed

2000 : side panels lay-up specified, higher frontal impact test speed

2001 : higher roll bar testing load , higher side impact test speed, side intrusion test

2002 : rear crash stucture push-off test

2003 : Hans (head and neck safety) system mandatory

2005 : side crash structure push-off test , higher side intrusion load

2006 : higher rear impact test speed

2007 : "softer" front and rear crash stuctures, higher frontal impact test speed, lower rear impact test speed, side zylon panels

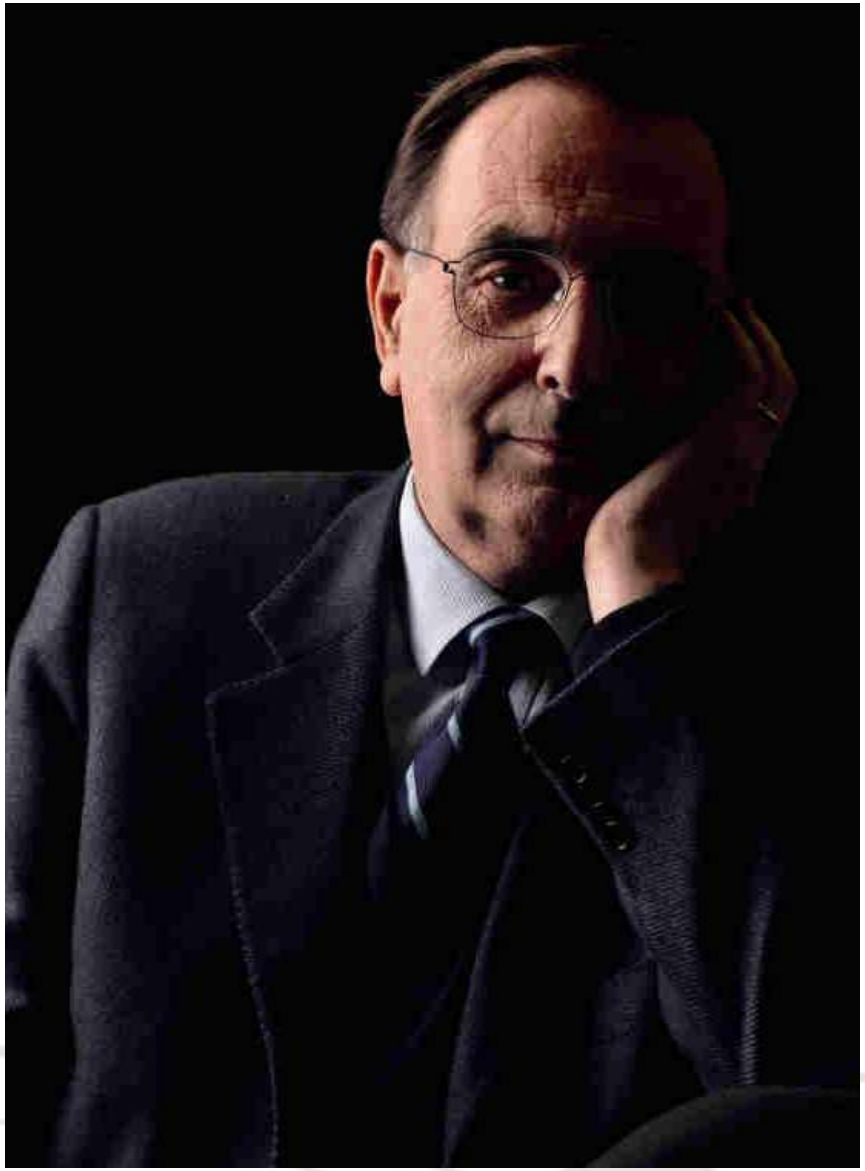
2009 : higher cockpit rim static test load

2010 : second frontal impact test with no nose and full tank

2011 : front side and bottom zylon panels, more demanding cockpit rim test, cockpit floor static test

"We wish to design and manufacture the fastest and the safest racing cars in the world"

