

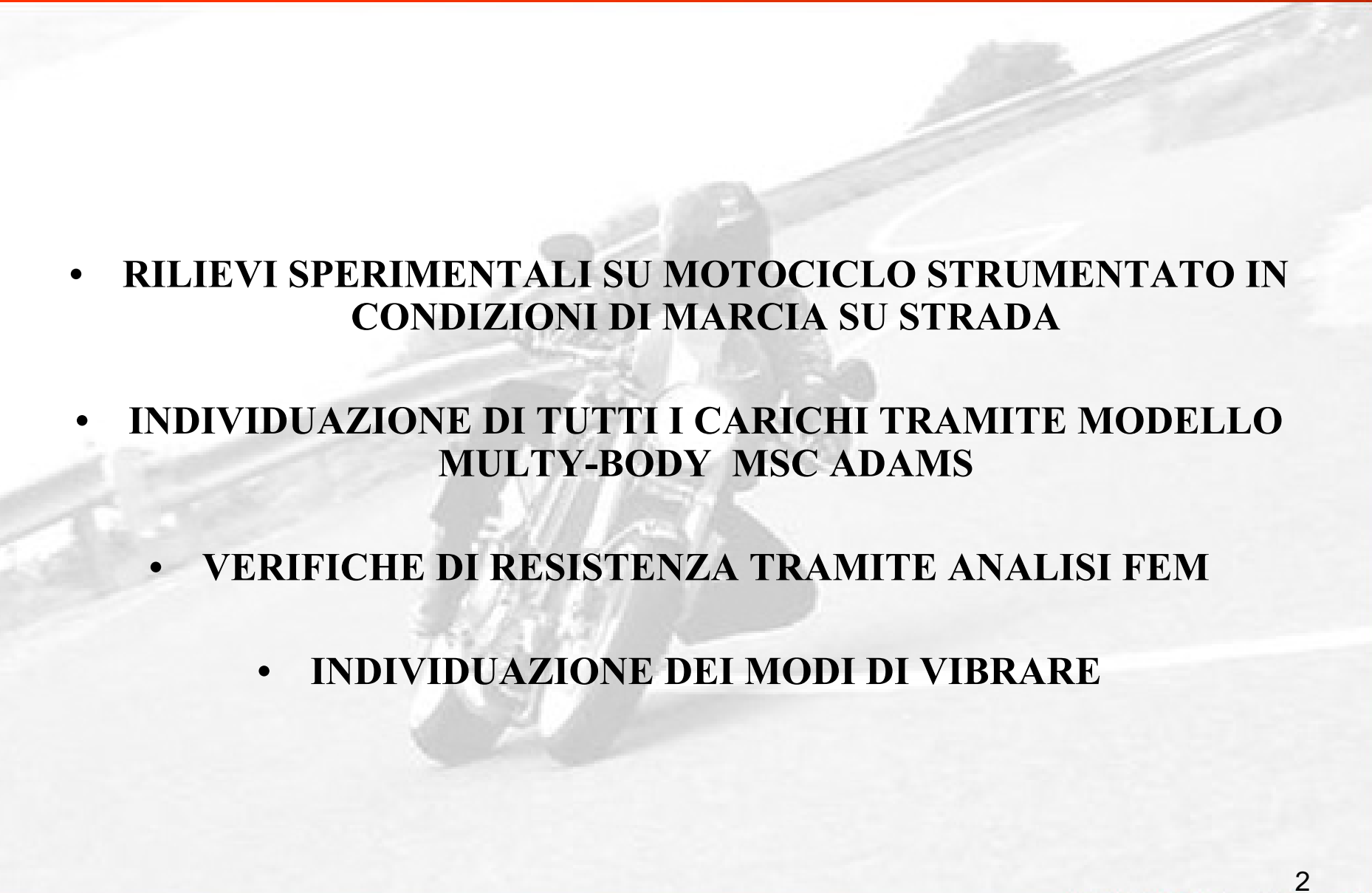


**STUDIO DELLA RISPOSTA STRUTTURALE
DEL TELAIO E DEL FORCELLONE POSTERIORE
DI UN MOTOCICLO DUCATI IN CONDIZIONI
DI MARCIA SU STRADA**

**Candidato:
Giacomo PERNA**

**Relatore:
Chiar.mo prof. Ing. Giorgio BARTOLOZZI**

**Correlatore:
Chiar.mo prof. Ing. Luca PIANCASTELLI
Ing. Stefano CASSANI**

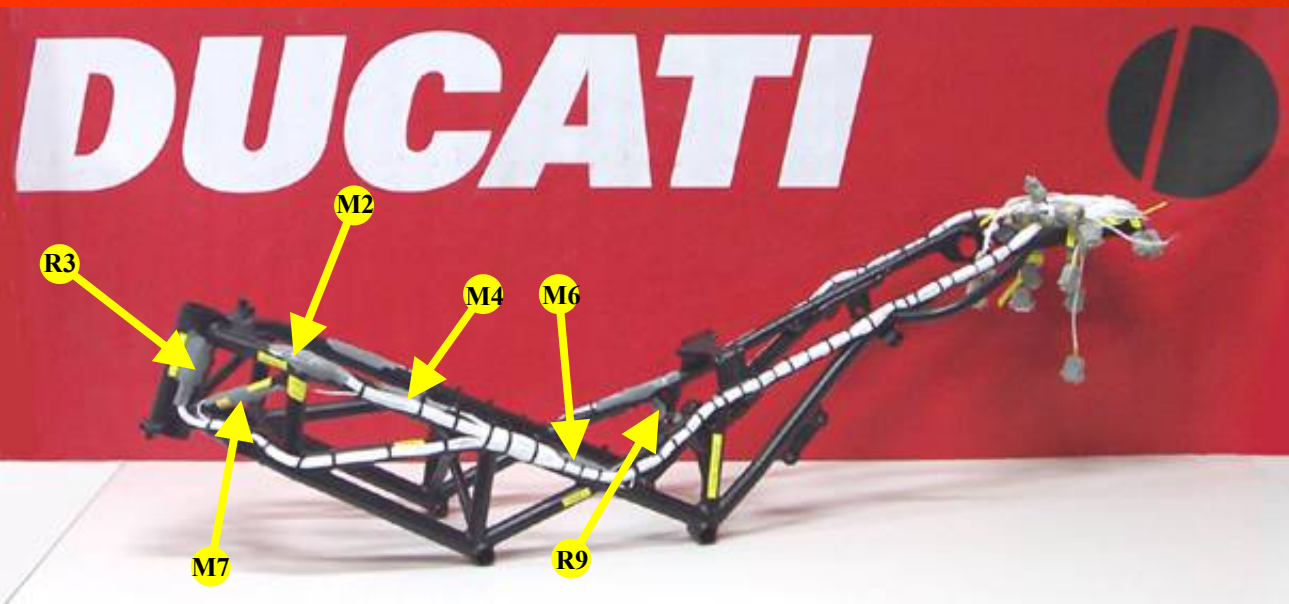
- 
- **RILIEVI SPERIMENTALI SU MOTOCICLO STRUMENTATO IN CONDIZIONI DI MARCIA SU STRADA**
 - **INDIVIDUAZIONE DI TUTTI I CARICHI TRAMITE MODELLO MULTY-BODY MSC ADAMS**
 - **VERIFICHE DI RESISTENZA TRAMITE ANALISI FEM**
 - **INDIVIDUAZIONE DEI MODI DI VIBRARE**



STRUMENTAZIONE DEL **TELAIO
DELLA **FORCELLA ANTERIORE**
E DEL **FORCELLONE POSTERIORE**
CON ESTENSIMETRI**

PROCEDURA DI MONTAGGIO DEGLI ESTENSIMETRI

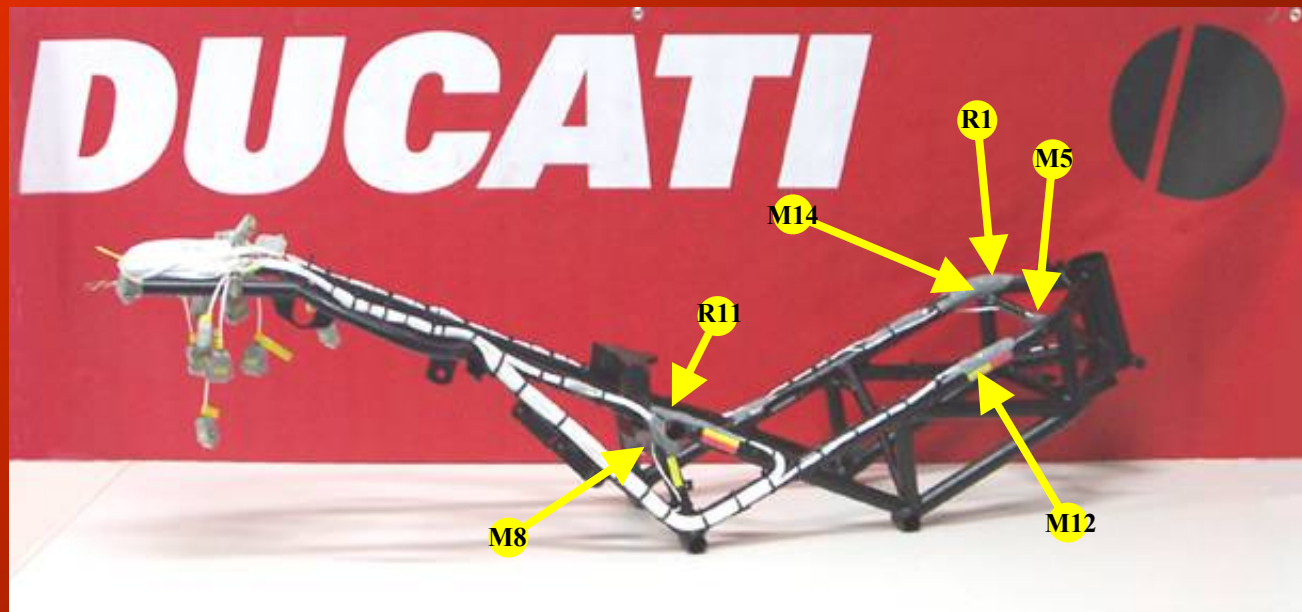
- **PREPARAZIONE DELLA SUPERFICIE**
- **INCOLLAGGIO DELL'ESTENSIMETRO**
- **PREPARAZIONE DEL CABLAGGIO**
- **L'APPLICAZIONE DELLE PROTEZIONI**

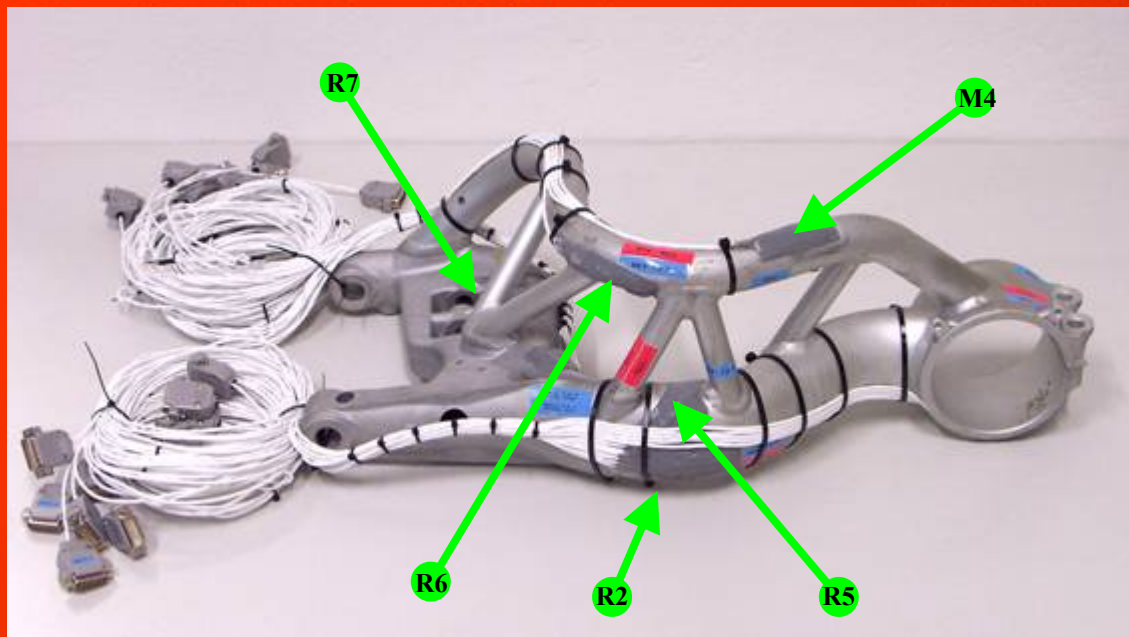


M = Estensimetro
monodirezionale

R = Rosetta

PUNTI SCELTI PREVIA
ANALISI FEM

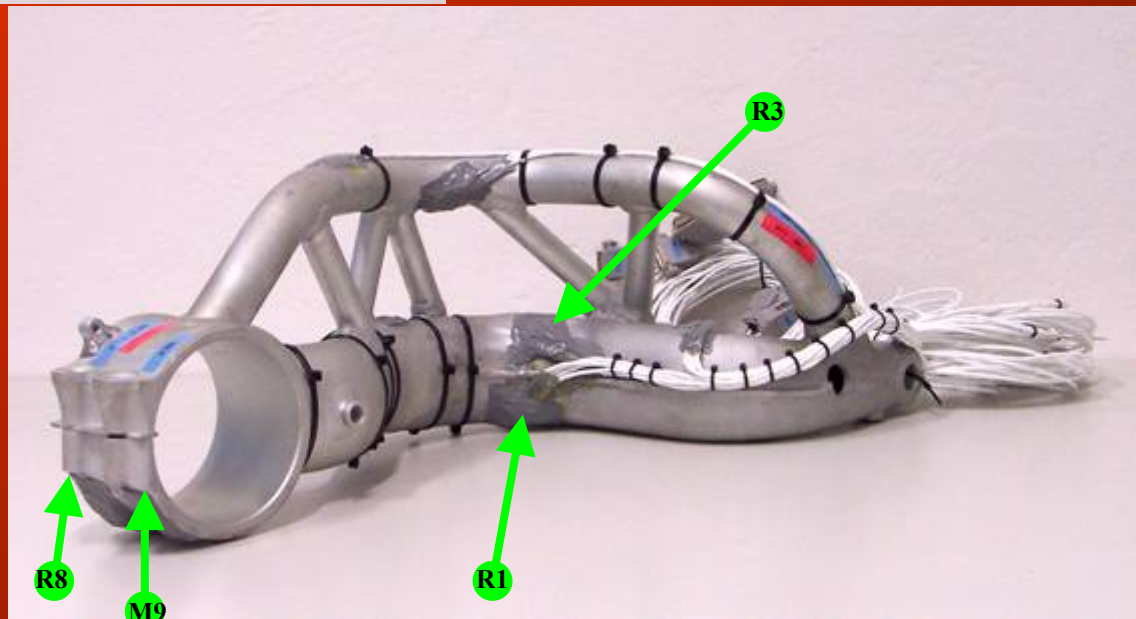


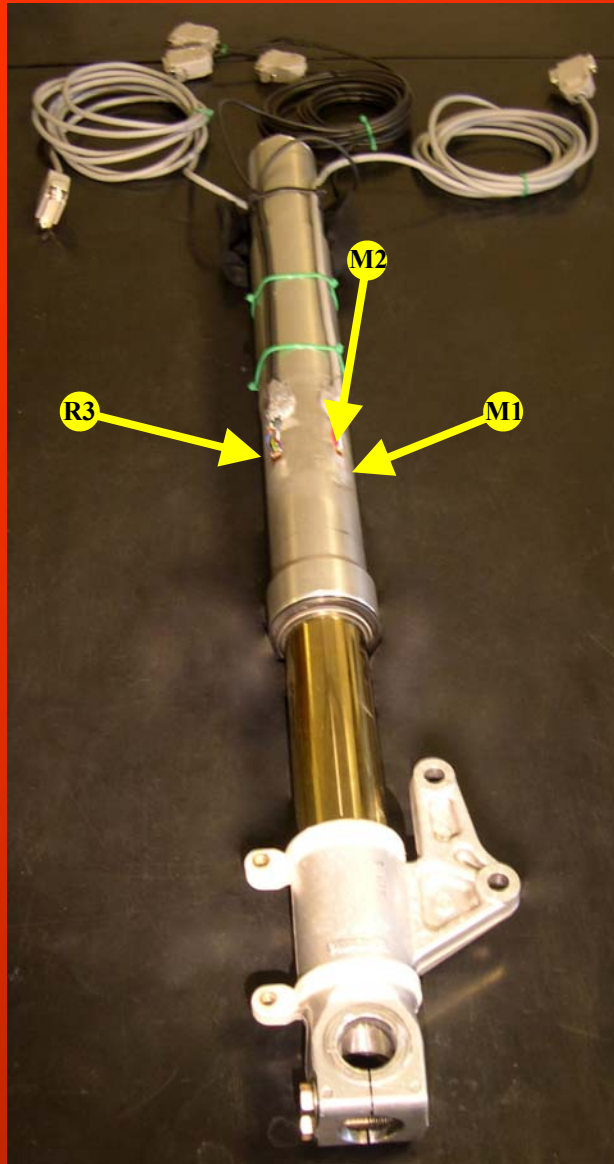


M = Estensimetro
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R = Rosetta

PUNTI SCELTI PREVIA
ANALISI FEM

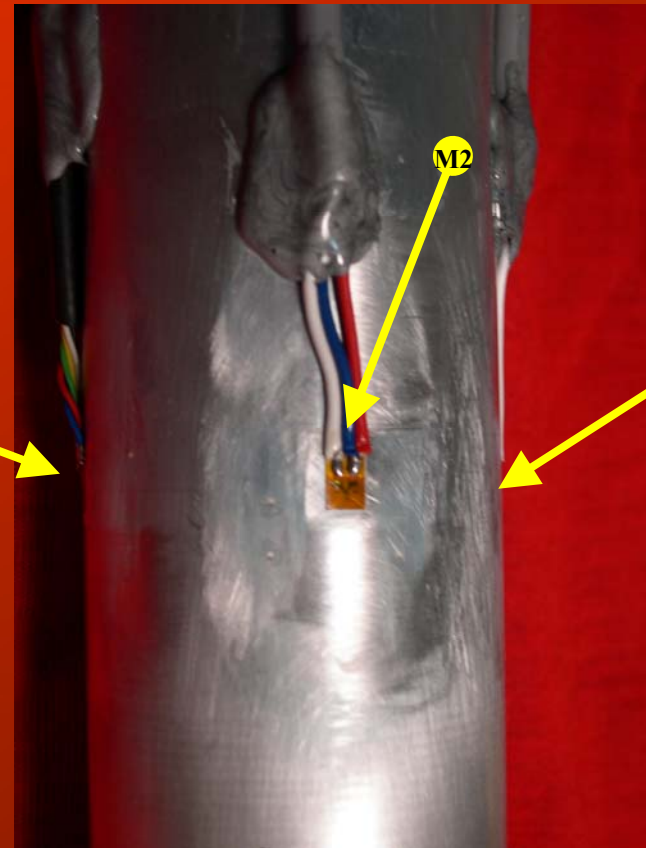


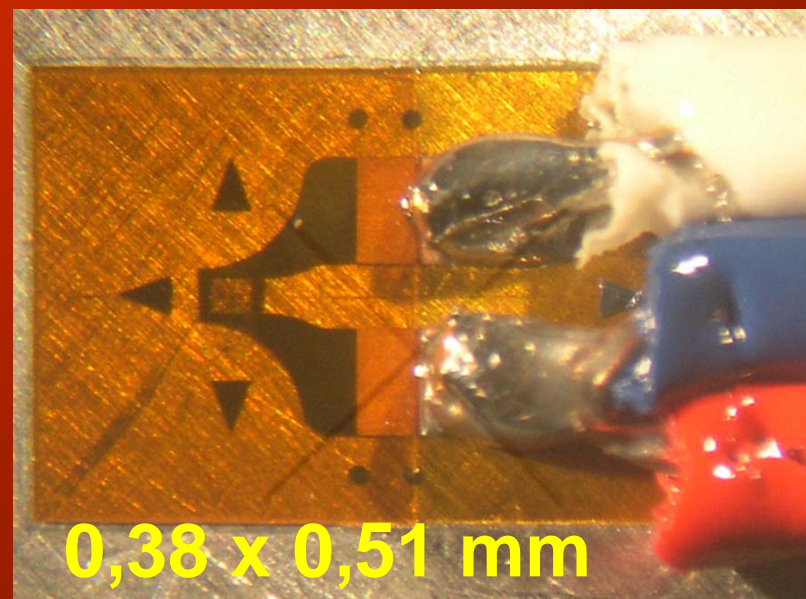
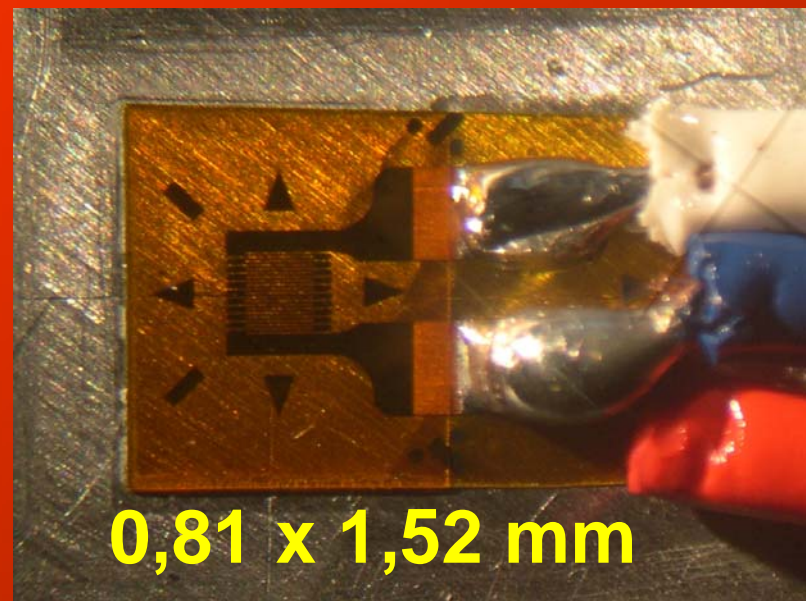
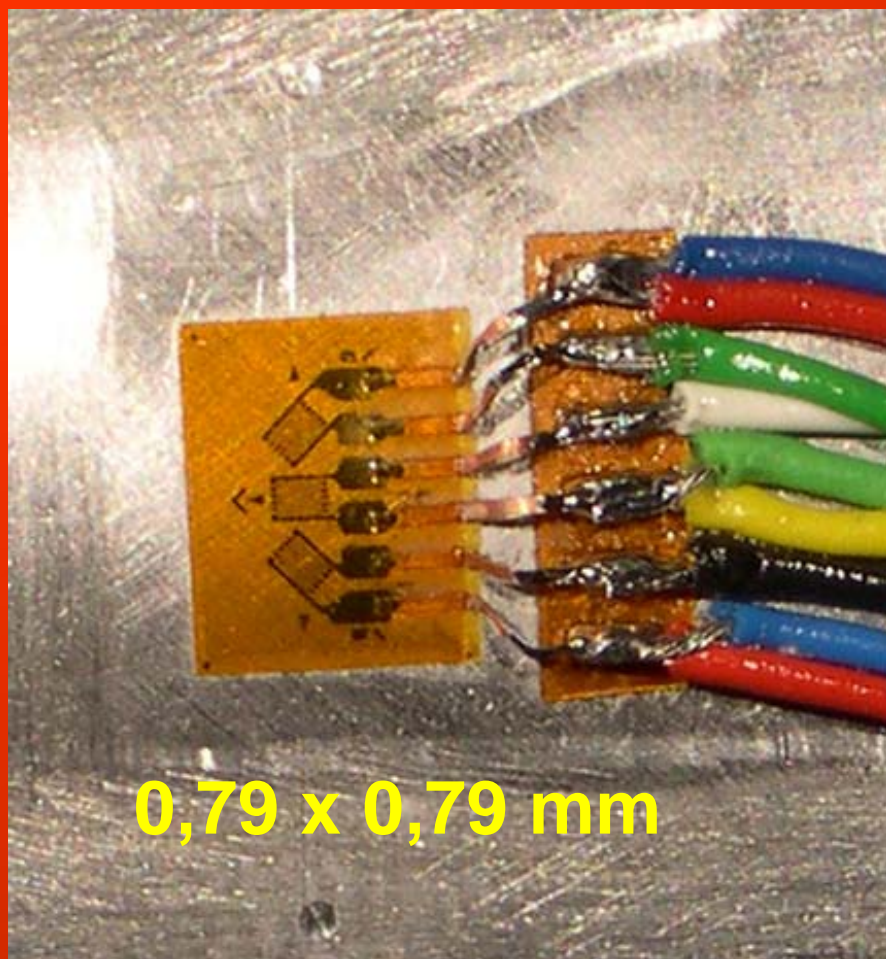