Gian Paolo Dallara
President



DALLARA RACE CARS

IndyCar

GP2

Renault World Series 3.5

Indylight

GP3

F3

Formulino

Grand-Am

AUTOMOTIVE CONSULTANCIES

KTM X-Bow

Bugatti Veyron 16.4

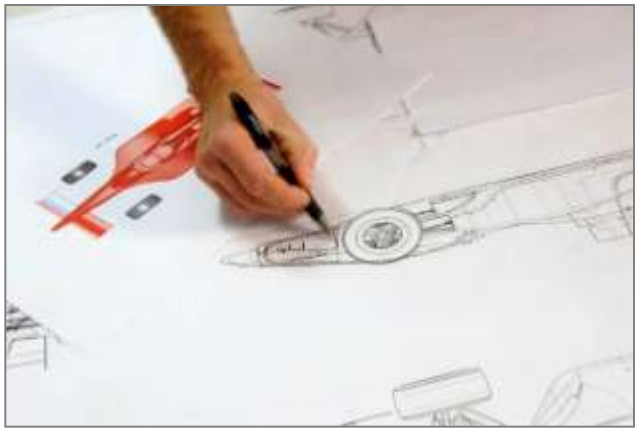
Alfa 8C

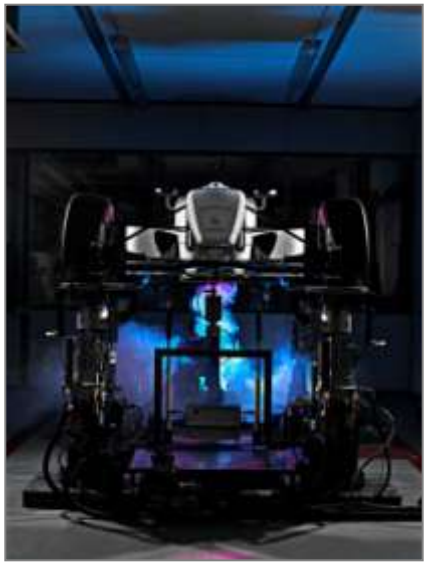
Maserati MC12

COMPANY PRESENTATION

In a world of increasing competition and knowledge distribution, our company strategy is focused on three areas of specialist knowledge:

1. Design and manufacturing
2. Aerodynamics
3. Vehicle Dynamics





A LONG CFRP CALCULATION HISTORY

1985
First carbon chassis

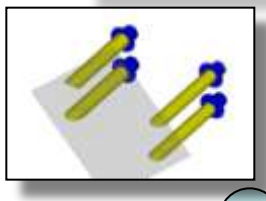
1990
Crash box

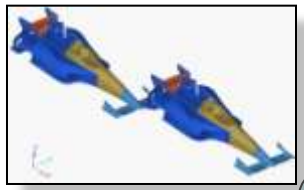
1998
First FEA on carbon chassis

2004
Specific tools

2005
Crash full scale model with carbon chassis

2008
Crash box with FE approach



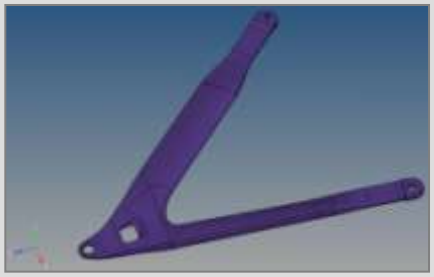


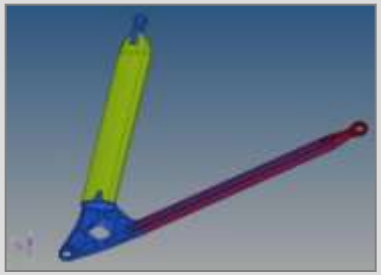
2010
Crash of racing cars – interaction between composite components

COMPOSITE MATERIALS : HIGH PERFORMANCE

FLWB in CFRP:
Displacement in cornering loadcase: 0.168 mm
Weight: 1.31 kg

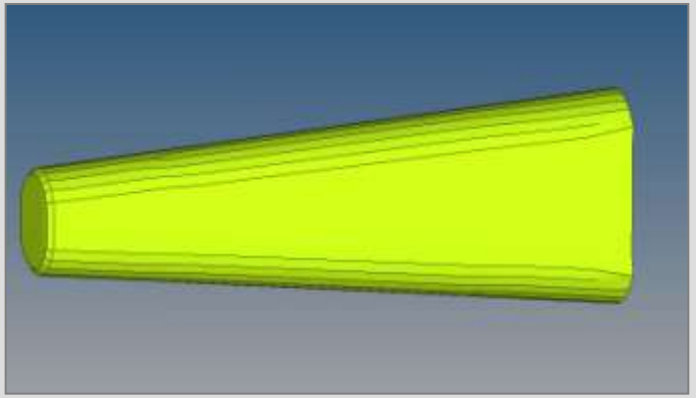
FLWB in Steel:
Displacement in cornering loadcase: 0.165mm
Weight: 2.29 kg