M = Estensimetro
monodirezionale

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PUNTI SCELTI PREVIA
ANALISI FEM

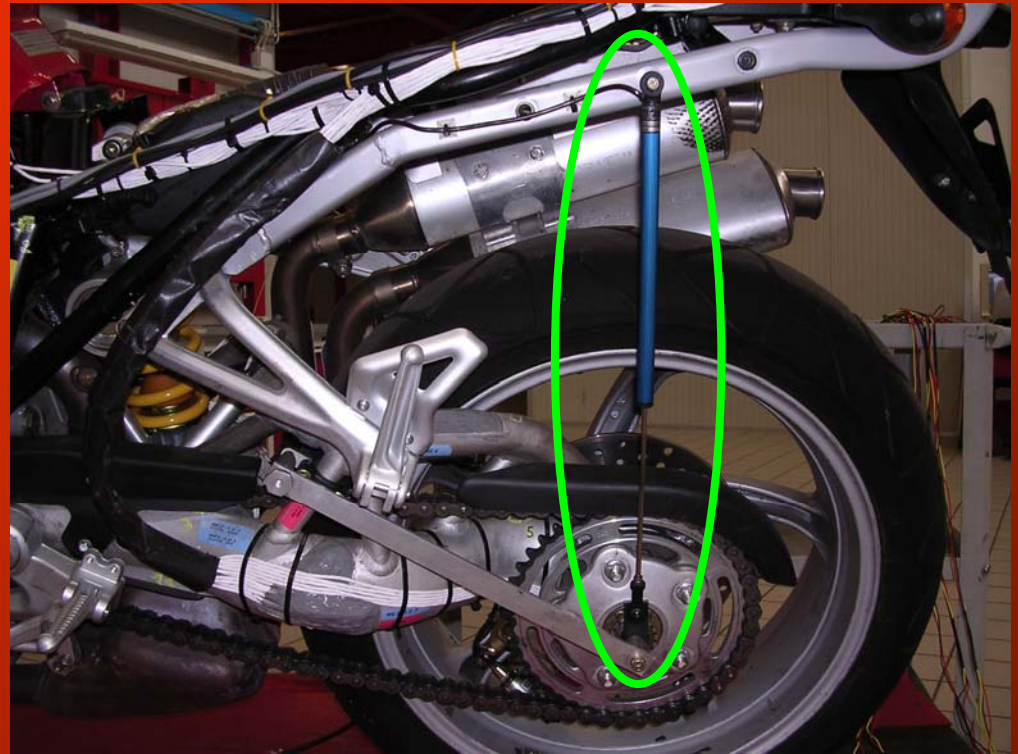






**STRUMENTAZIONE
DEL MOTOCICLO
CON POTENZIOMETRI**

POTENZIOMETRI LINEARI



STRUMENTAZIONE DEL MOTOCICLO CON :

- **SENSORI DI PRESSIONE PINZE DEI FRENI**
 - **SENSORE DI VELOCITA'**
- **SENSORE DI APERTURA VALVOLA A FARFALLA**
- **SENSORE VELOCITA' ANGOLARE MOTORE**

SENSORI DI PRESSIONE PINZE DEI FRENI



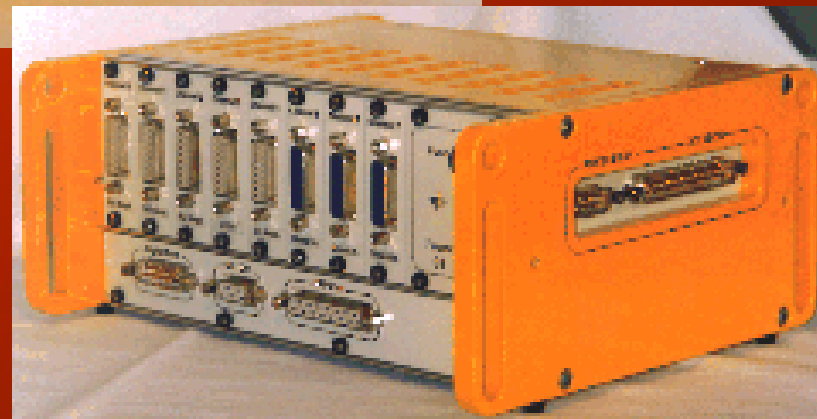
SENSORE DI VELOCITA'



- **SENSORE DI APERTURA VALVOLA A FARFALLA**
- **SENSORE VEL. ANGOLARE MOTORE**



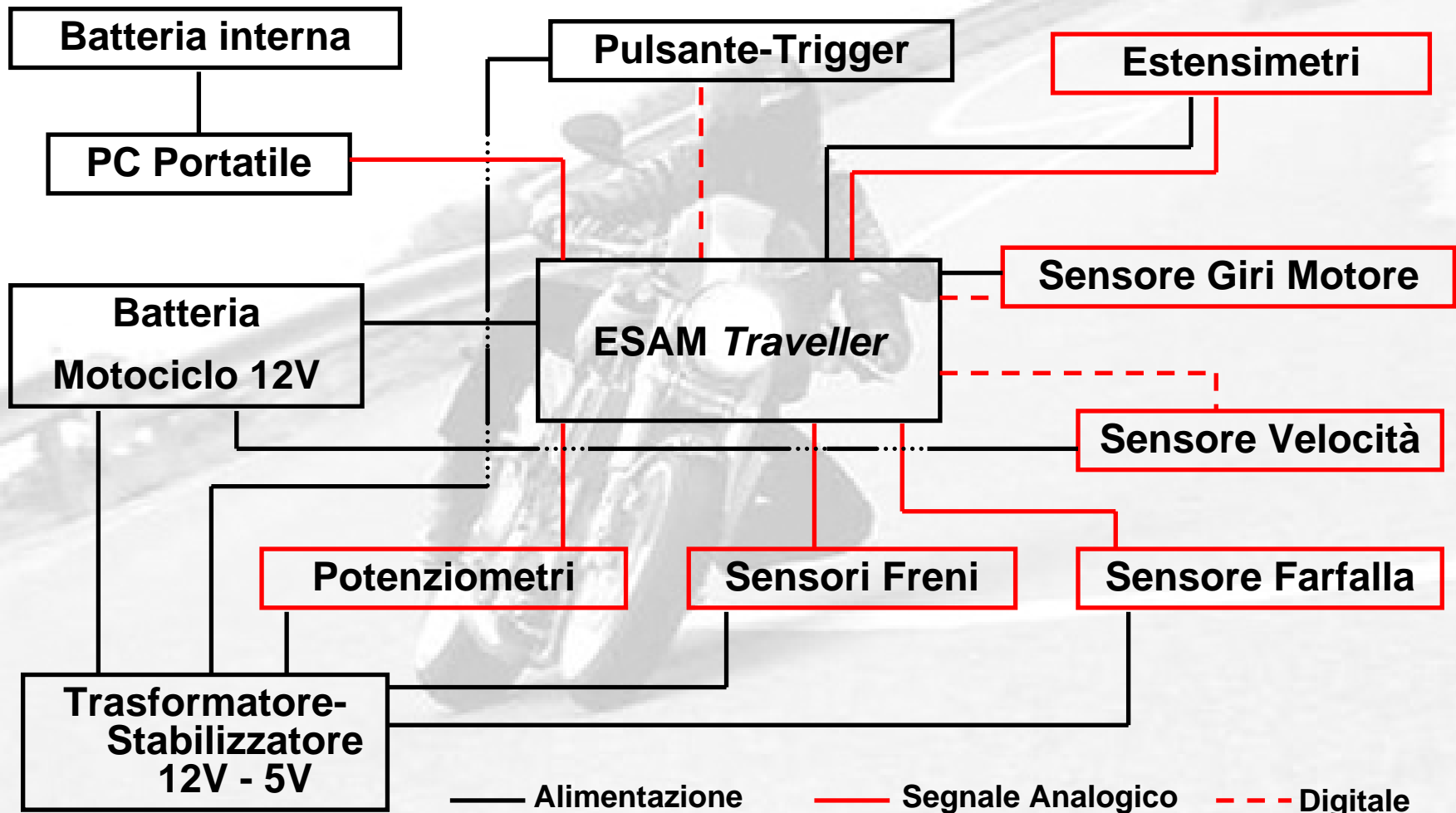
CENTRALINA DI ACQUISIZIONE DATI



Pulsante Trigger



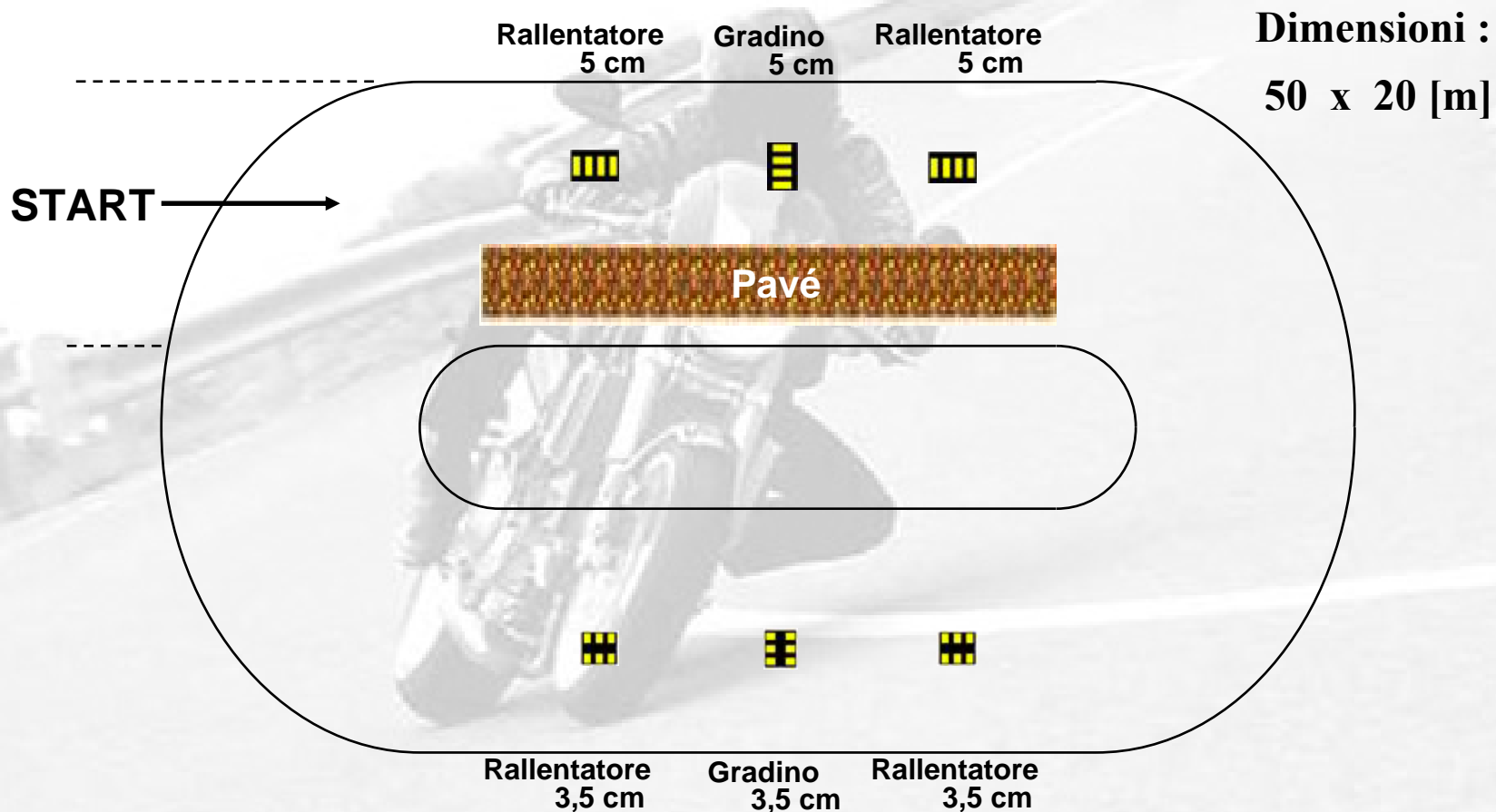
SCHEMA DELLA STRUMENTAZIONE COMPLETA





**PROVE SPERIMENTALI
SU CIRCUITO INTERNO ALLO
STABILIMENTO DUCATI**

IL CIRCUITO

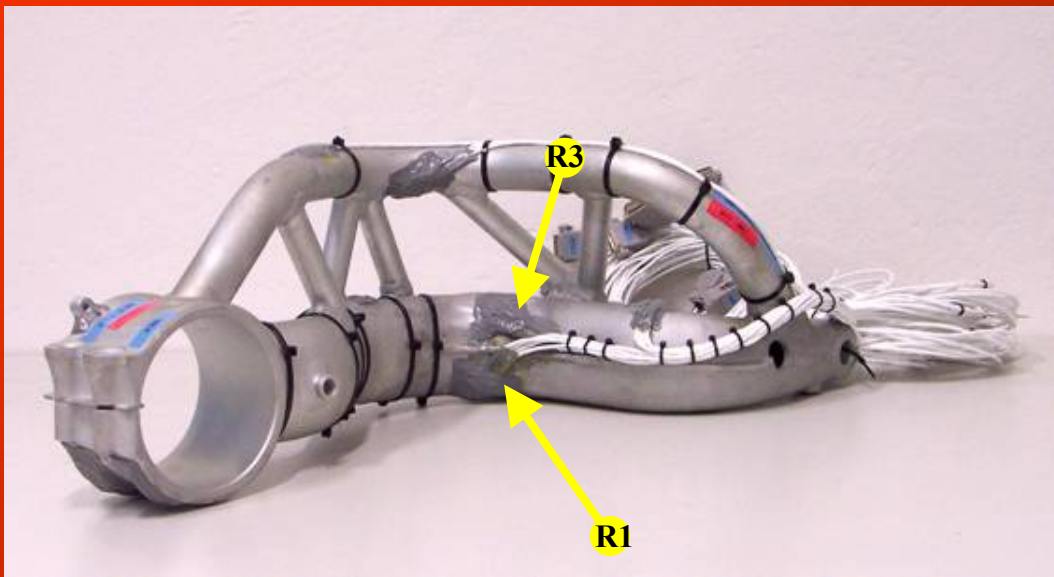




**RISULTATI DELLE PROVE
SPERIMENTALI**



DUCATI



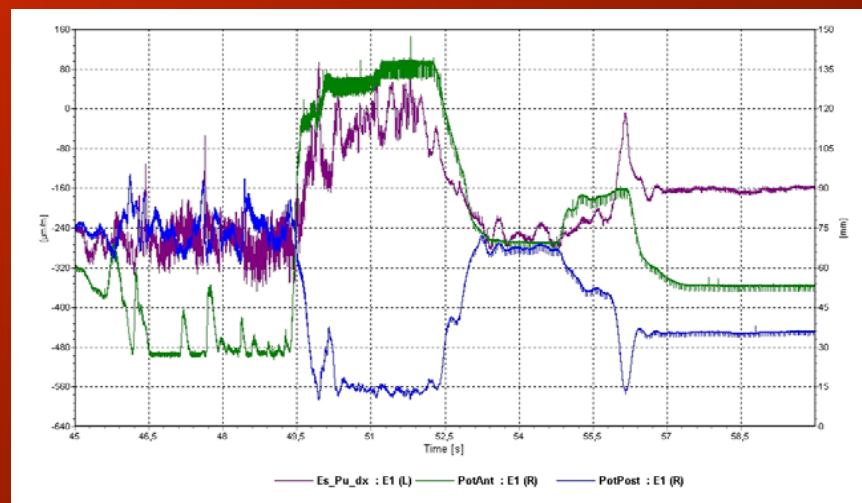
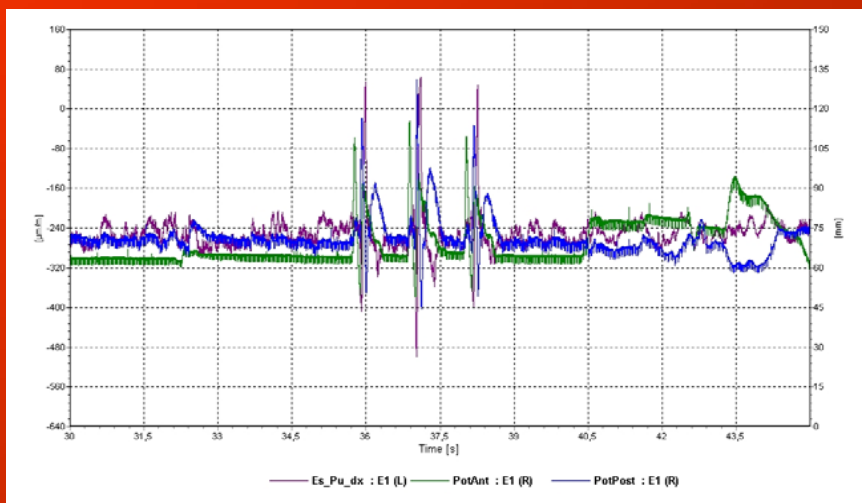
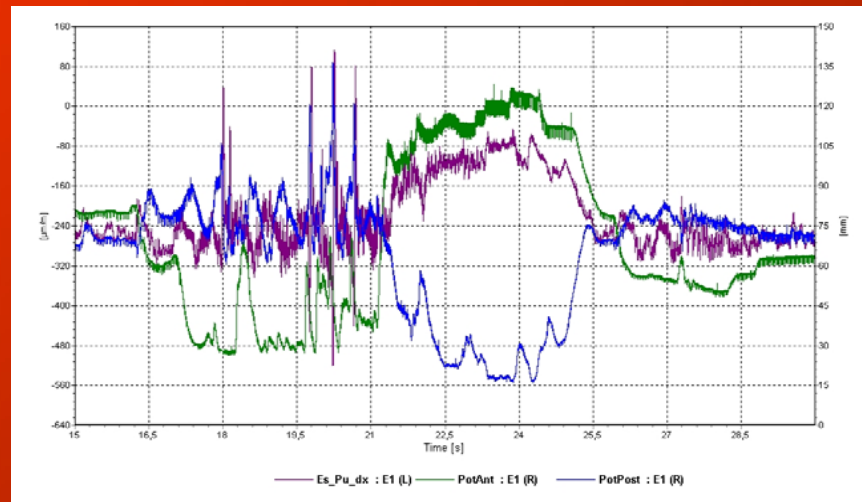
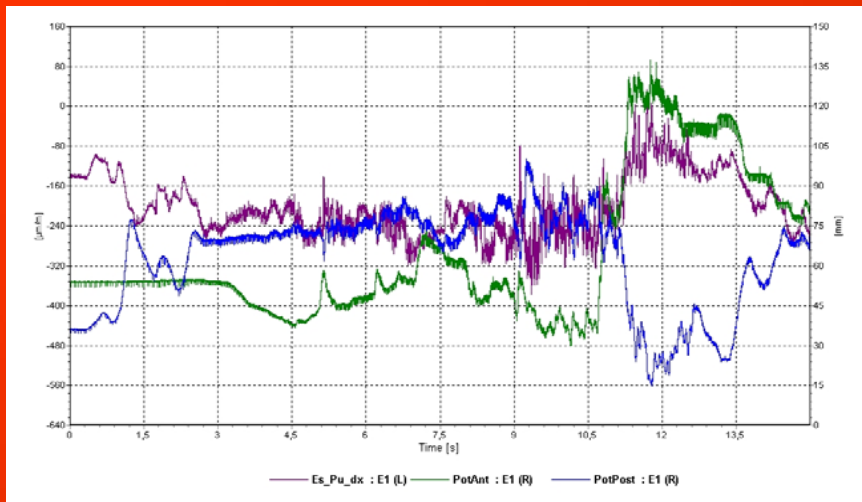
DUCATI



ESTENS PUNTONE

POT ANT

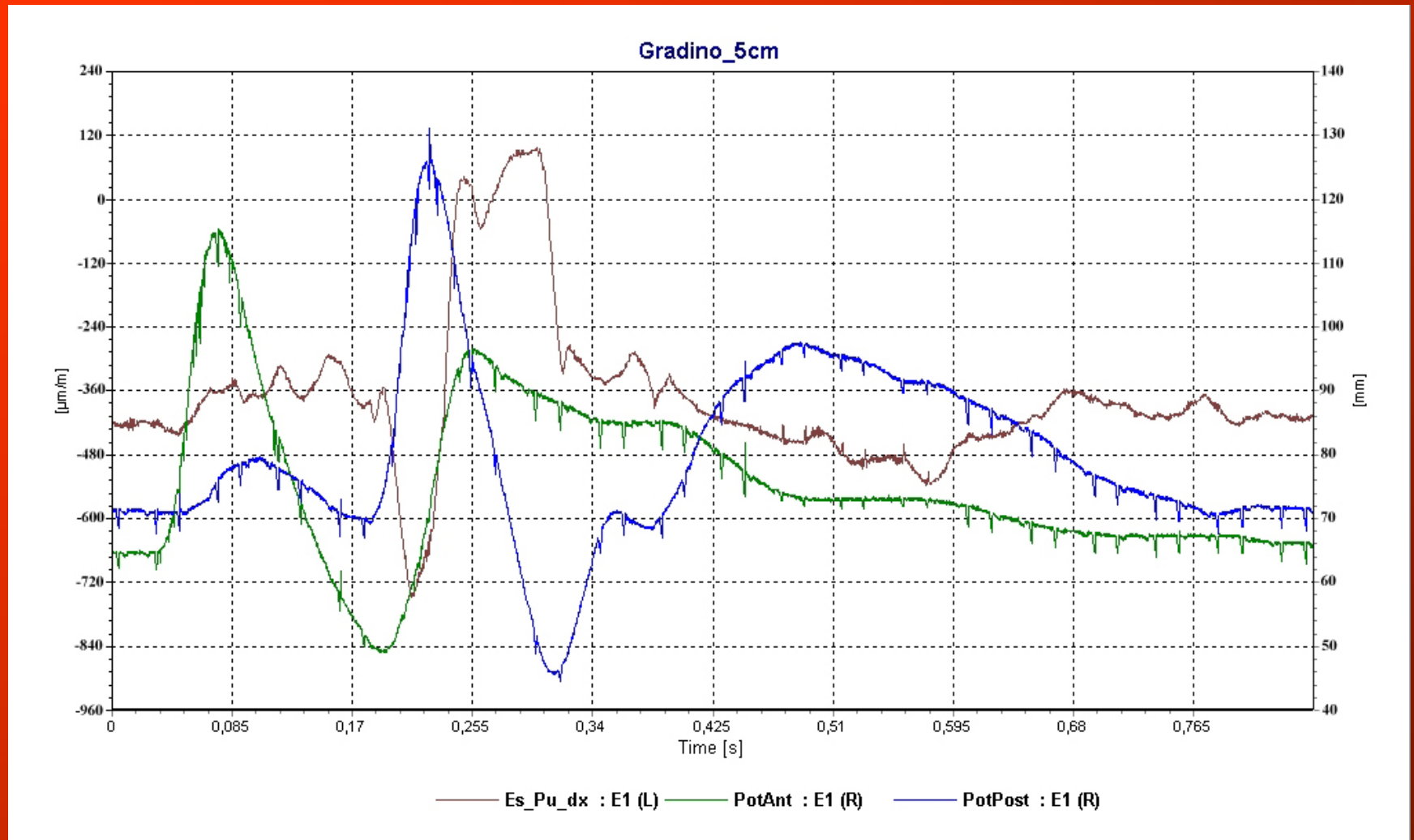
POT POST



ESTENS PUNTONE

POT ANT

POT POST



Grazie alle informazioni ottenute dall'estensimetro posto sul puntone della sospensione posteriore si è potuto risalire alla forza agente su tale componente utile per la verifica di resistenza delle strutture e per la validazione del modello MULTY-BODY

$$\sigma = \varepsilon \cdot E \quad F = \sigma \cdot A$$

Evento	$\mu\varepsilon$ [microdef.]	Tensioni [Pa]	Forza [N]
Gradino 5 cm 40 km/h	$744 \cdot 10^{-6}$	54'312'000	13'056,94425
Gradino 3,5 cm 70 km/h	$520 \cdot 10^{-6}$	37'960'000	9'125,82125
Gradino 5 cm 30 km/h	$498 \cdot 10^{-6}$	36'354'000	8'739,7288125
Rallentatore 3,5 cm 70 km/h	$451 \cdot 10^{-6}$	32'923'000	7'914,89496875
Rallentatore 5 cm 30 km/h	$408 \cdot 10^{-6}$	29'784'000	7'160,25975

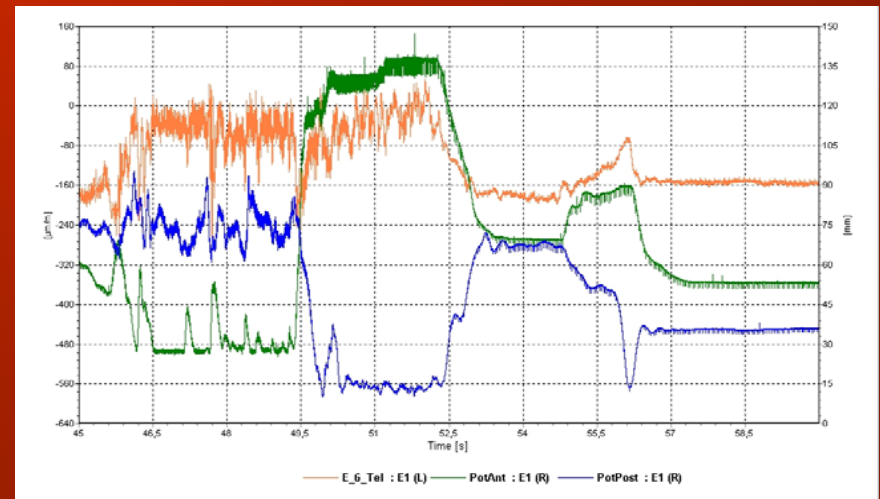
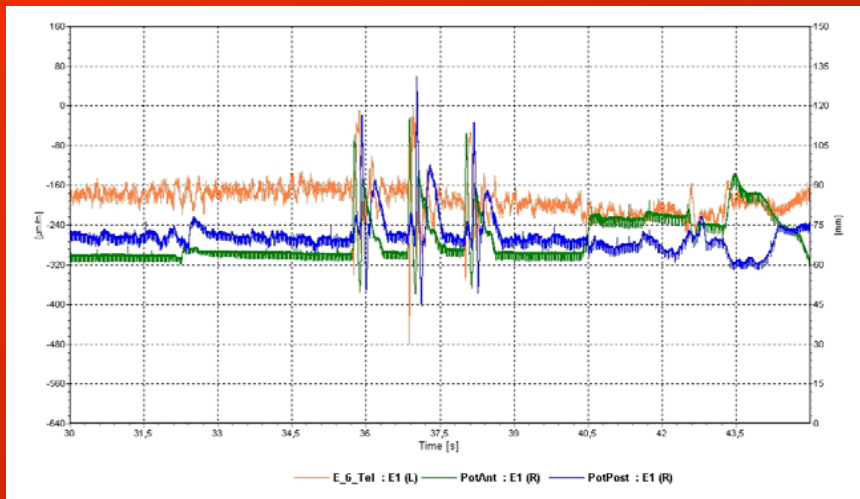
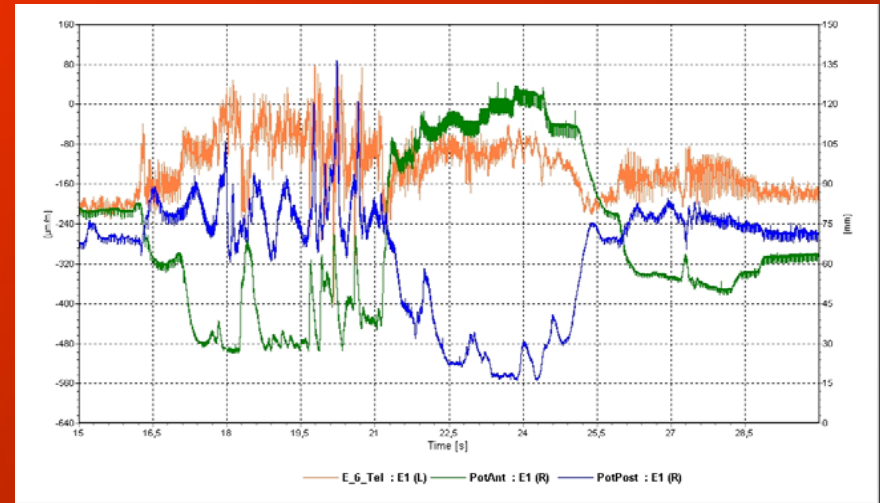
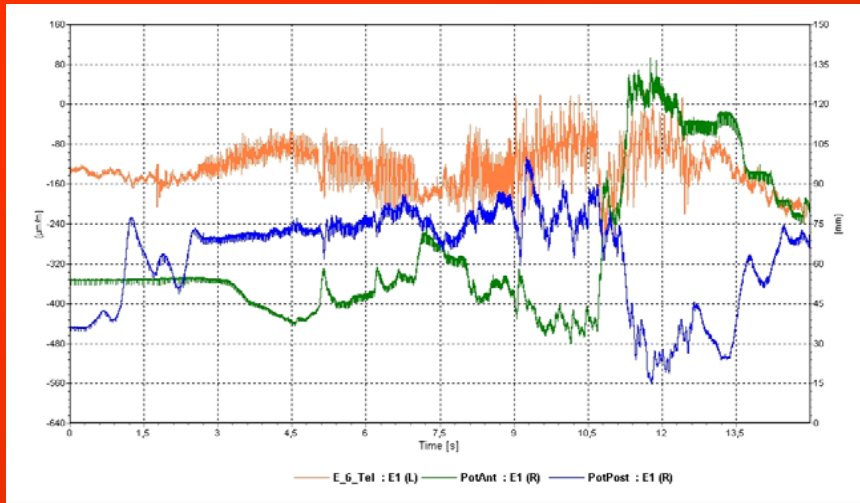
$$E = 73'000'000'000 \text{ Pa}$$

$$A = 0,00024040625 \text{ m}^2$$

ESTENS 6 TELAIO

POT ANT

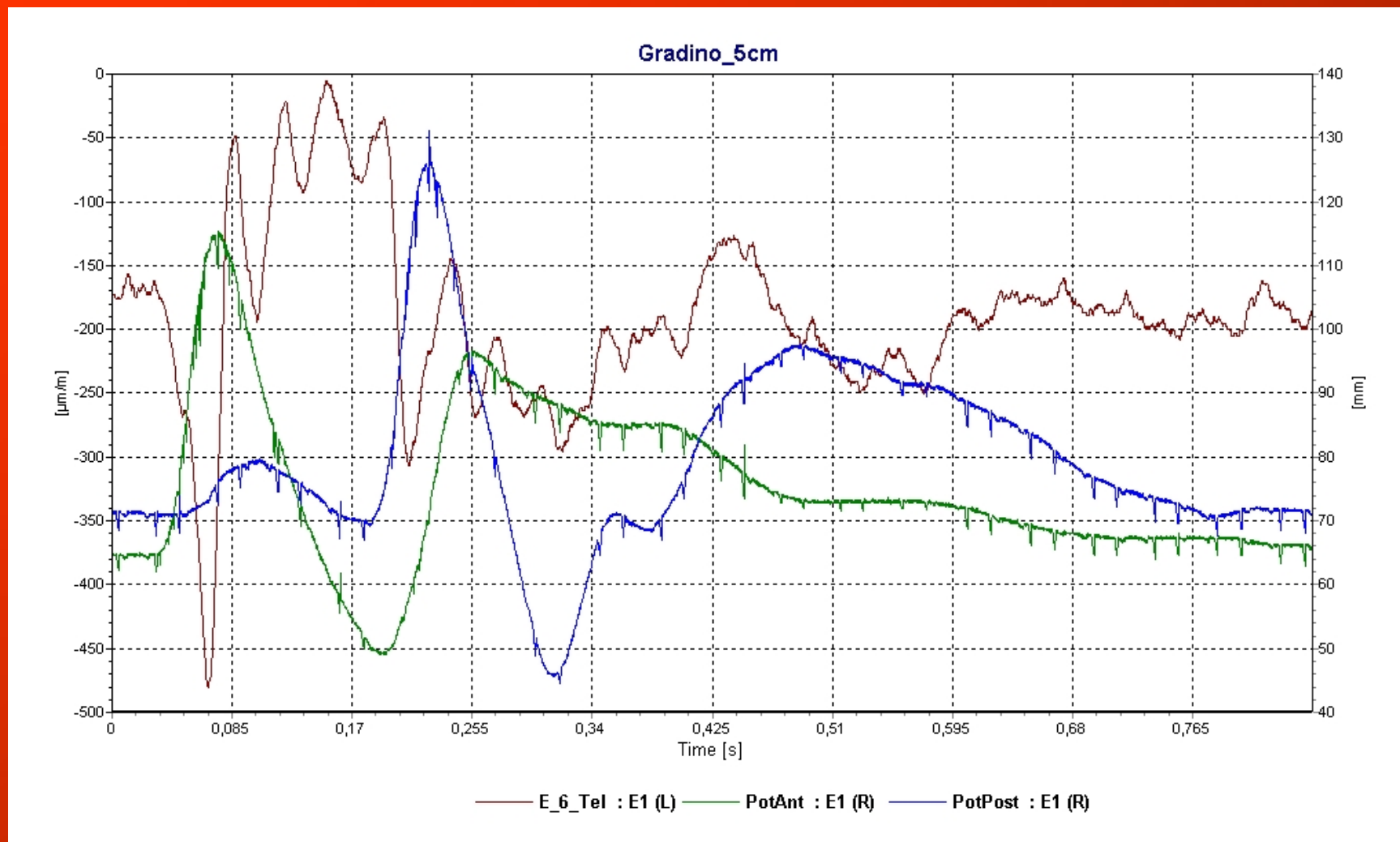
POT POST



ESTENS 6 TELAIO

POT ANT

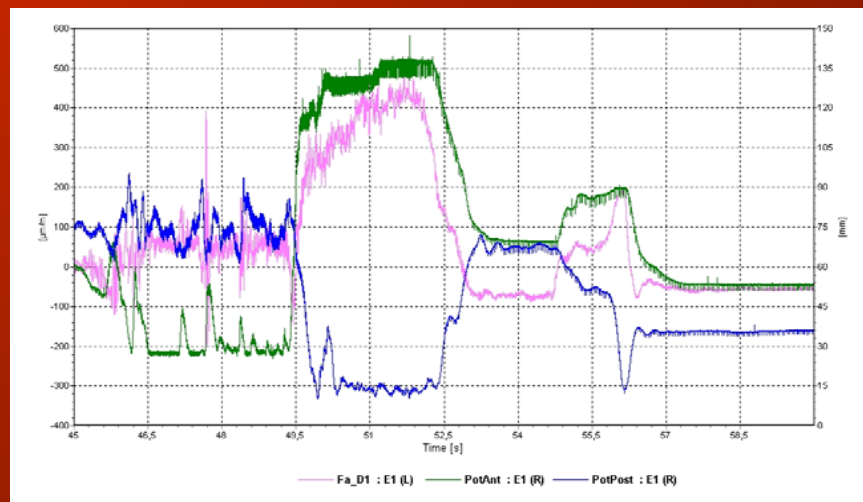
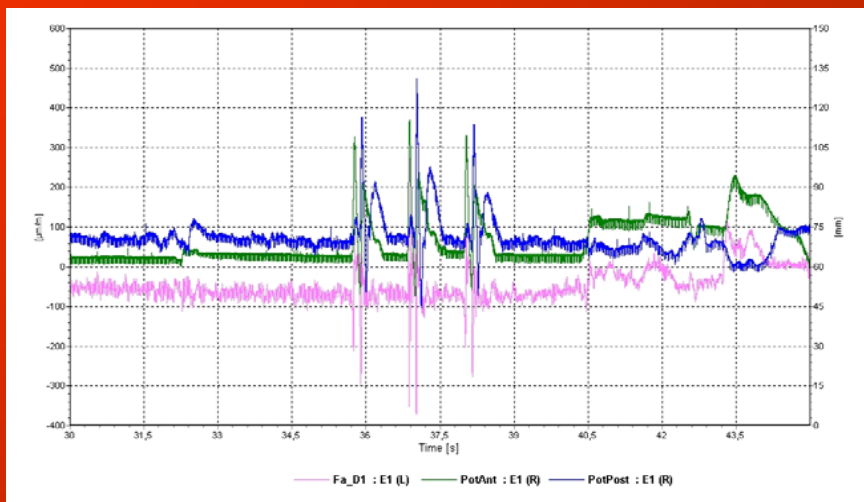
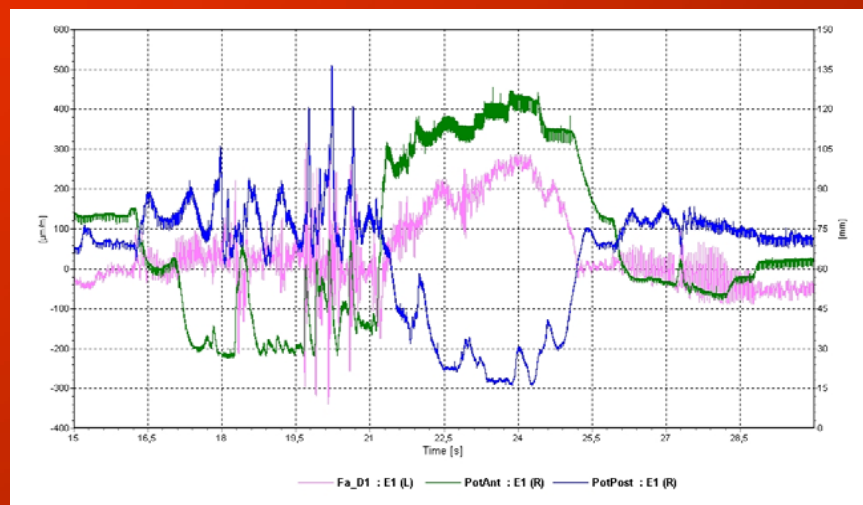
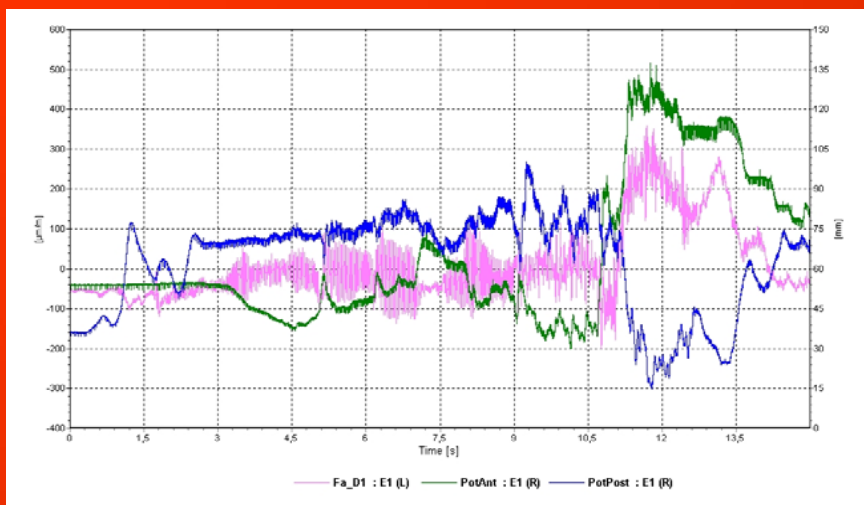
POT POST