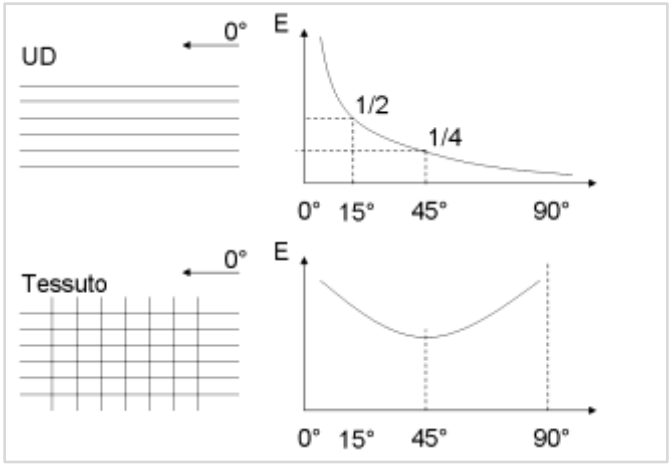
Crash Cone in CFRP:
Energy absorption: 110000 J
Weight: 4.6 kg

Crash Cone in Aluminium:
Energy absorption: 110000 J
Weight: 7.8kg



COMPOSITE MATERIALS : HIGH TECH

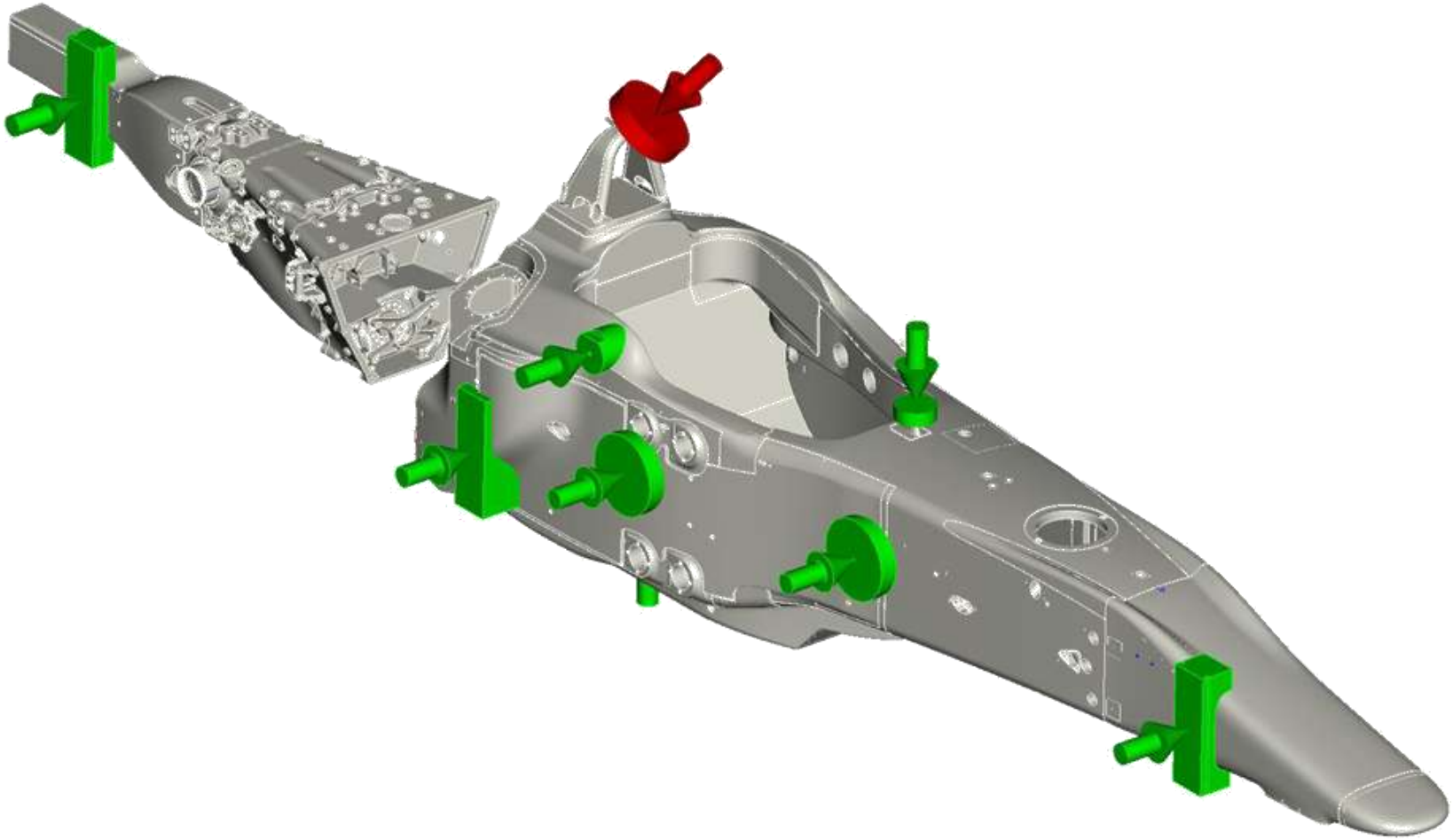
- Big experience and knowledge are required
- A lot of data necessary to do the analysis
- Physical phenomena very complex



KEY SYNERGIES WITH :

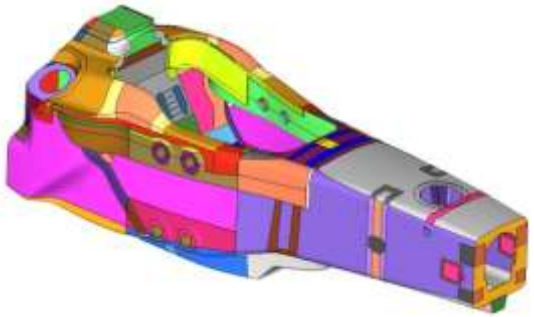
- The main raw material market suppliers, keeping us constantly informed about CFRP new developments and solutions
- The main software developers to test and improve new calculation and simulation tools
- The most reliable CFRP components suppliers including series manufacturing, allowing us to adapt the component design to the proper manufacturing technology.

TEST CASES



CASE STUDY: GP2 CHASSIS ANALYSIS

Phase 1
cleanup&mesh

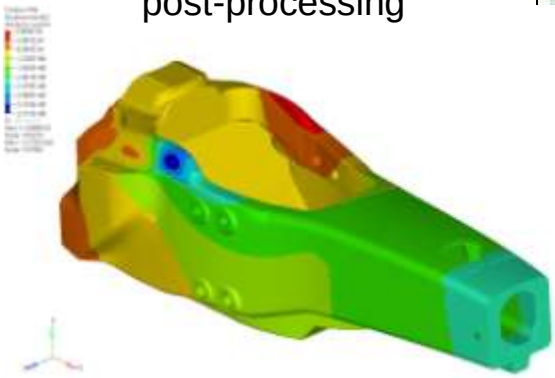


Hypermesh

Phase 2