ESTENS Fa D1 FORC

POT ANT

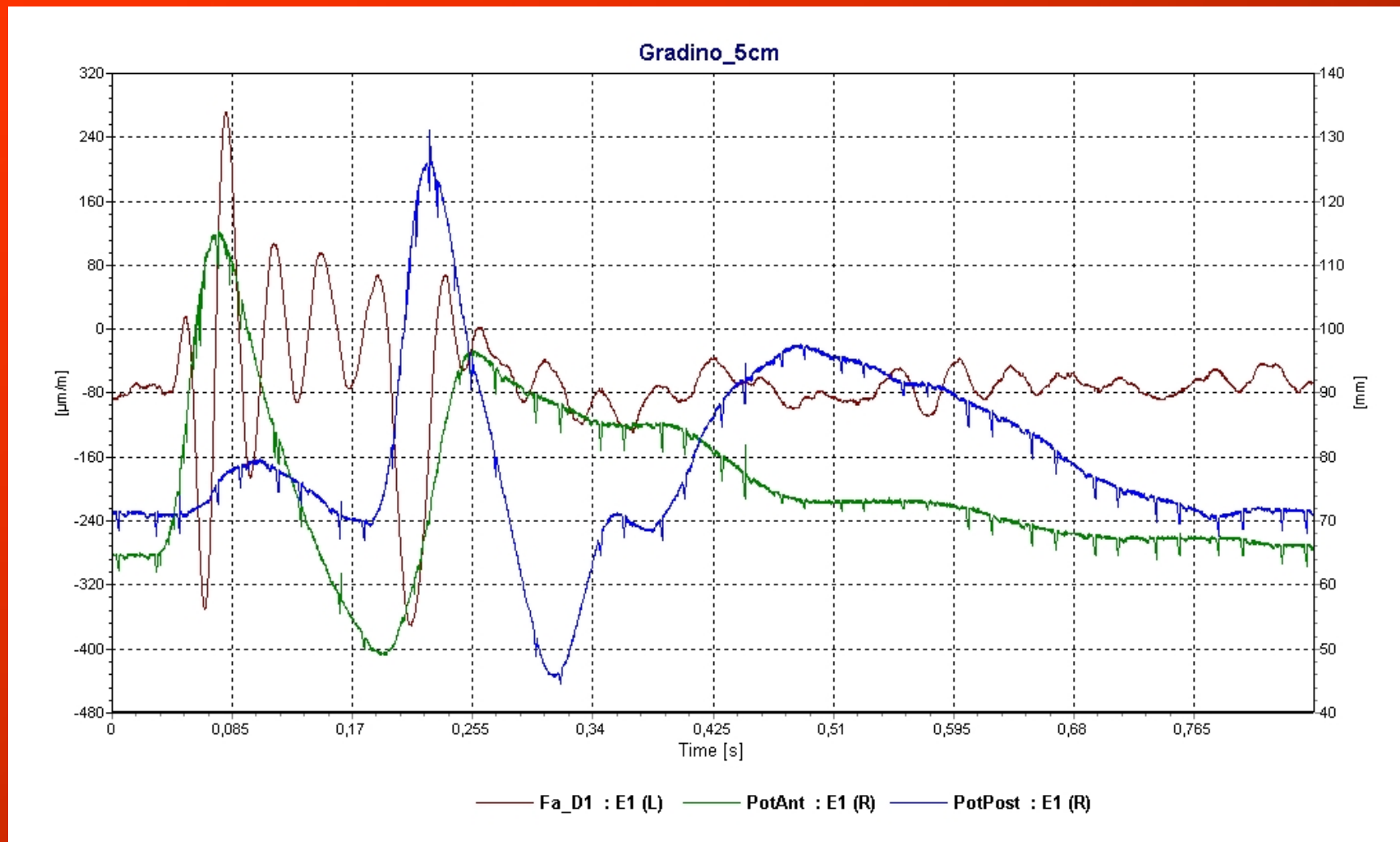
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ESTENS Fa D1 FORC

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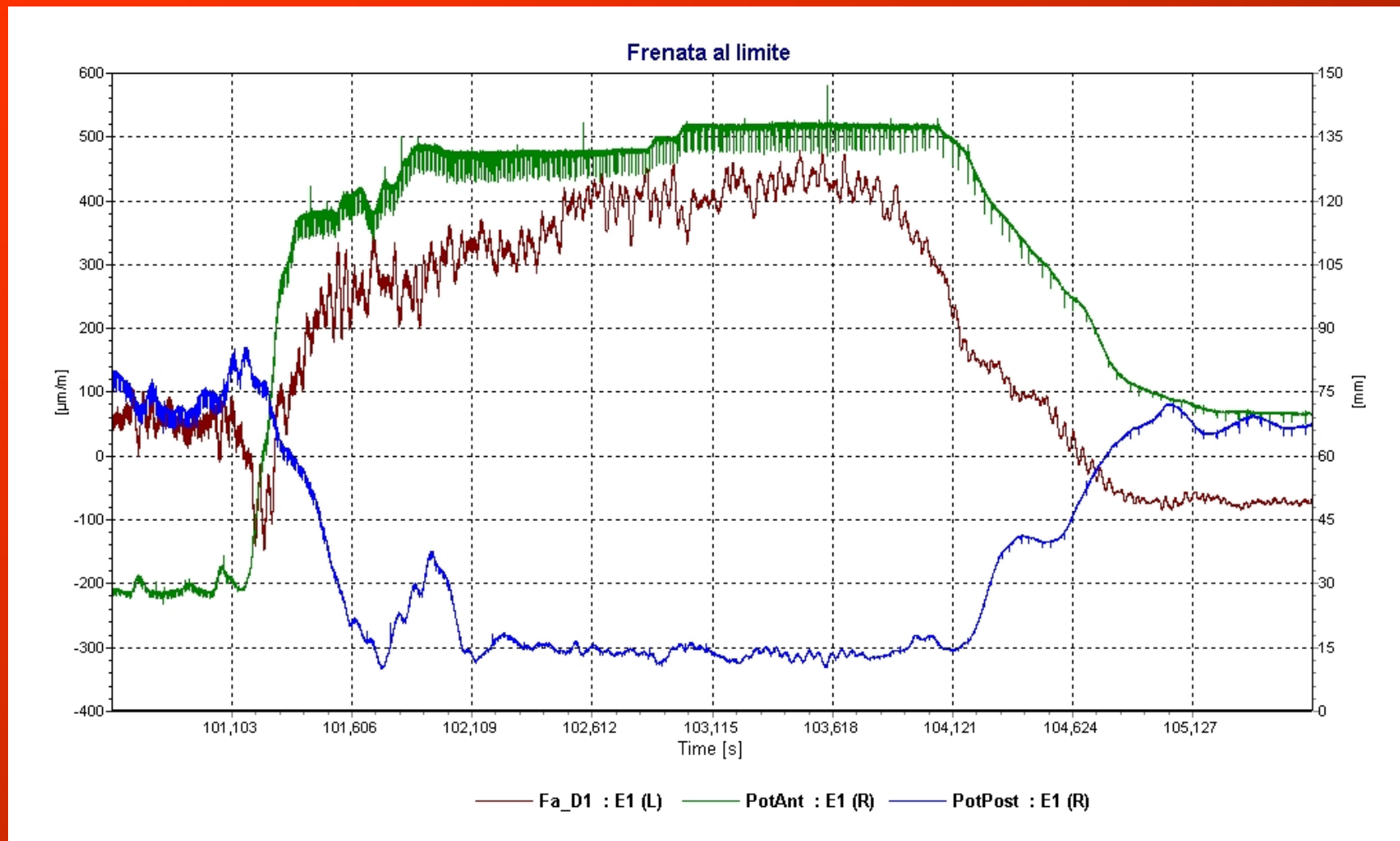
POT POST



ESTENS Fa D1 FORC

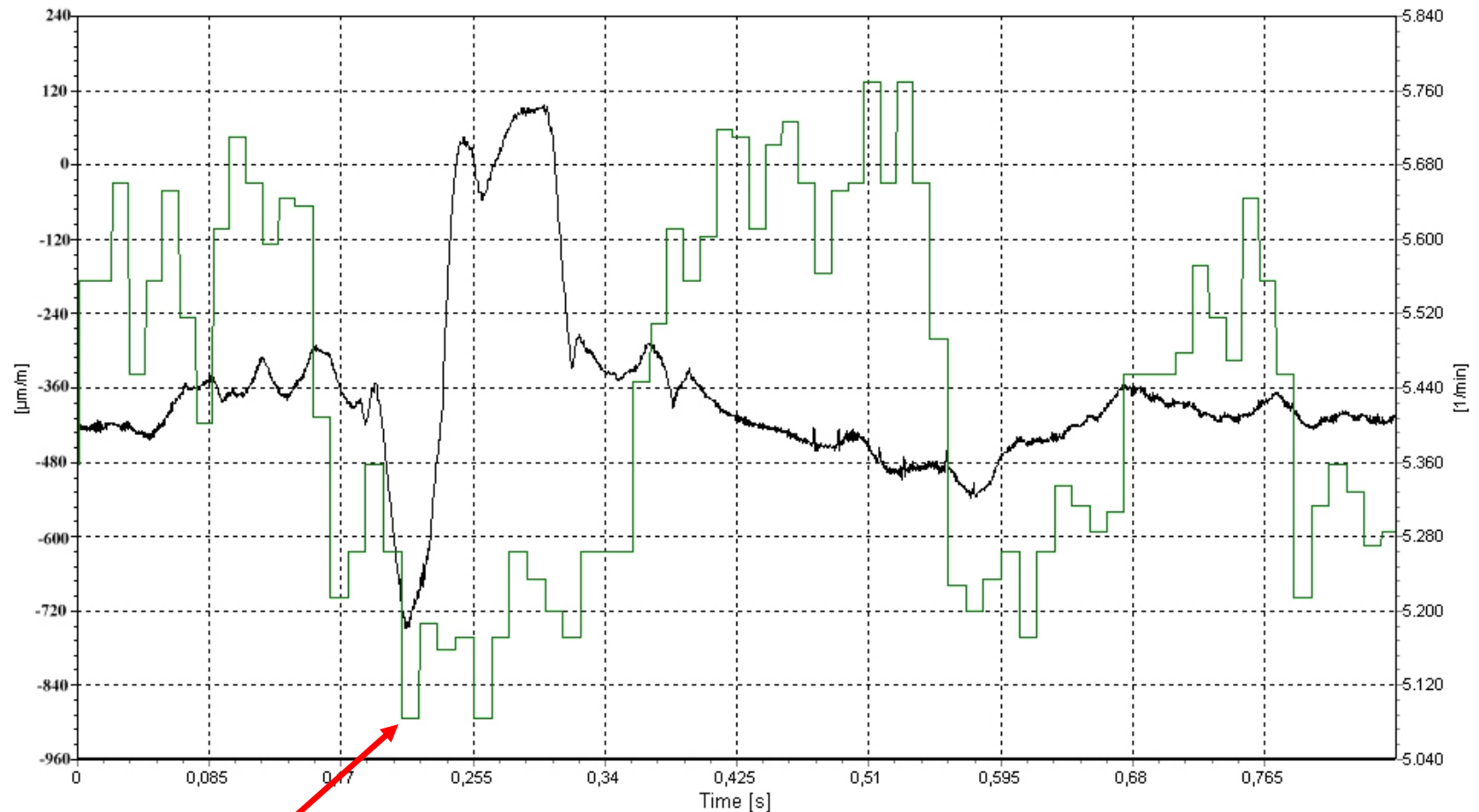
POT ANT

POT POST



GIRI MOTORE

ESTENS PUNTONE



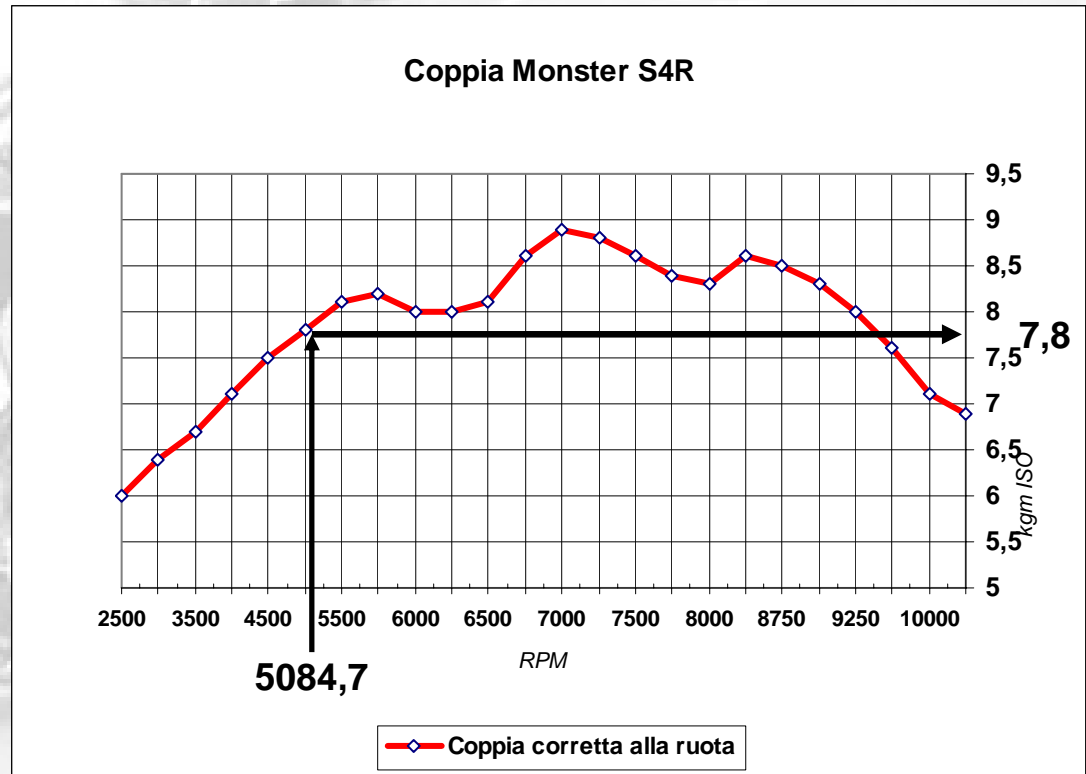
5'084,7 rpm

— Es_Pu_dx : E1 (L) — 1001 : E1 (R)

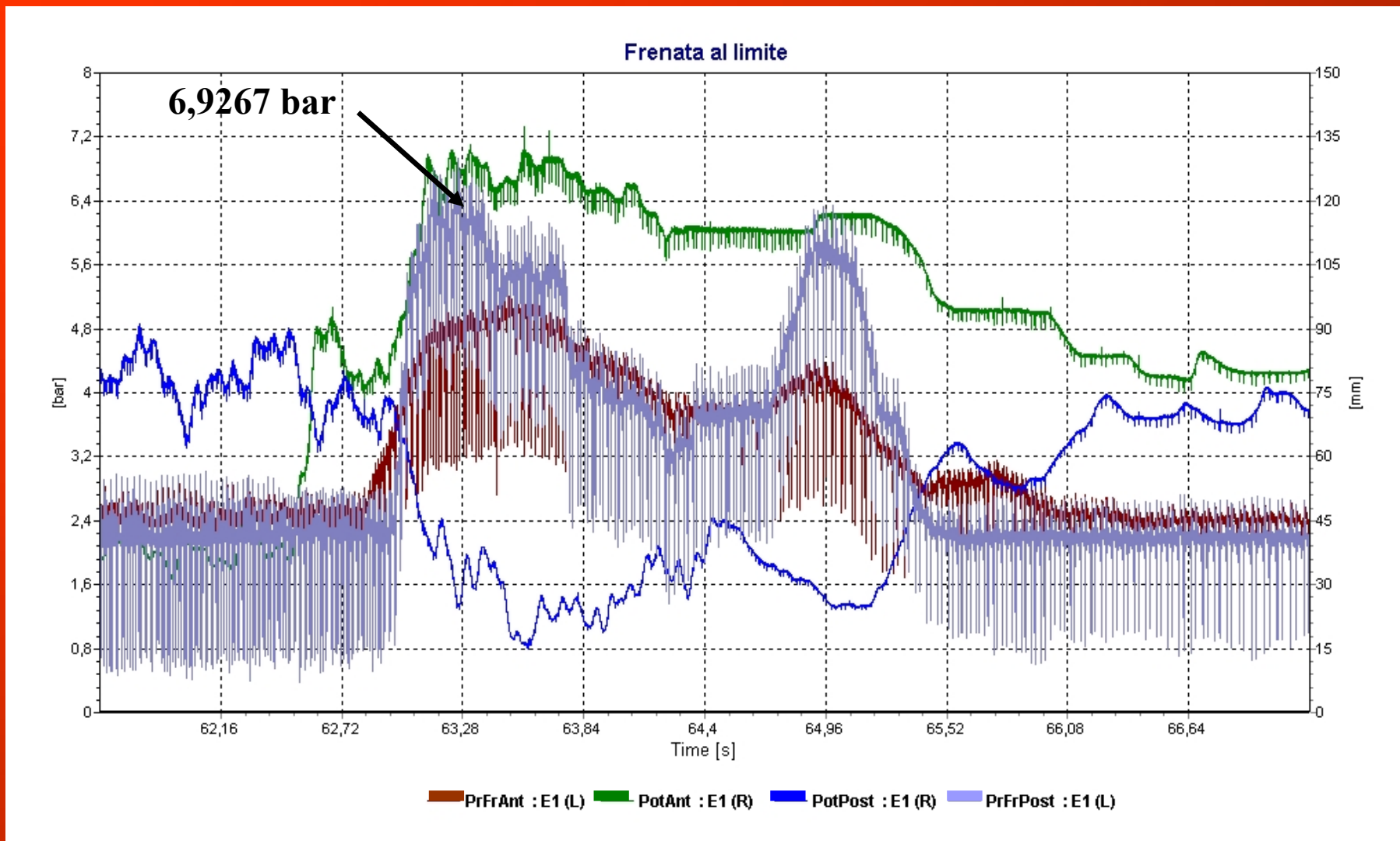
Grazie al sensore conta giri motore si è trovato il valore della forza del tiro catena nel momento di impatto contro il gradino di 5 cm utile per la verifica di resistenza del forcellone.

$$7,8 \cdot 9,81 = 76,518 \text{ N}\cdot\text{m}$$

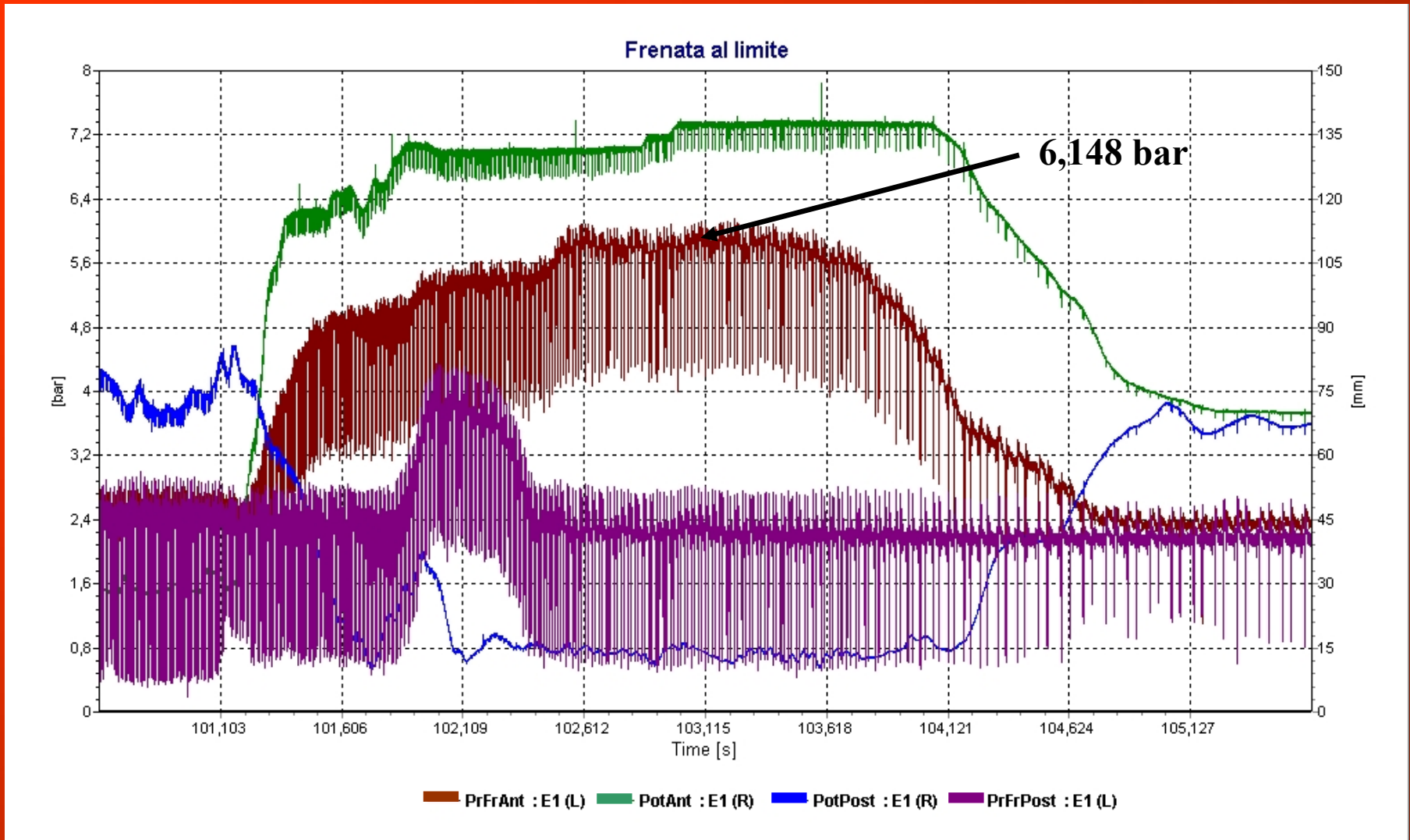
$$T = \frac{76,518}{r_c} = \frac{76,518}{0,105} = 728,74 \text{ N}$$



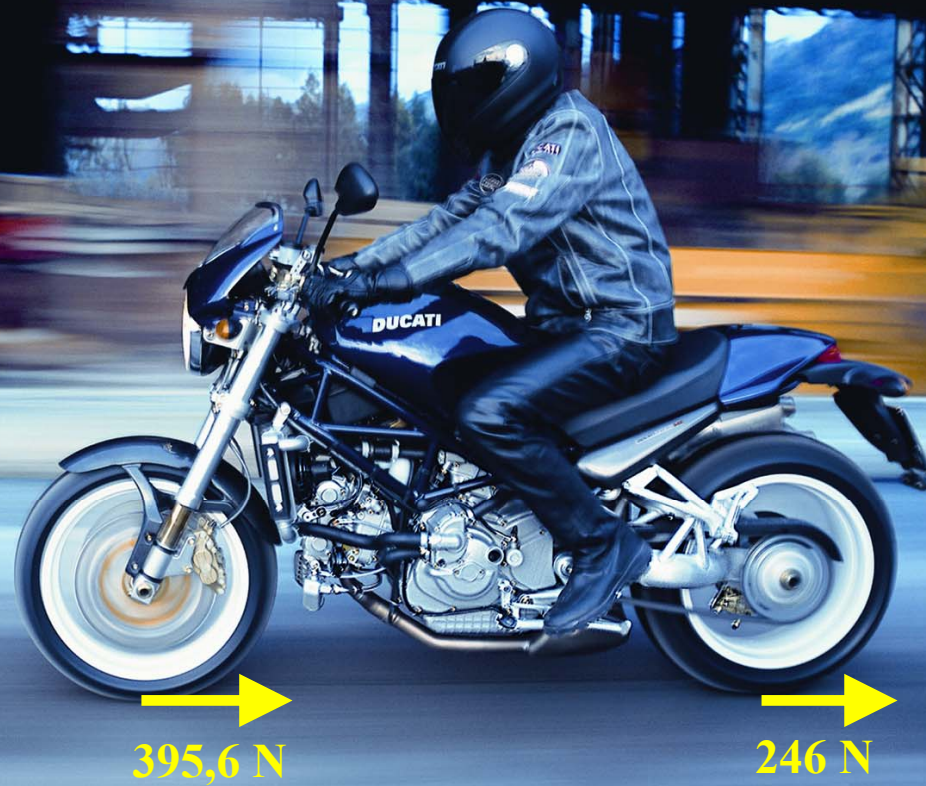
ANDAMENTO DELLE PRESSIONI NELLE PINZE FRENI