materials&properties

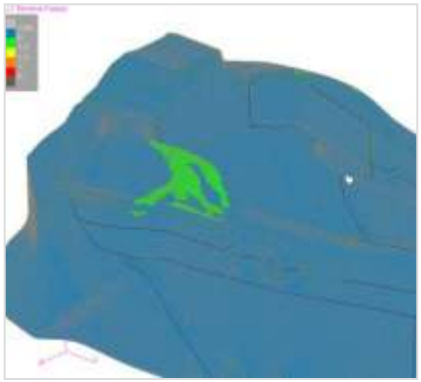
HyperLaminate and
Laminate Tools

Phase 3
post-processing



Hyperview

Phase 4
post-processing

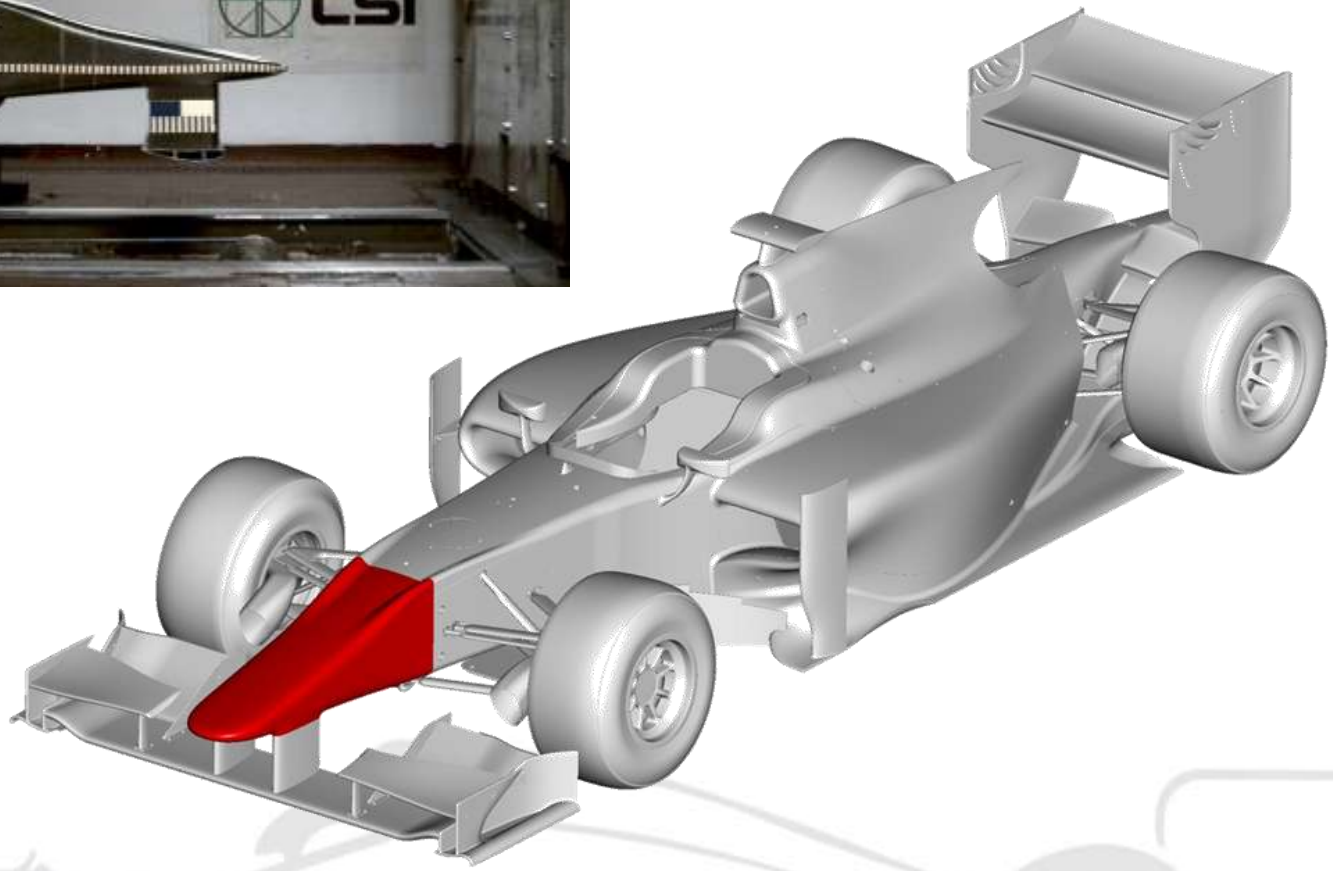


Laminate Tools

PROVEN METHOD

- Fiber and resin definition (strength, stiffness, resin content)
- Experimental data from tension and compression tests on different directions
- Creation of the FE model
- Definition of the composite material card
- Loadcases definition and analysis performing
- Analysis results validation by testing of complete or partial samples