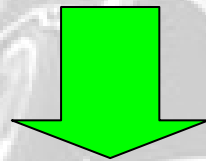
ANDAMENTO DELLE PRESSIONI NELLE PINZE FRENI



Forze in frenata



**NELL'INDUSTRIA DEI TRASPORTI, LA NECESSITA' DI
COMPETERE IN UN MERCATO CARATTERIZZATO
DA COMPETITORI SEMPRE PIU' AGGUERRITI,
SPINGE LE AZIENDE AD UN'AZIONE VOLTA ALLA
RIDUZIONE DEL TEMPO DI SVILUPPO DEL
PRODOTTO**



PROTOTIPAZIONE VIRTUALE

LA PROTOTIPAZIONE VIRTUALE RICHIEDE:

- **L'INDIVIDUAZIONE DEI CARICHI AGENTI SUI COMPONENTI**
 - **LA CREAZIONE DI UN MODELLO GEOMETRICO VIRTUALE DI OGNI SINGOLO COMPONENTE**
 - **L'APPLICAZIONE SUL MODELLO VIRTUALE DEI VINCOLI E DEI CARICHI**
 - **LA VERIFICA DI RESISTENZA DEI COMPONENTI IN ESAME**



**PER INDIVIDUARE I CARICHI AGENTI
SUI SINGOLI COMPONENTI CI SI
AVVALE DI UN
MODELLO DINAMICO
MULTI-BODY**

**CON IL MODELLO DINAMICO
SI POSSONO INDIVIDUARE:**

- **SPOSTAMENTI**
- **VELOCITA'**
- **ACCELERAZIONI**
- **FORZE**

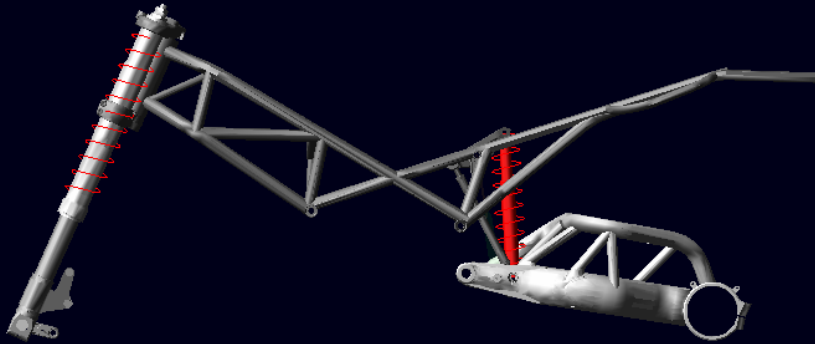
AGENTI SUI VARI COMPONENTI

PROCEDURA:

- **COSTRUZIONE DEL MODELLO DINAMICO**
- **DEFINIZIONE DEI VINCOLI CINEMATICI**
- **IMPOSIZIONE DELLA LEGGE DI MOTO**
- **ACQUISIZIONE DEI RISULTATI**

COSTRUZIONE DEL MODELLO

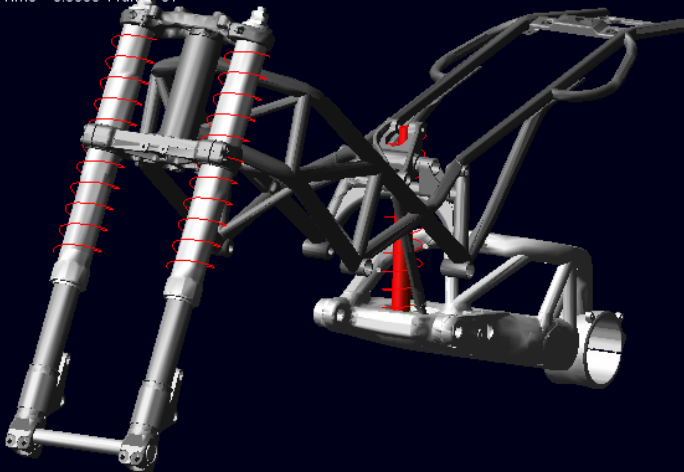
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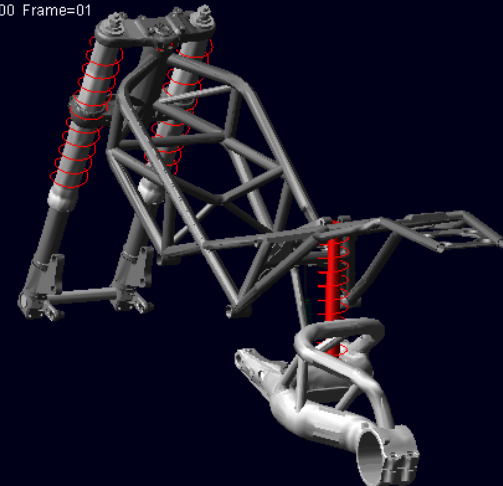
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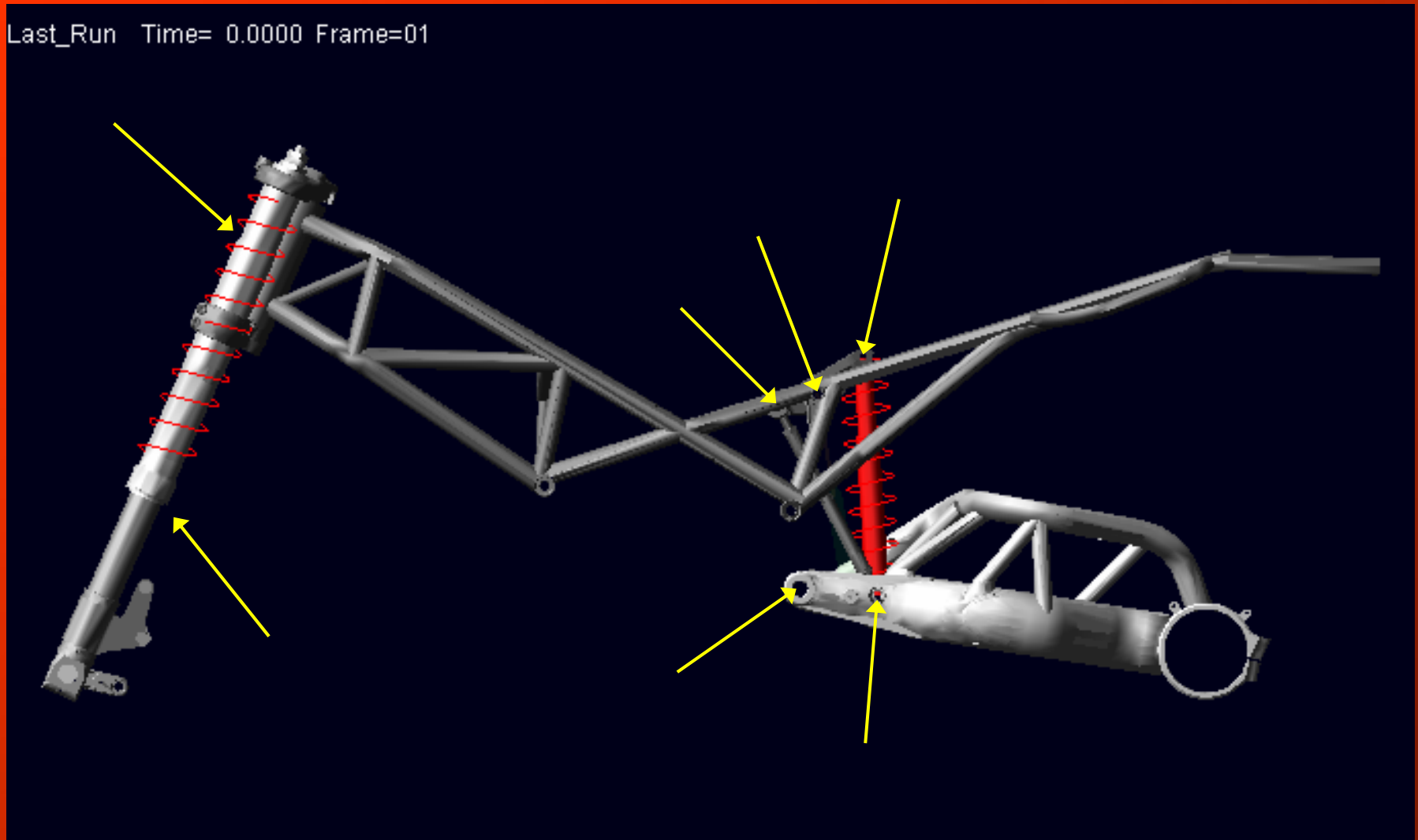
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Last_Run Time= 0.0000 Frame=01



DEFINIZIONE DEI VINCOLI

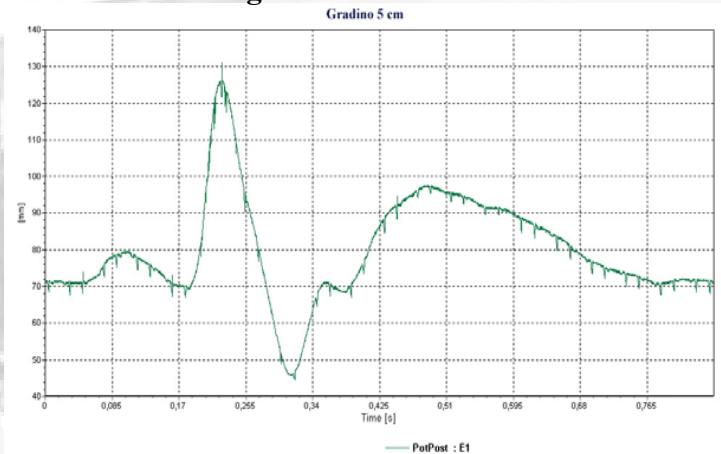
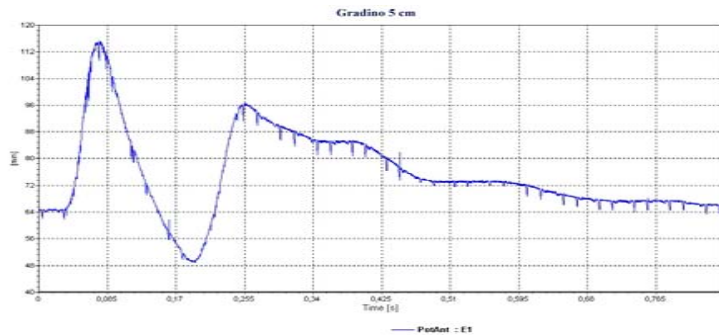


IMPOSIZIONE DELLA LEGGE DI SPOSTAMENTO

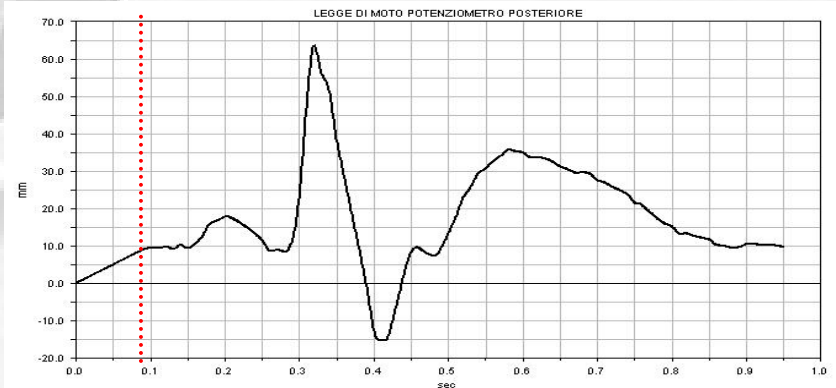
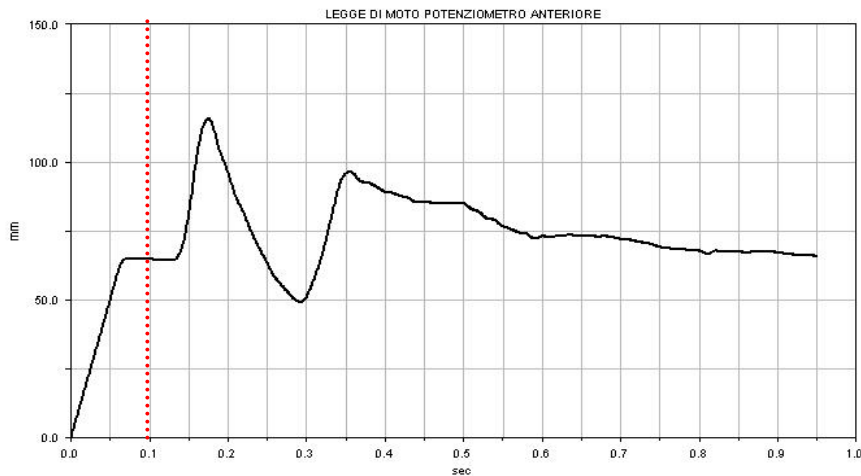
- 1) **INDIVIDUAZIONE DELL'EVENTO DA SIMULARE**
- 2) **FILTRAGGIO DEL SEGNALE ACQUISITO DAI POTENZIOMETRI**
- 3) **ASSEGNAZIONE DELLA LEGGE DI MOTO AL MODELLO**

IMPOSIZIONE DELLA LEGGE DI SPOSTAMENTO

1) INDIVIDUAZIONE DELL'EVENTO DA SIMULARE: Attraversamento del gradino di 5 cm a 40 km/h

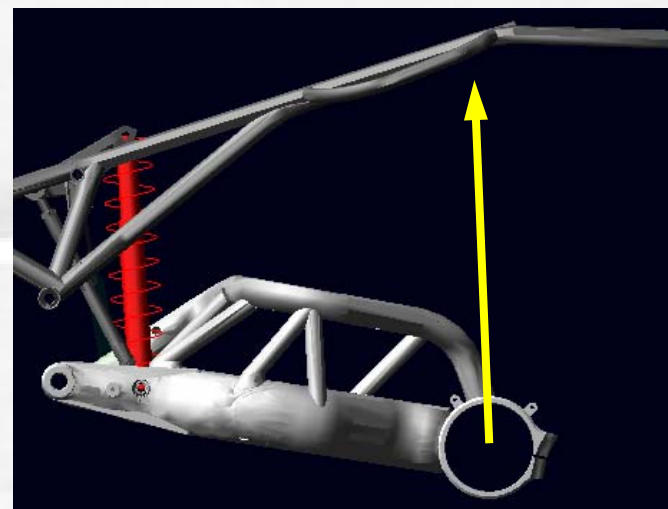
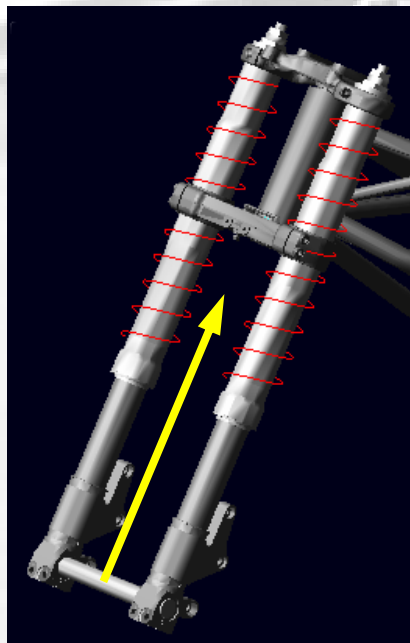


2) FILTRAGGIO DEL SEGNALE ACQUISITO DAI POTENZIOMETRI



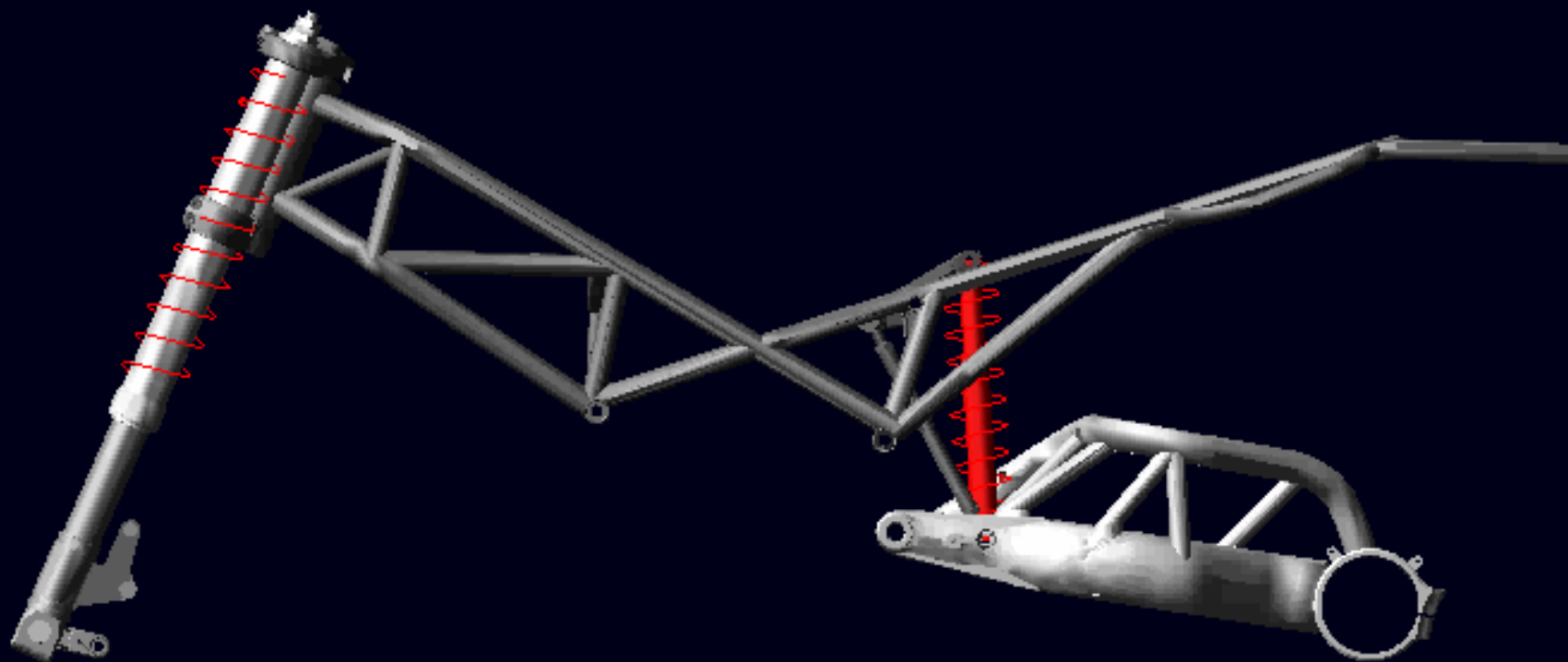
IMPOSIZIONE DELLA LEGGE DI SPOSTAMENTO

3) ASSEGNAZIONE DELLA LEGGE DI SPOSTAMENTO AL MODELLO



IMPOSIZIONE DELLA LEGGE DI SPOSTAMENTO

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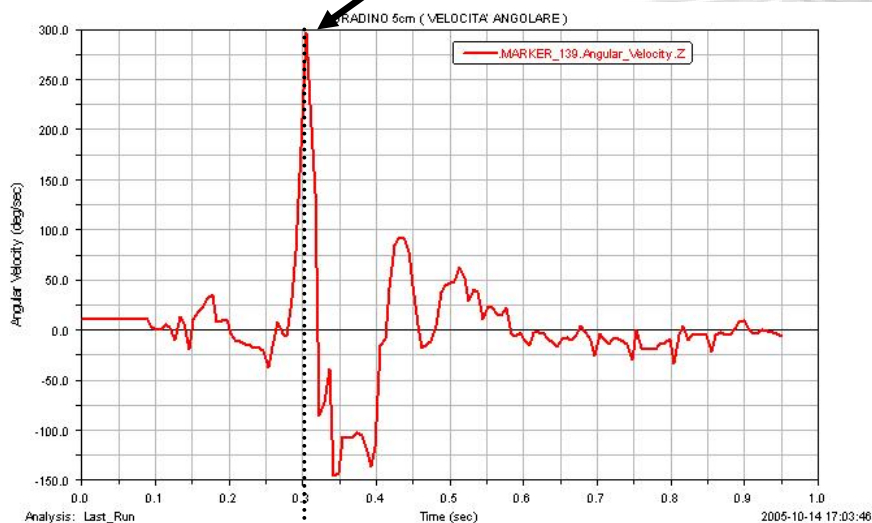


ACQUISIZIONE DEI RISULTATI

ATTRAVERSAMENTO DEL GRADINO DI 5 CM A 40 km/h

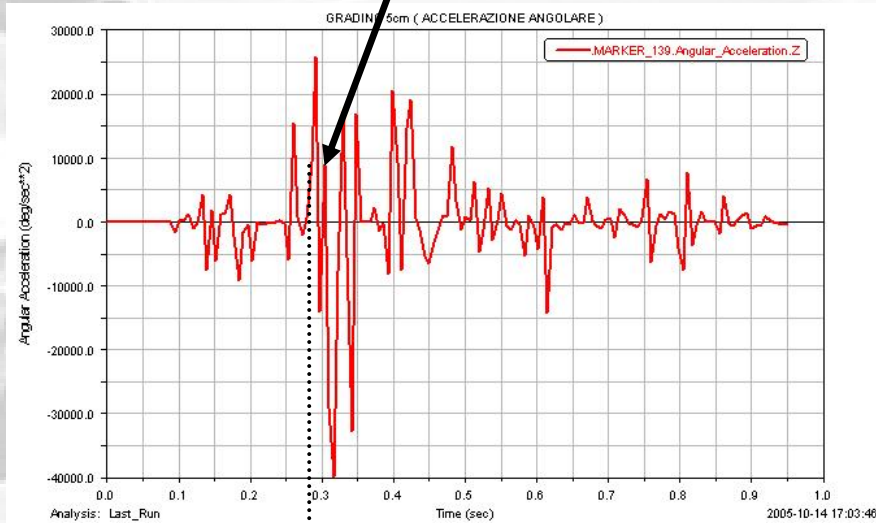
Andamento della velocità ed accelerazione angolare del forcellone