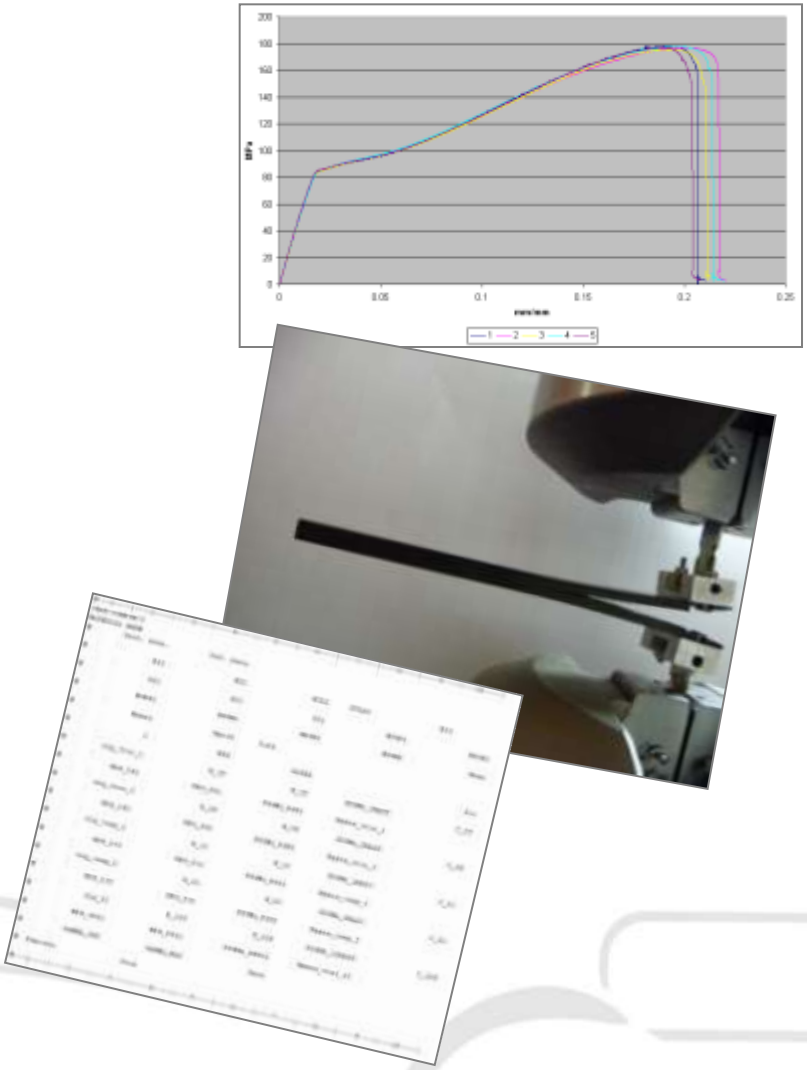
SAFETY STRUCTURES – NOSE BOX



WHAT HAPPENS IN A DYNAMIC SCENARIO?

Dynamic Phenomena on CFRP

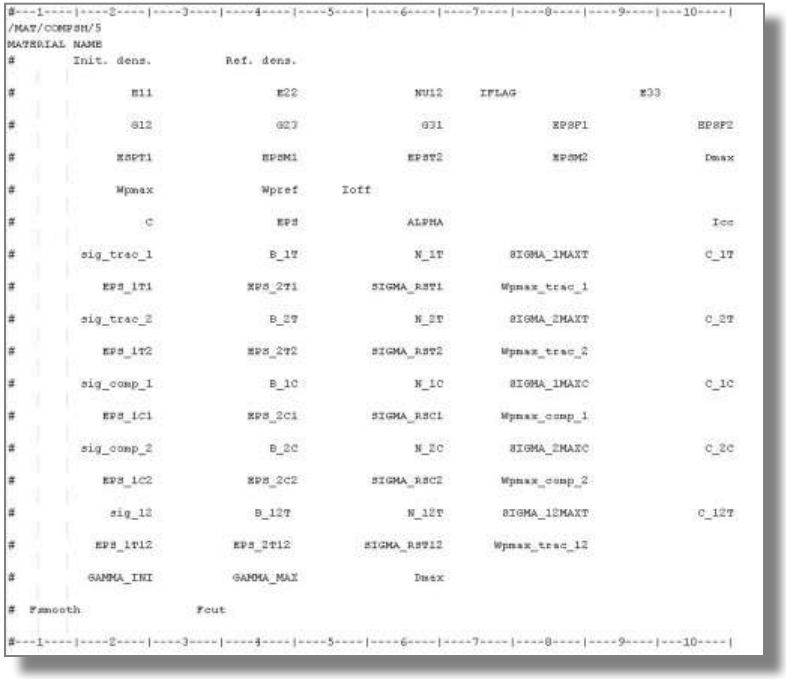
- Failure criteria
- Damages
- Failure propagation
- Inertial phenomena
- Instability
- Delamination
- Energy absorption
- Strain rate effect



DYNAMIC SCENARIO

Material CARD

- 74 parameters
- Different failure theories
- Combination of different criteria



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#---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|----9----|---10----|
/MAT/COMPSH/5
MATERIAL NAME
#       Init. dens.          Ref. dens.
#                E11                E22               NU12     IFLAG                E33
#                G12                G23                G31              EPSP1               EPSP2
#             ESPT1              EPSM1              EPST2              EPSM2               Dmax
#             Wpmax              Wpref      Ioff
#                 C                EPS              ALPHA                                  Icc
#        sig_trac_1                B_1T               N_1T         SIGMA_1MAXT               C_1T
#           EPS_1T1            EPS_2T1          SIGMA_RST1        Wpmax_trac_1
#        sig_trac_2                B_2T               N_2T         SIGMA_2MAXT               C_2T
#           EPS_1T2            EPS_2T2          SIGMA_RST2        Wpmax_trac_2
#        sig_comp_1                B_1C               N_1C         SIGMA_1MAXC               C_1C
#           EPS_1C1            EPS_2C1          SIGMA_RSC1        Wpmax_comp_1
#        sig_comp_2                B_2C               N_2C         SIGMA_2MAXC               C_2C
#           EPS_1C2            EPS_2C2          SIGMA_RSC2        Wpmax_comp_2
#             sig_12              B_12T              N_12T         SIGMA_12MAXT              C_12T
#          EPS_1T12           EPS_2T12         SIGMA_RST12       Wpmax_trac_12
#         GAMMA_INI          GAMMA_MAX               Dmax
#  Fsmooth                Fcut
#---1----|----2----|----3----|----4----|----5----|----6----|----7----|----8----|----9----|---10----|
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- Importance of the software house support
- Importance of being involved in the development
- Reliability of the software and of the testing laboratories
- Importance of the reasearch&development activities

DALLARA AND ALTAIR
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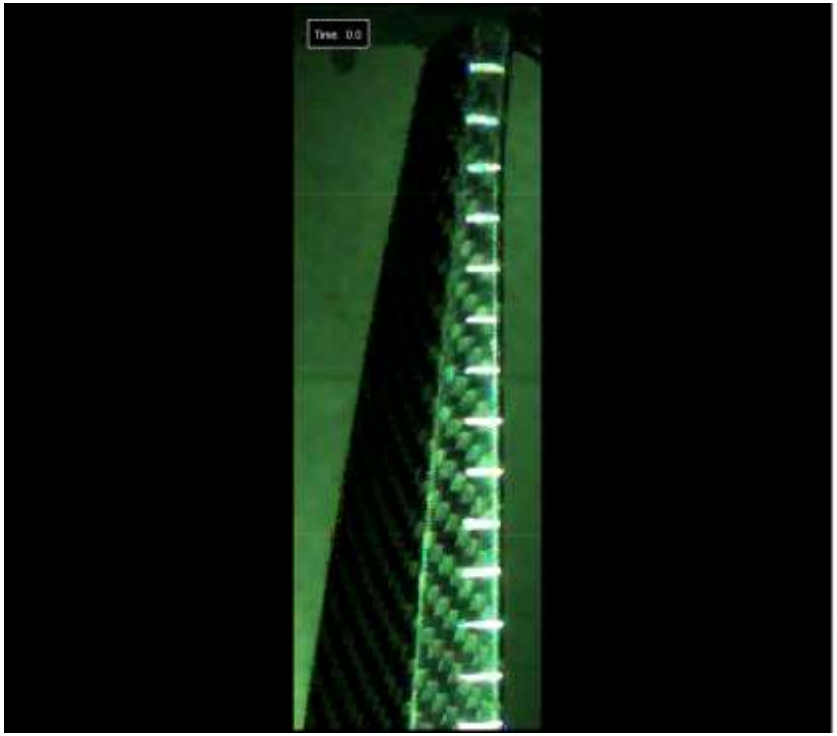
CASE STUDY: CRASH BOX STRUCTURE