296 gradi/s



0,304 s

8'943 gradi/s²

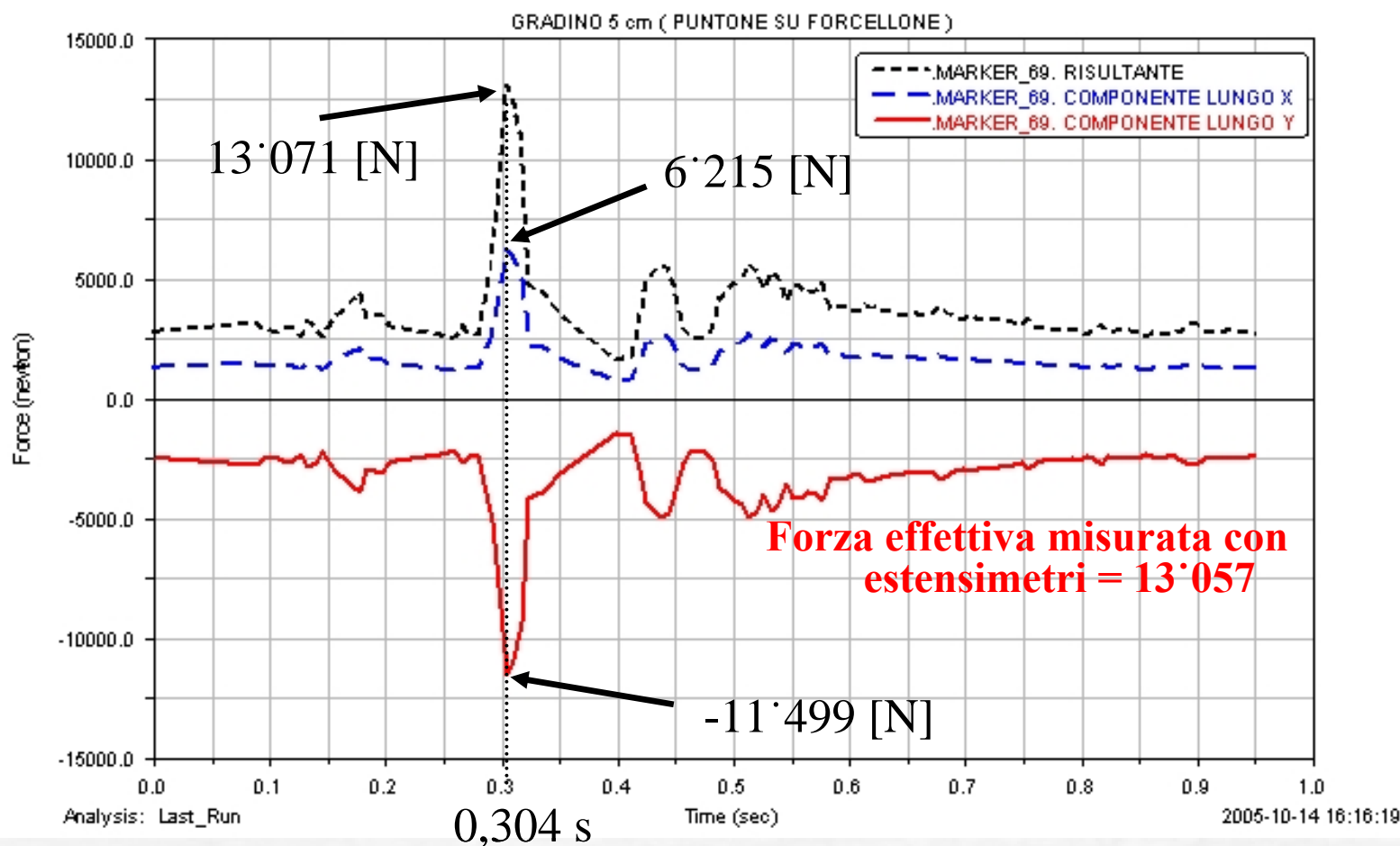


0,304 s

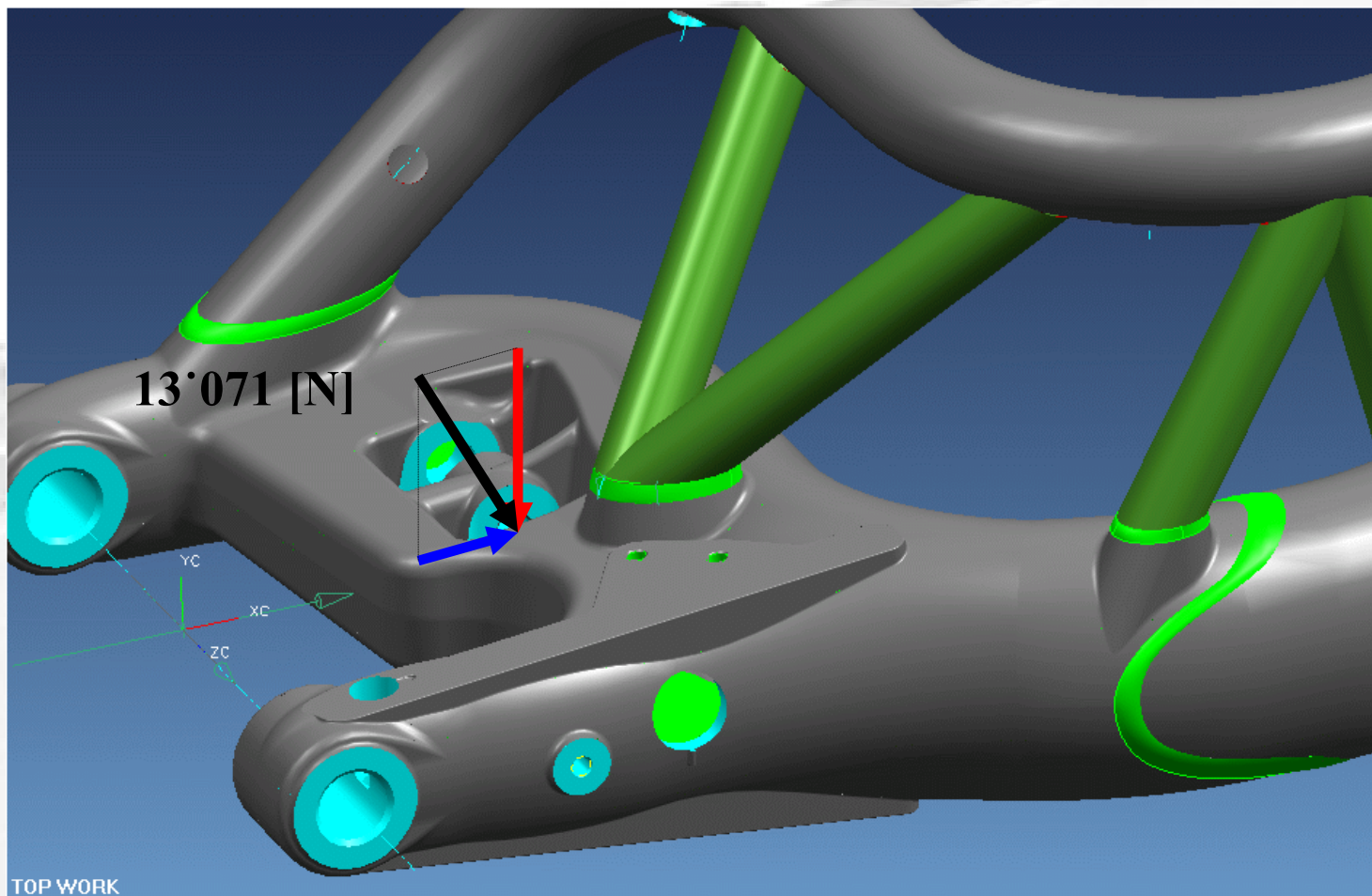
ACQUISIZIONE DEI RISULTATI

ATTRAVERSAMENTO DEL GRADINO DI 5 CM A 40 km/h

Andamento delle forze che il puntone esercita sul forcellone



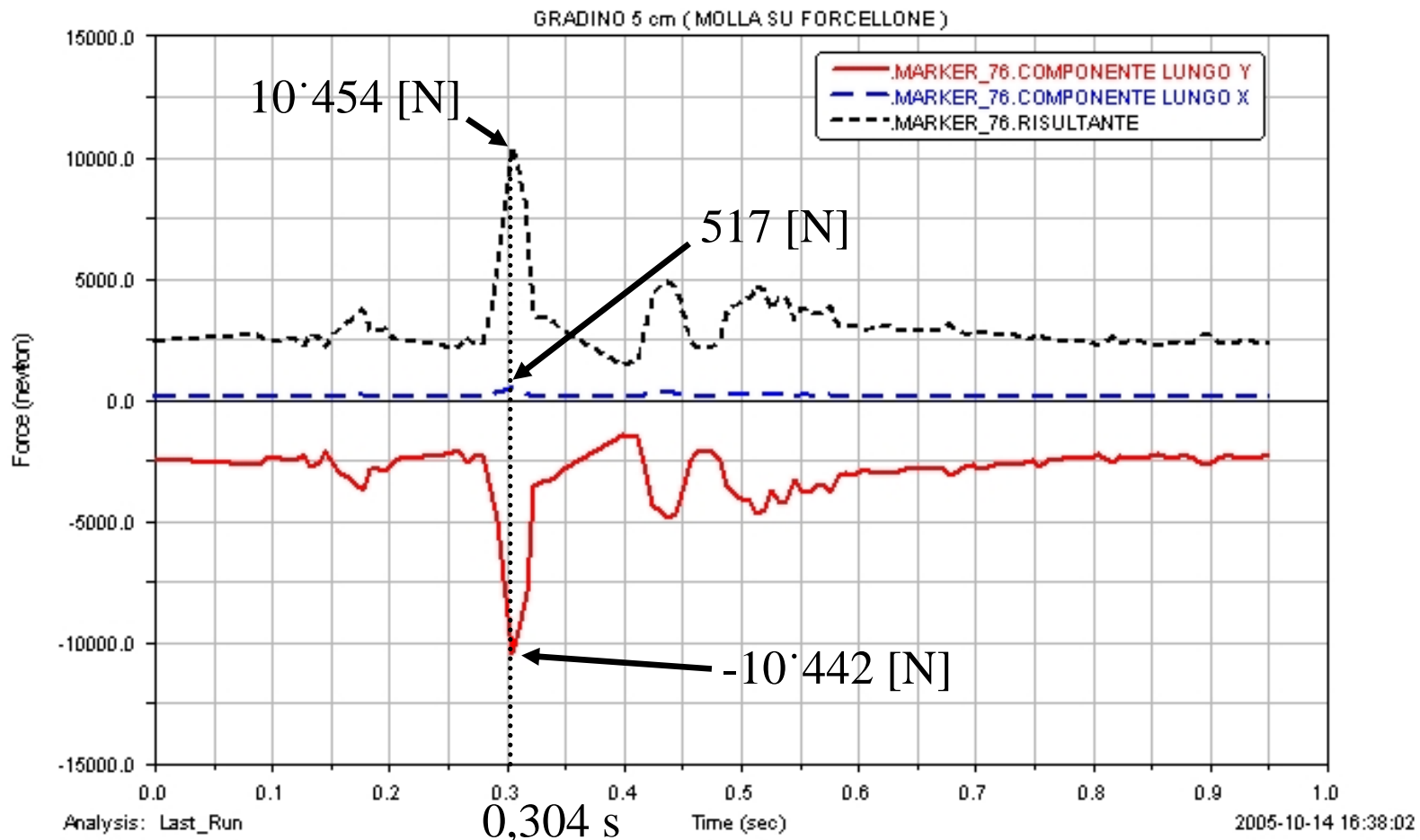
ACQUISIZIONE DEI RISULTATI



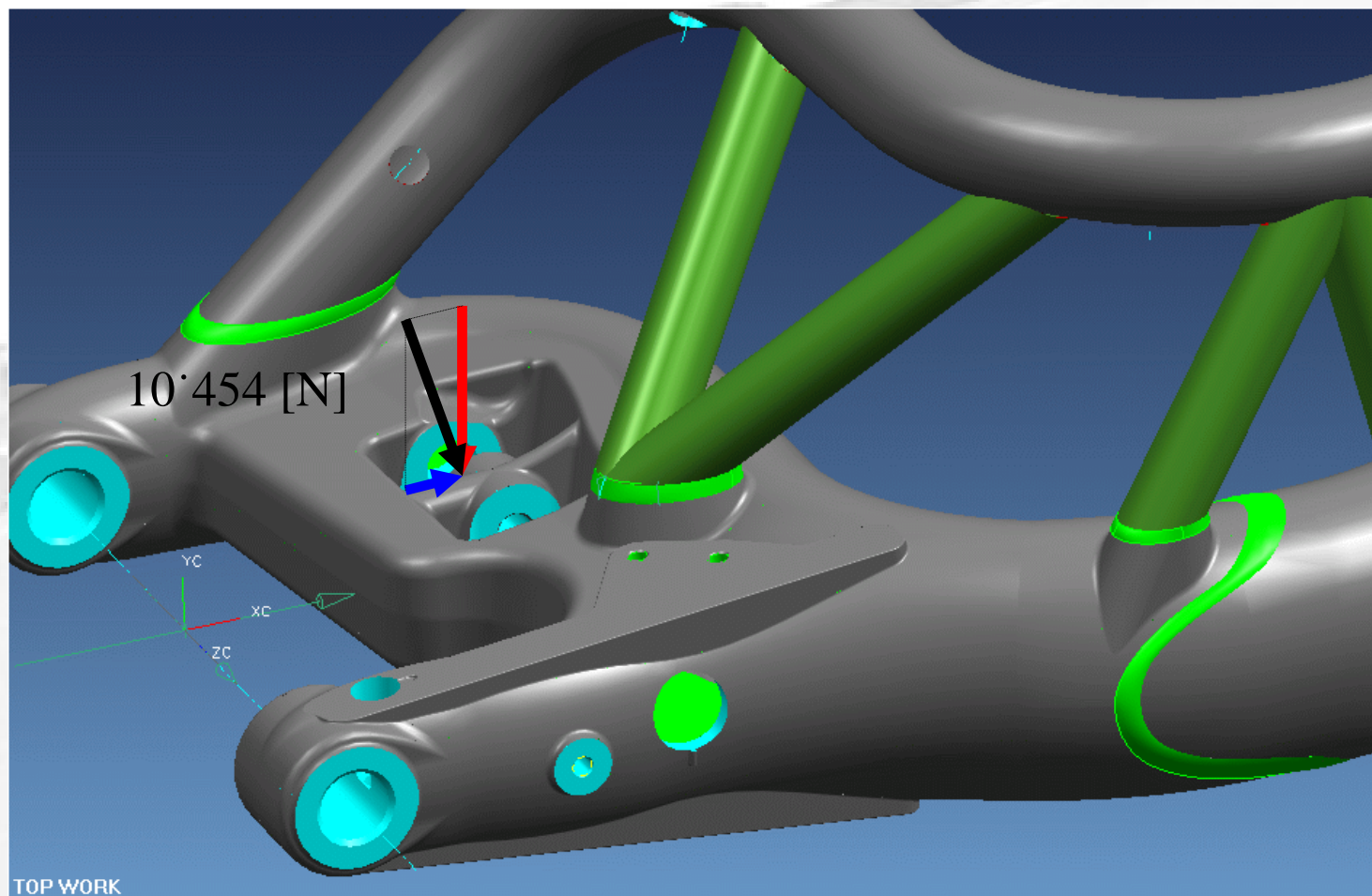
ACQUISIZIONE DEI RISULTATI

ATTRAVERSAMENTO DEL GRADINO DI 5 CM A 40 km/h

Forze che la sospensione esercita sul forcellone



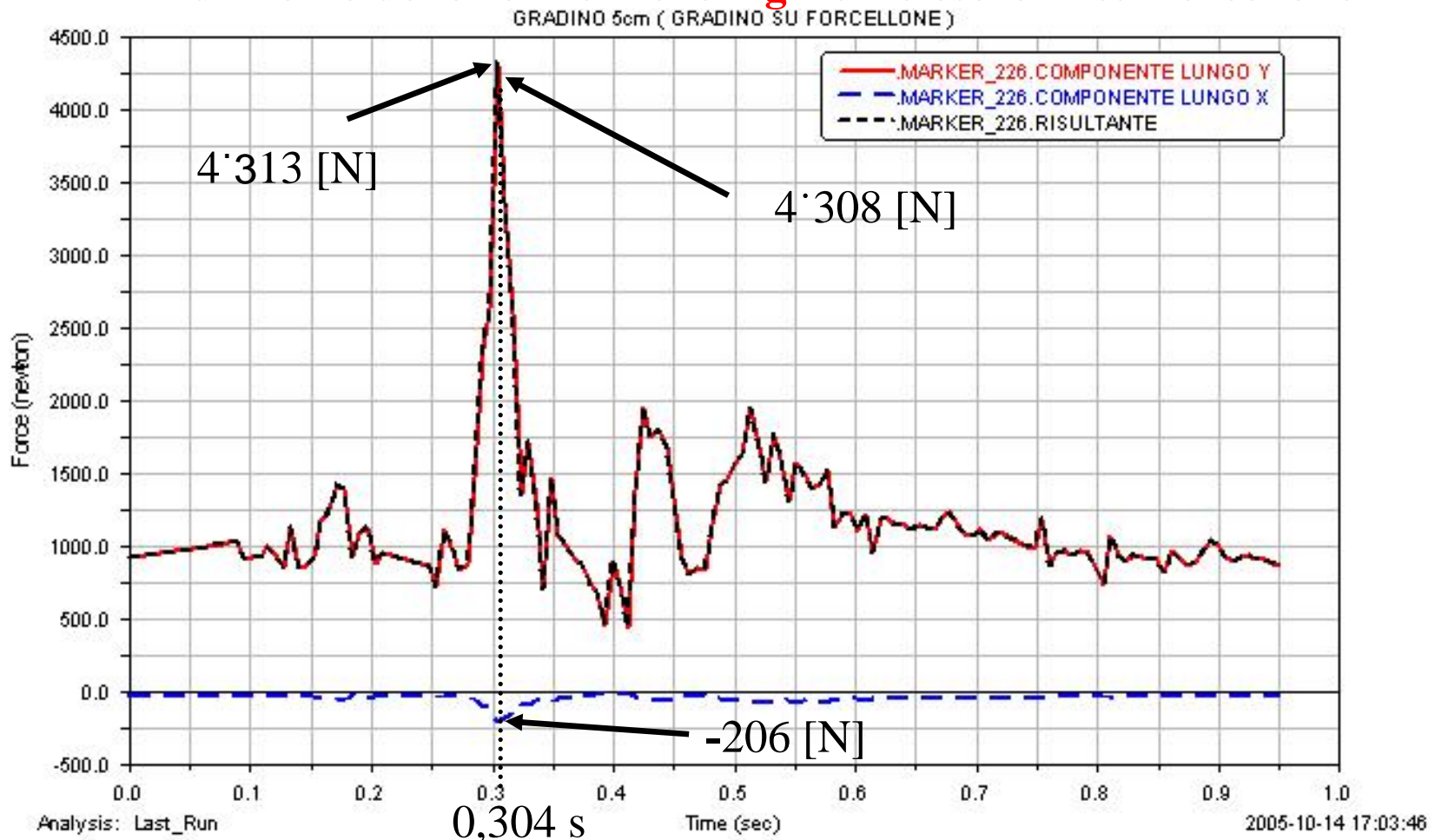
ACQUISIZIONE DEI RISULTATI



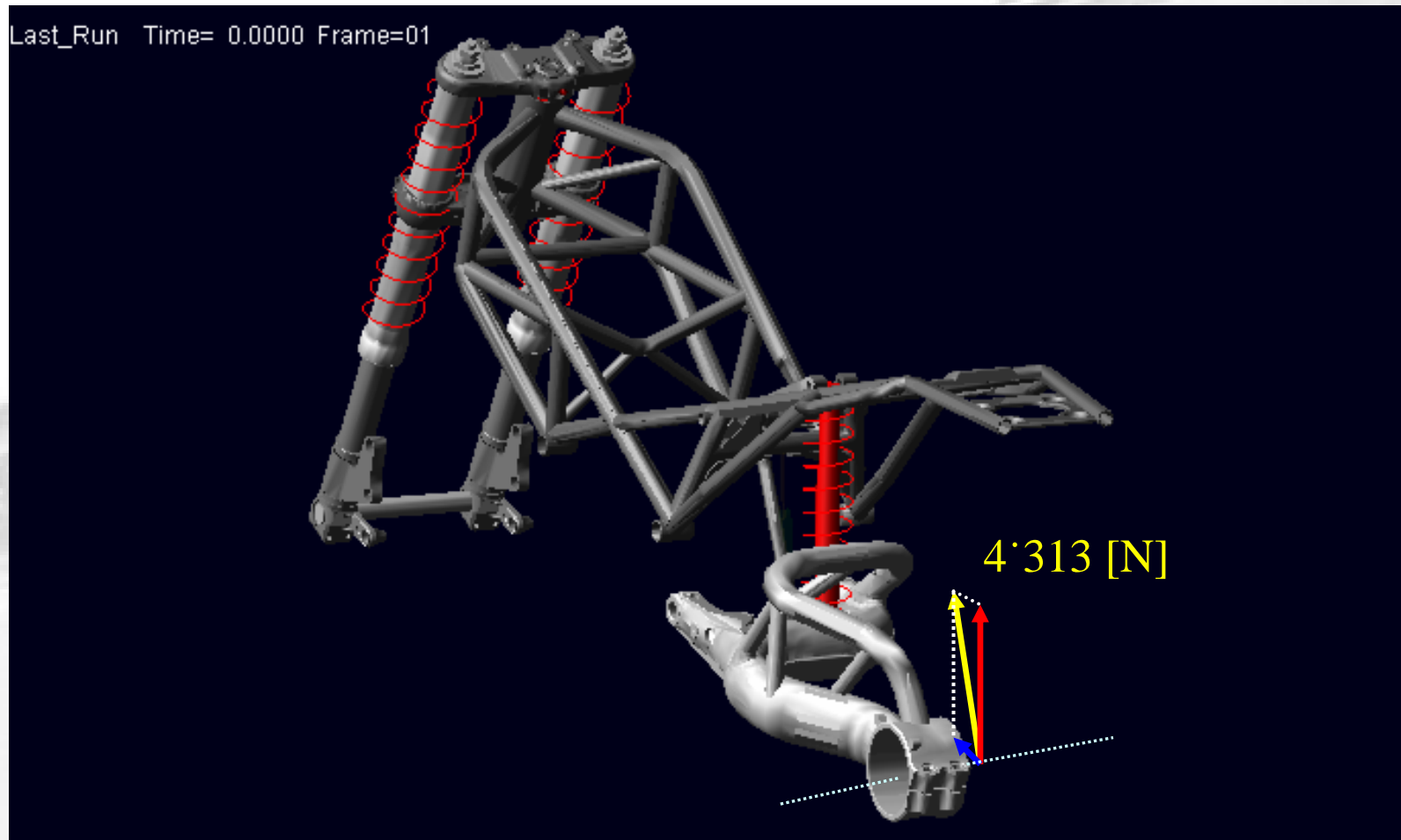
ACQUISIZIONE DEI RISULTATI

ATTRAVERSAMENTO DEL GRADINO DI 5 CM A 40 km/h

Andamento delle reazioni che il gradino esercita sul forcellone



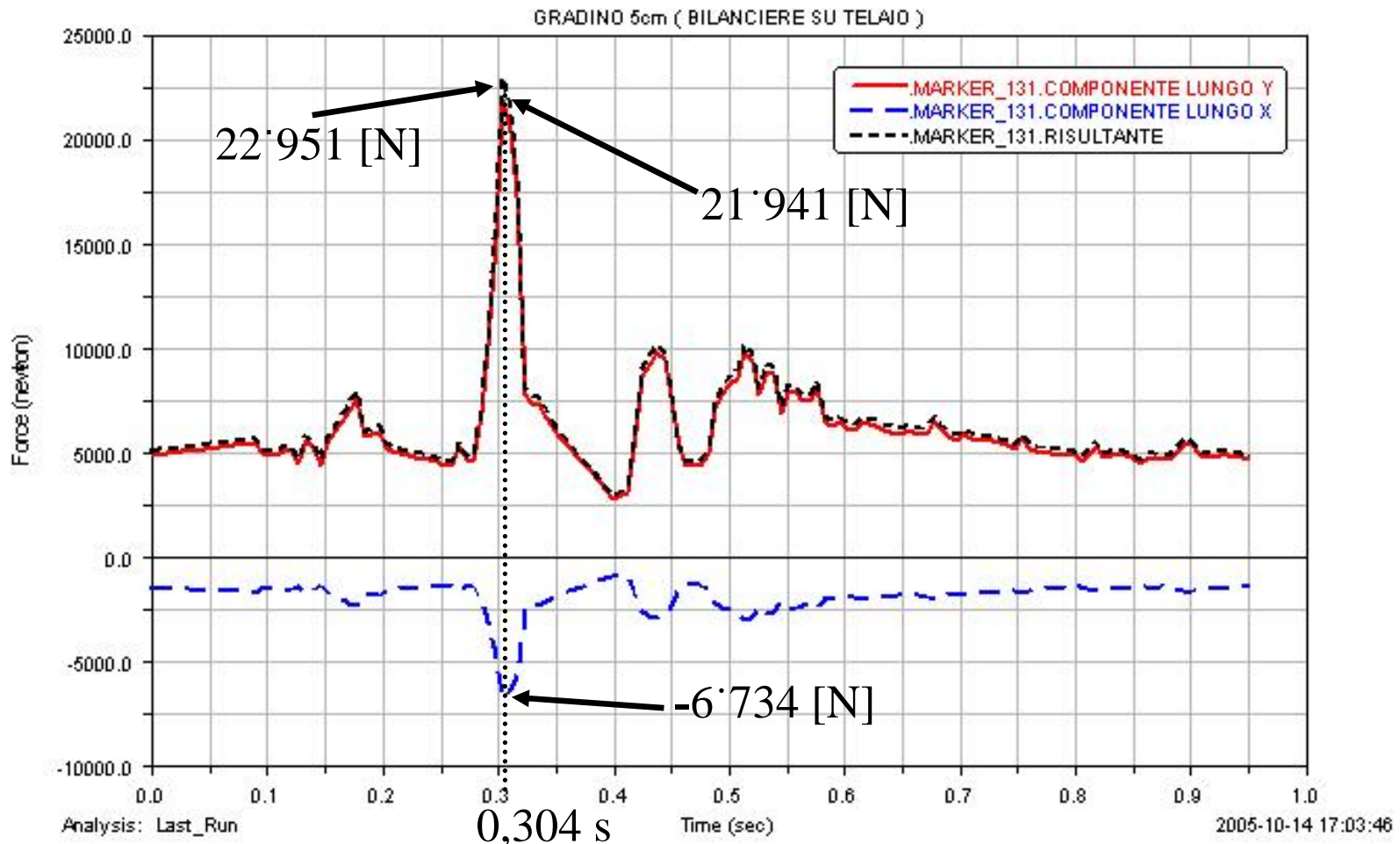
ACQUISIZIONE DEI RISULTATI



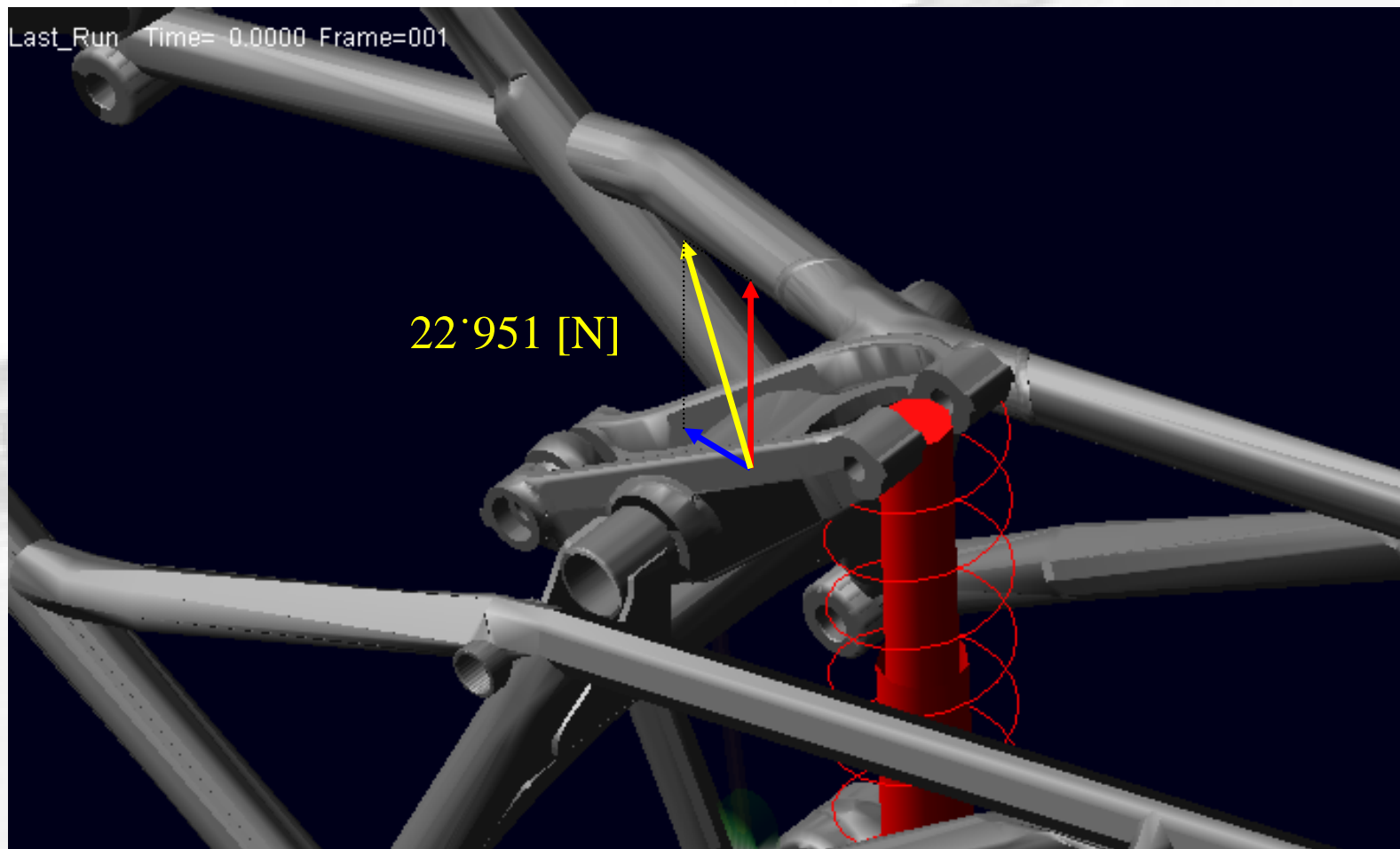
ACQUISIZIONE DEI RISULTATI

ATTRAVERSAMENTO DEL GRADINO DI 5 CM A 40 km/h

Andamento delle forze che il bilanciante esercita sul telaio



ACQUISIZIONE DEI RISULTATI

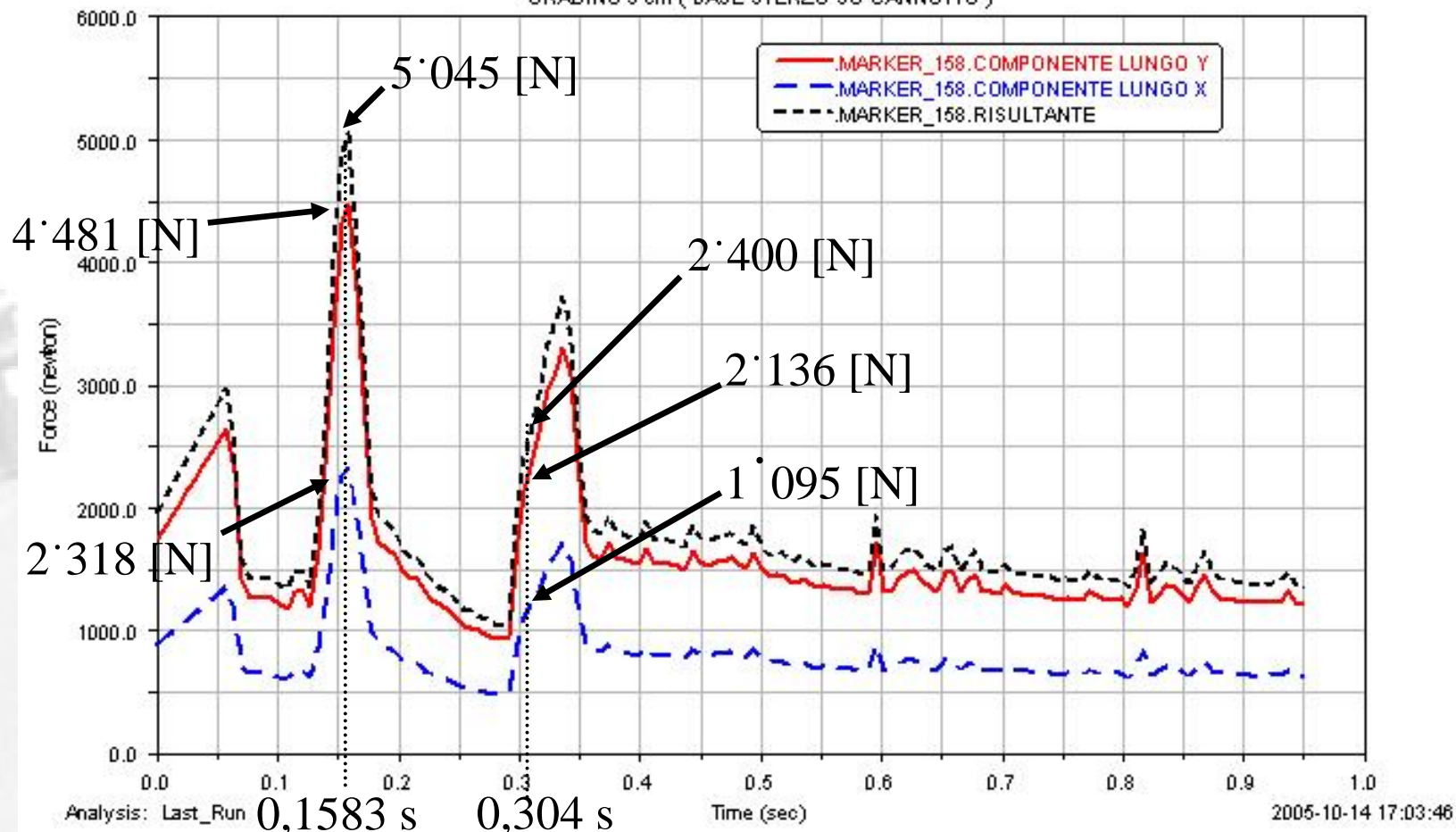


ACQUISIZIONE DEI RISULTATI

ATTRAVERSAMENTO DEL GRADINO DI 5 CM A 40 km/h

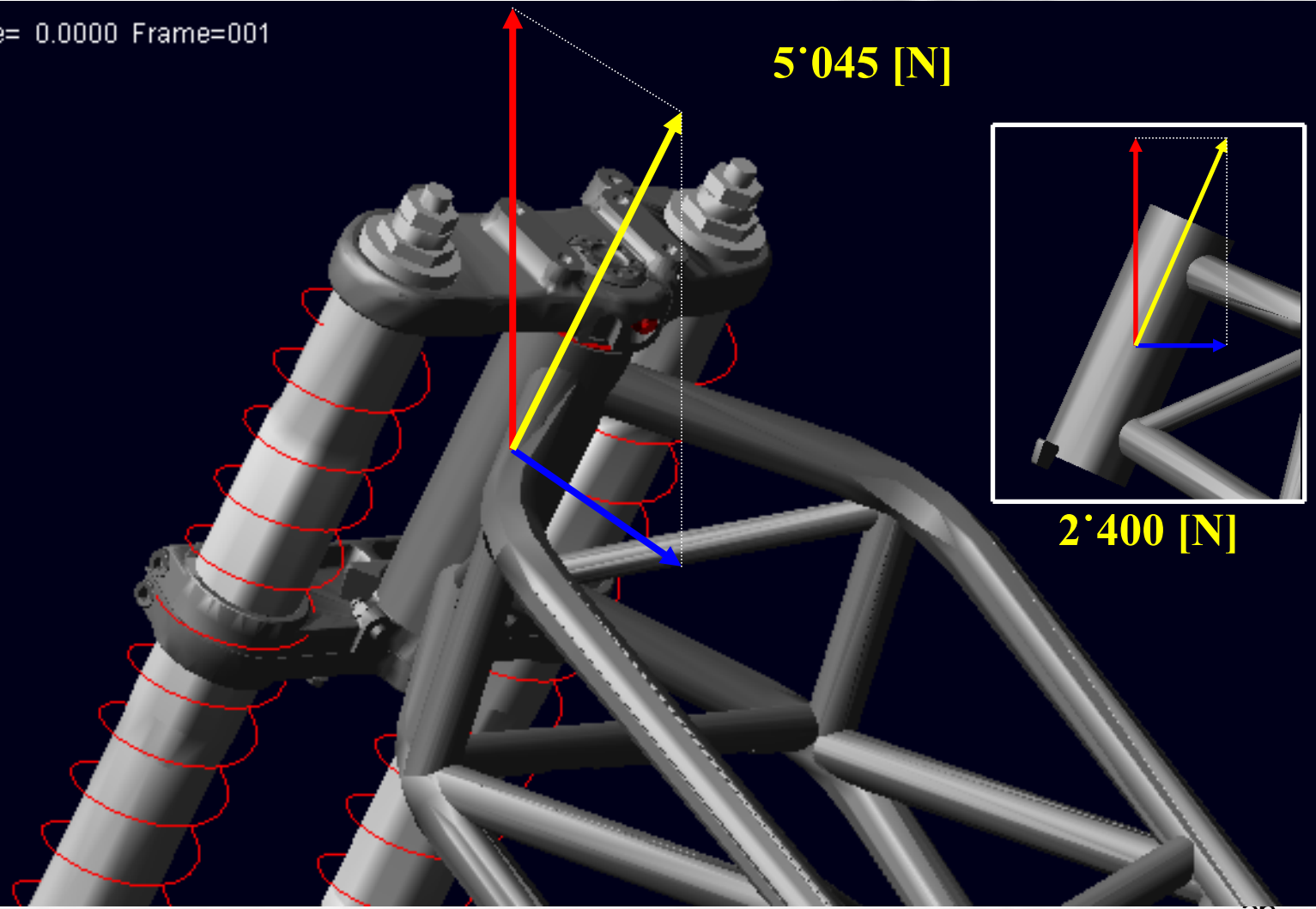
Andamento delle forze che la forcella anteriore esercita sul telaio

GRADINO 5 cm (BASE STERZO SU CANNOTTO)



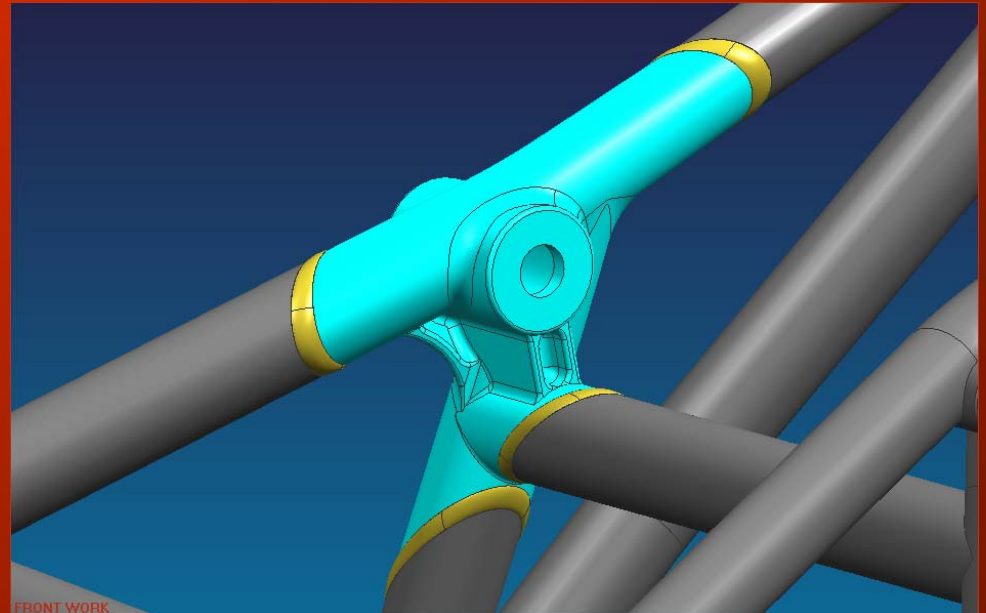
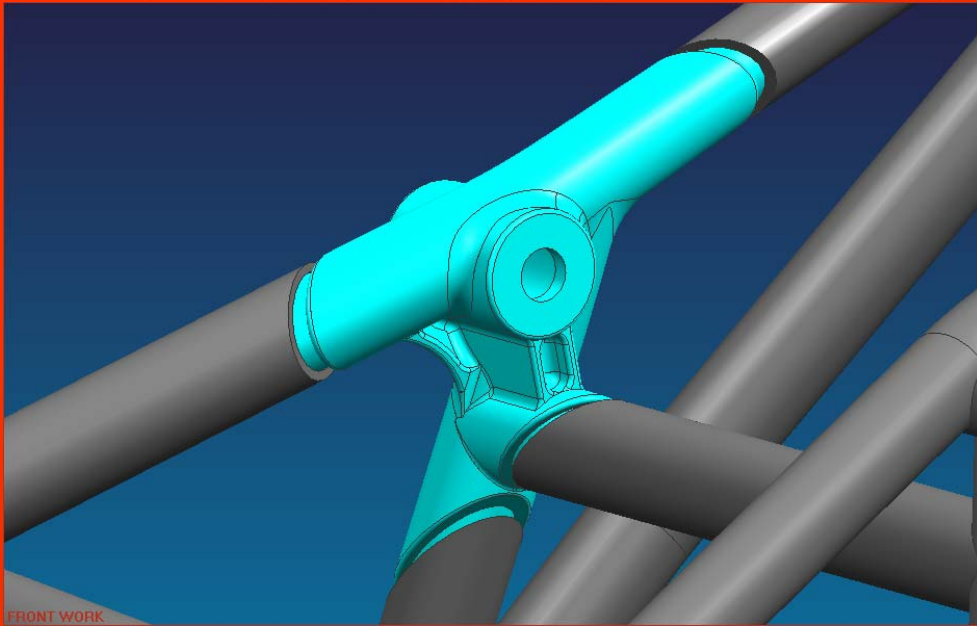
ACQUISIZIONE DEI RISULTATI