DALLARA AND ALTAIR
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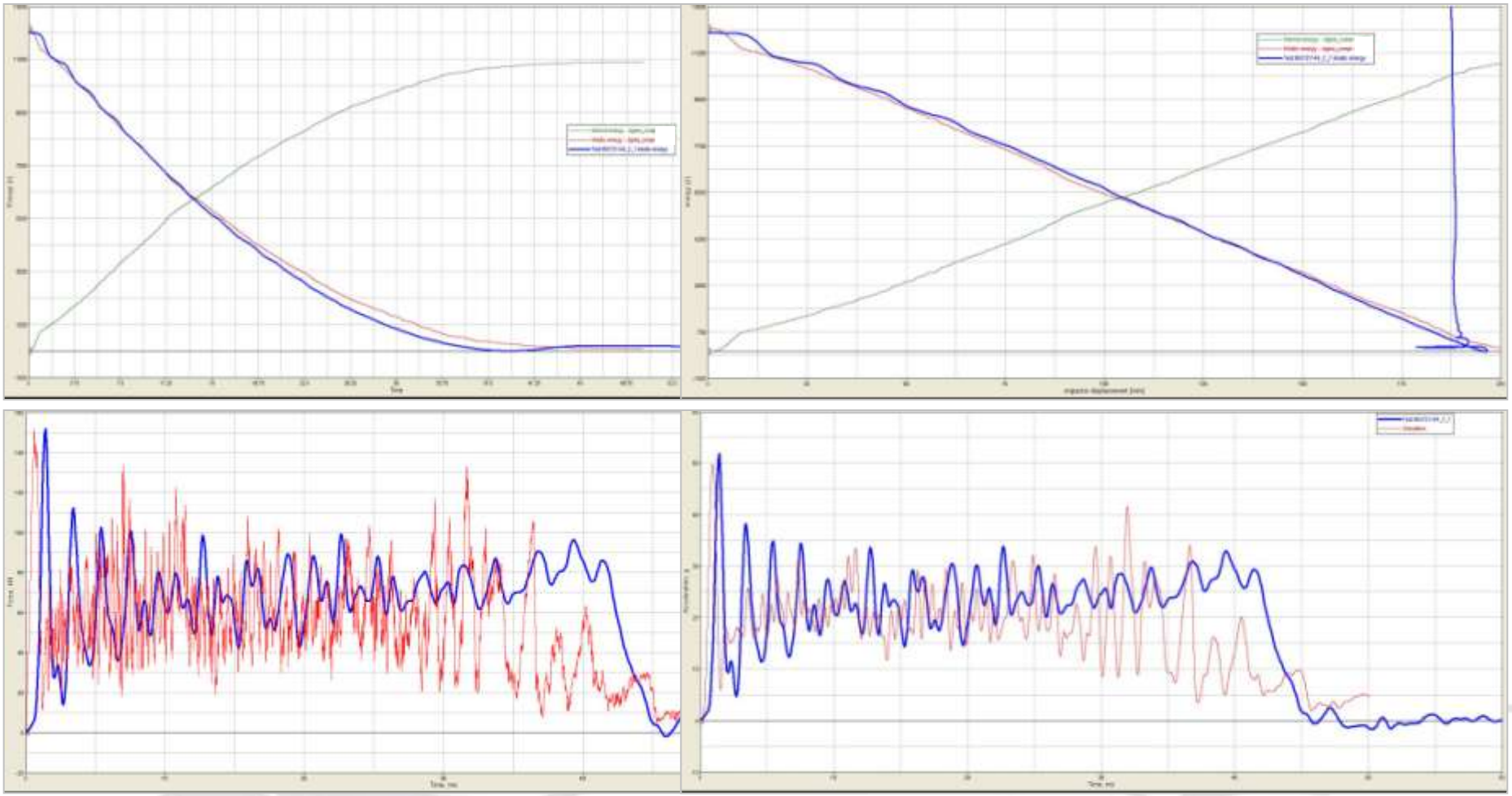

THE BEST SATISFACTION

"I've had a long and good relationship with Dallara. I won the world's largest motor race, the Indianapolis 500 in one of their chassis. But performance is not the only thing Dallara think about. They are also extremely safetyconscious. I drove one of their chassis when I had the biggest accident in my career at Texas Motor Speedway, when my car was launched into the barriers at 220 miles per hour while battling for the podium in the latest stages of the race. The g-force of the impact was measured an incredible 214 g's, as the car virtually exploded from the impact. It was highest the highest g-force to be recorded in an impact, ever. But the safety cell was intact. The sheer energy from the impact left me severely injured and hospitalized for 3 months. It's not in the nature of motorsports to be "bulletproof", but ***I am convinced that it was thanks to Dallara's innovation and safety thinking that I lived to race another day".***

KENNY BRACK
Former Indianapolis 500 Champion

INFRASTRUCTURE

- 336 core IBM cluster
- PBS Workload Management System
- HyperWorks CAE Suite

OUR NEXT CHALLENGE