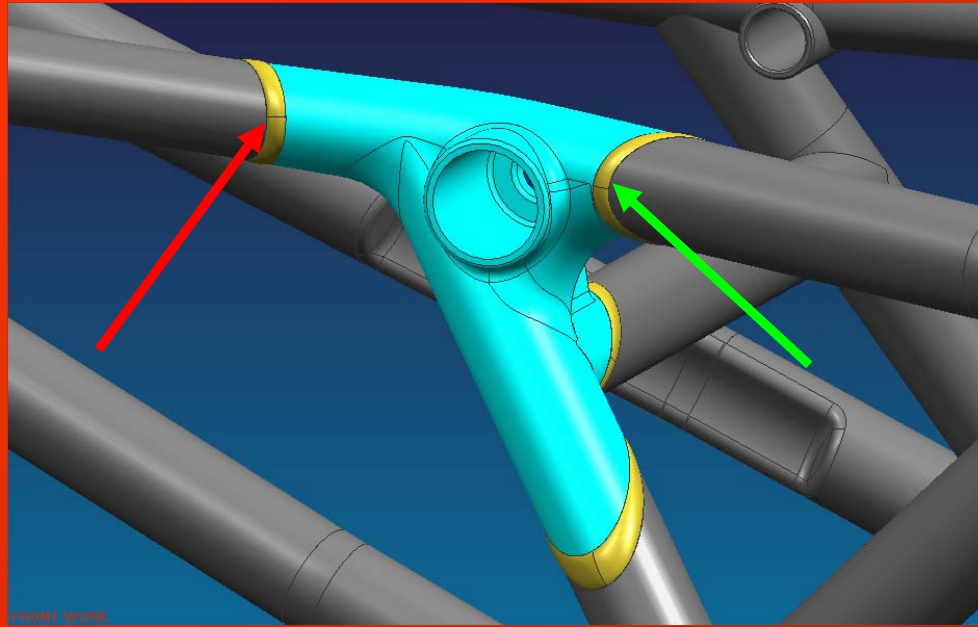
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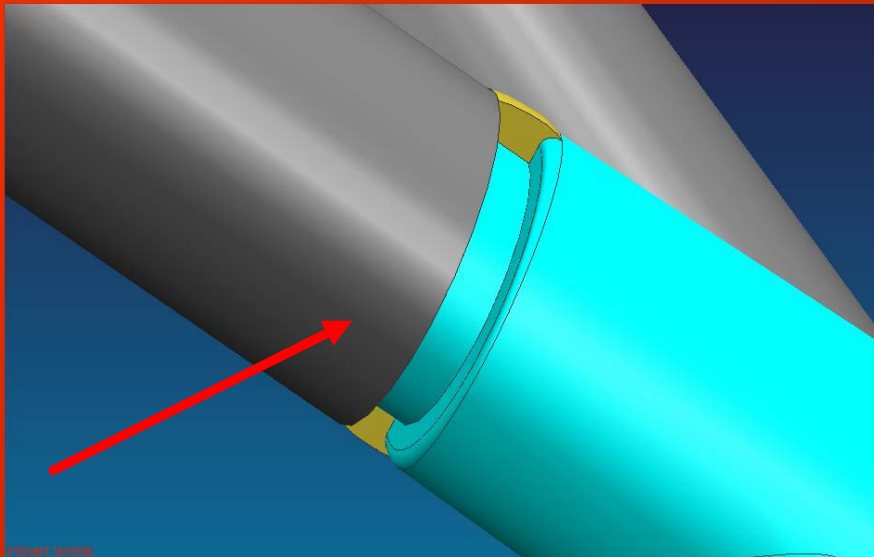


**COSTRUZIONE DEL
MODELLO GEOMETRICO
VIRTUALE**

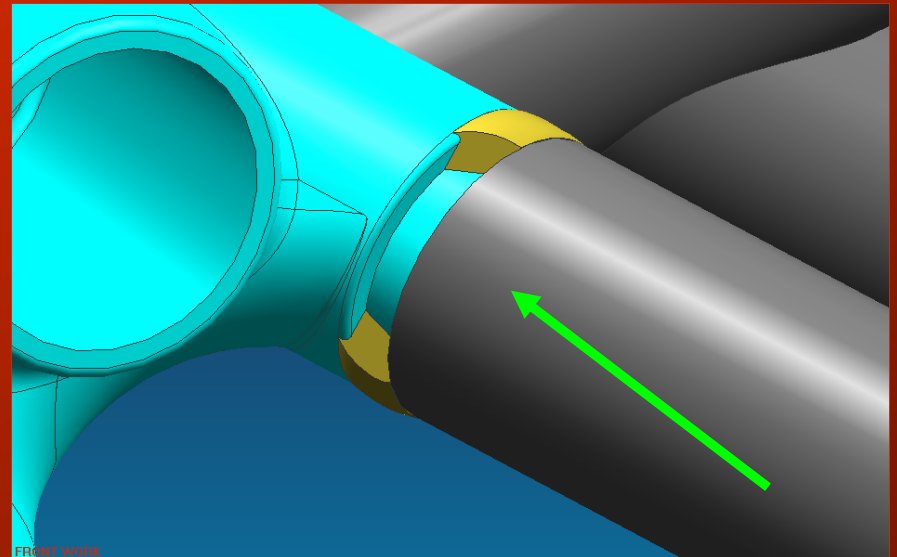




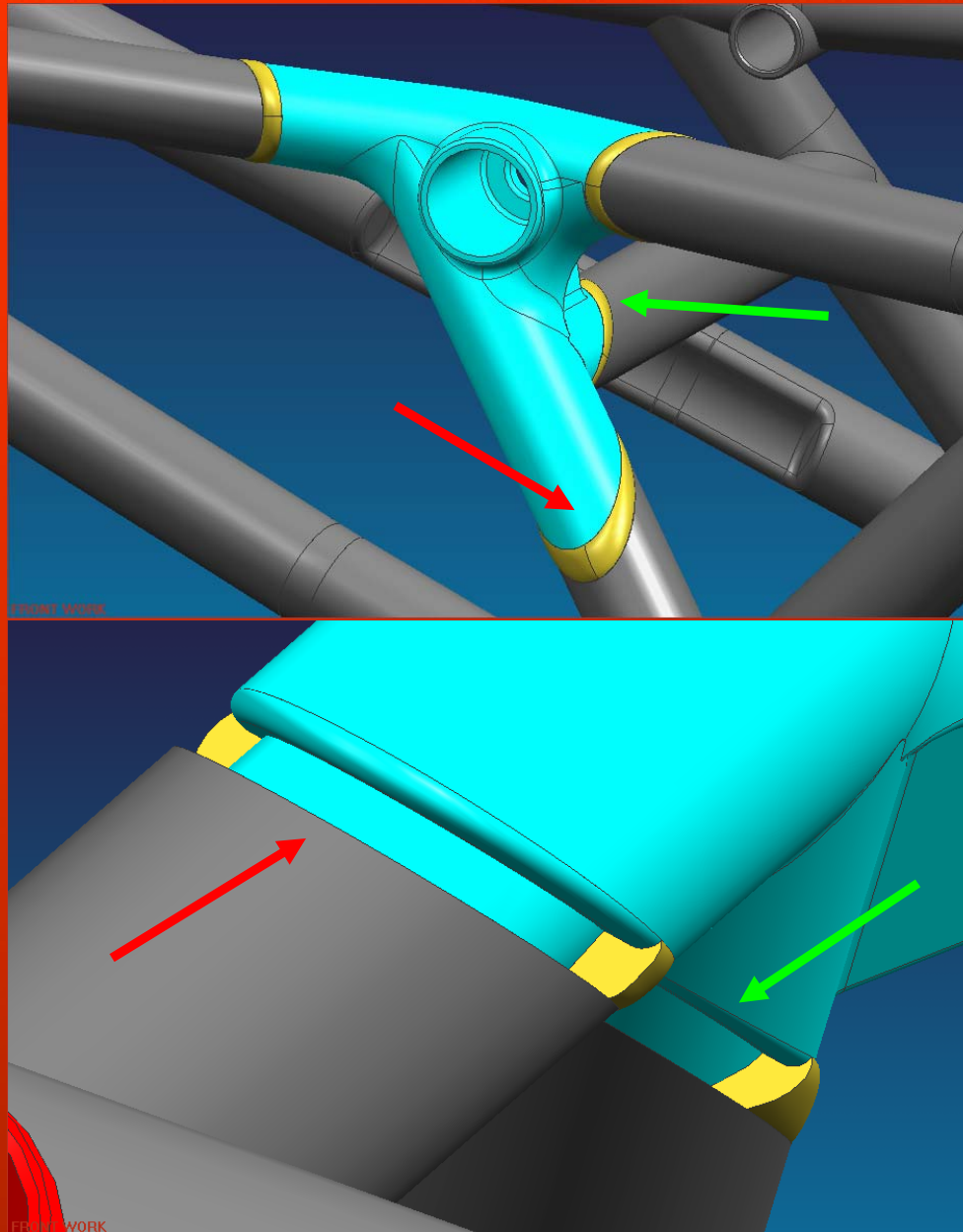
FRONT VIEW

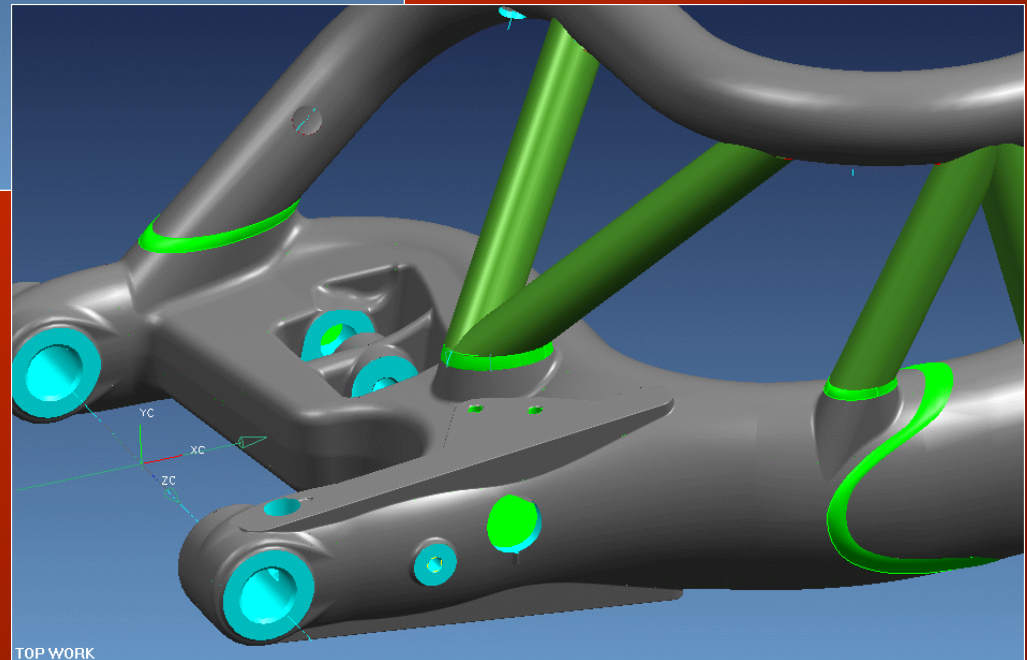
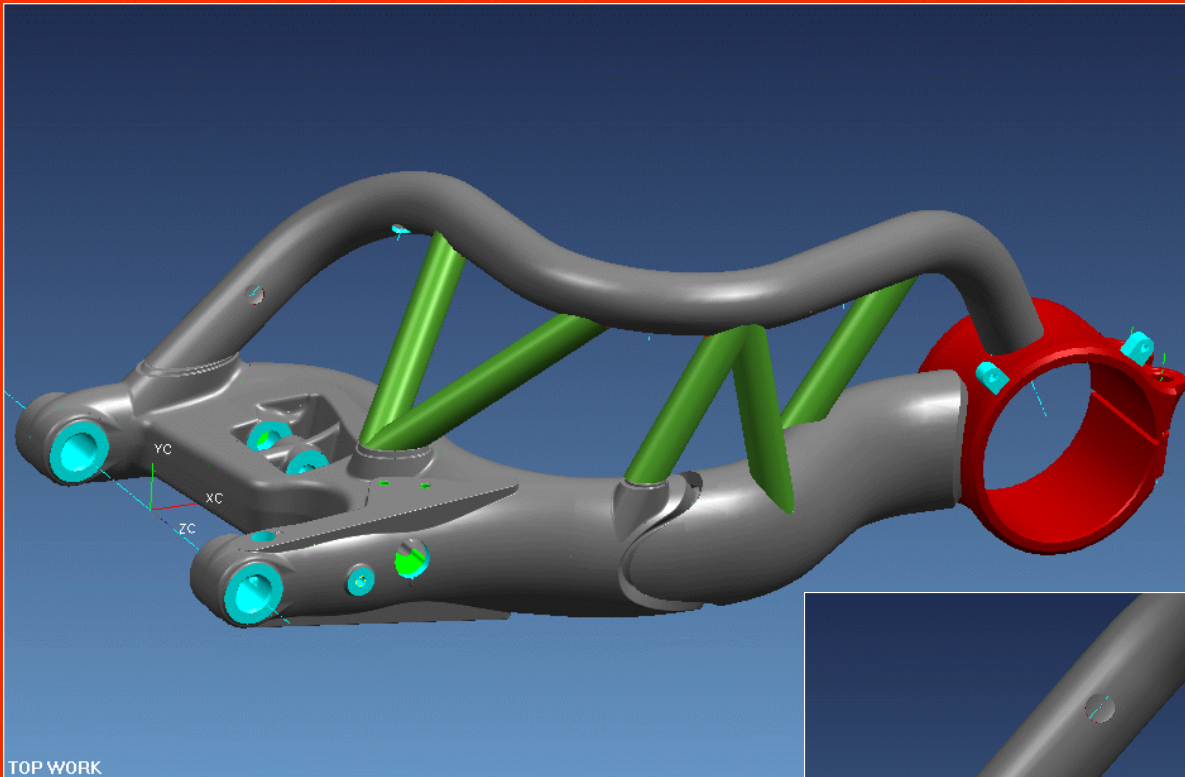


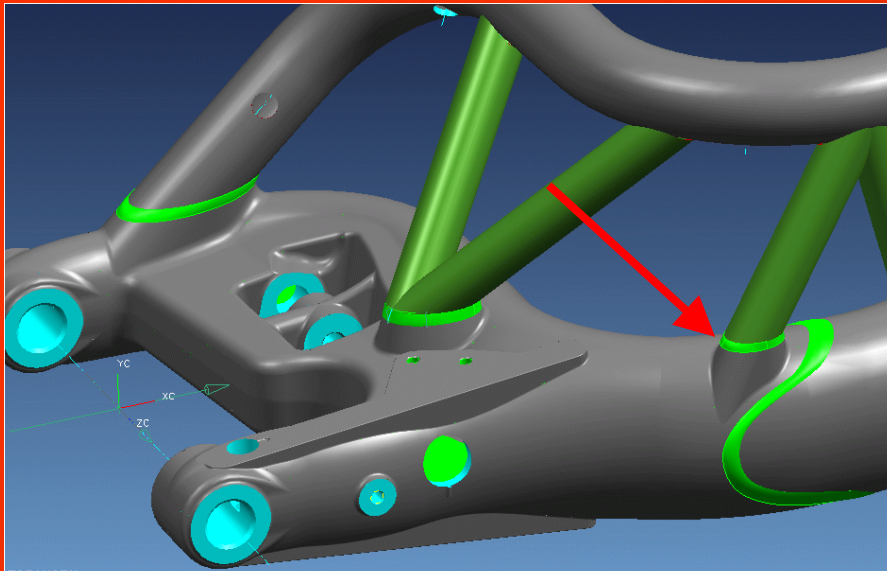
FRONT VIEW



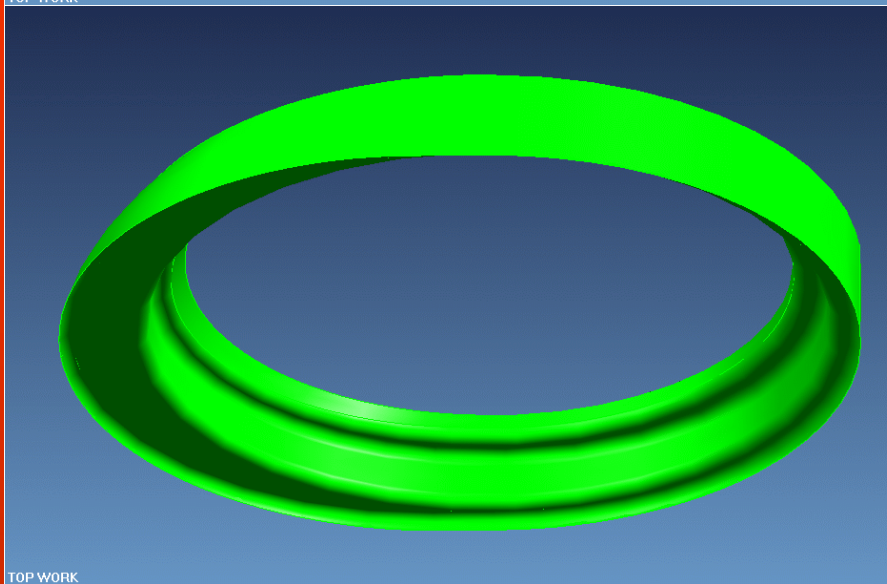
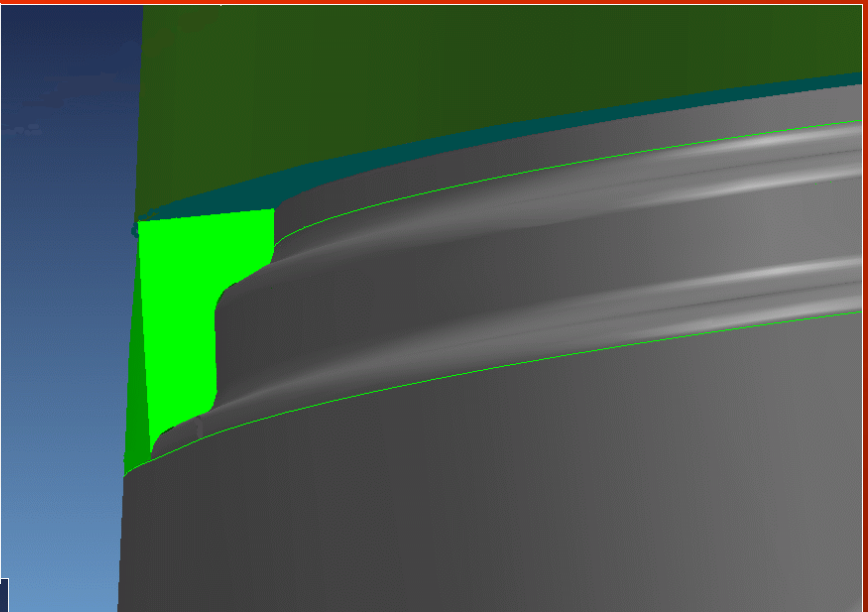
FRONT VIEW



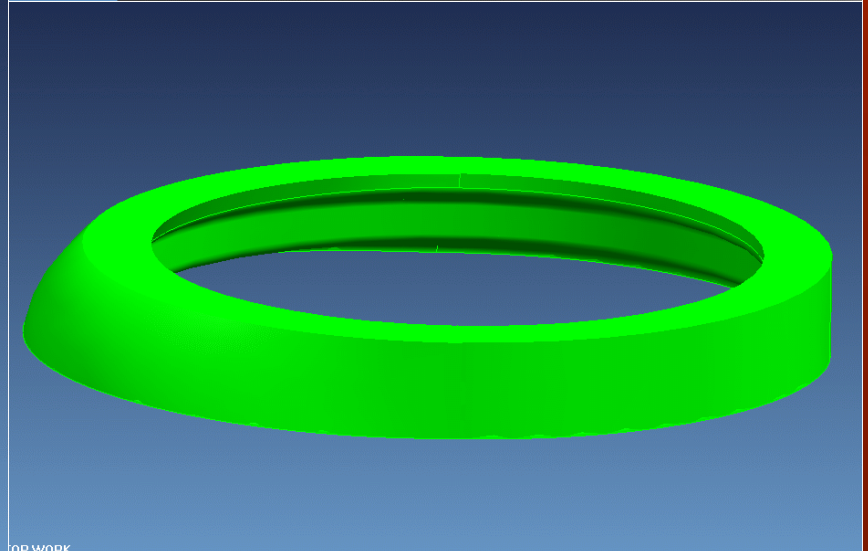




TOP WORK

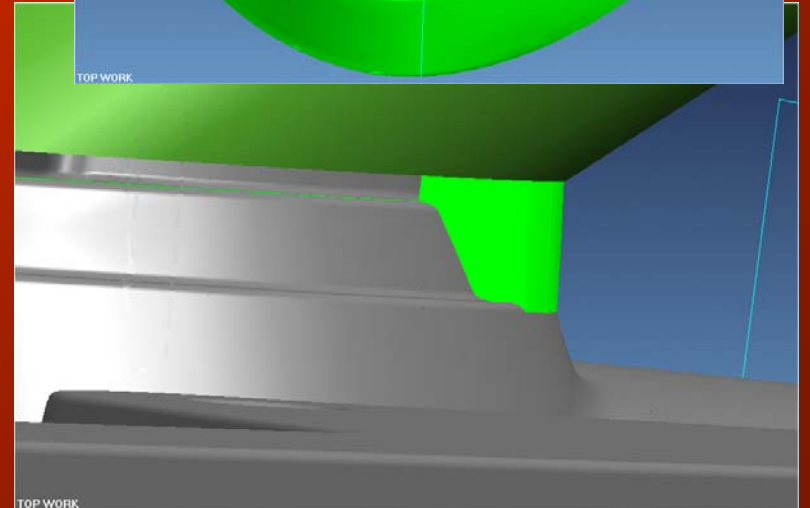
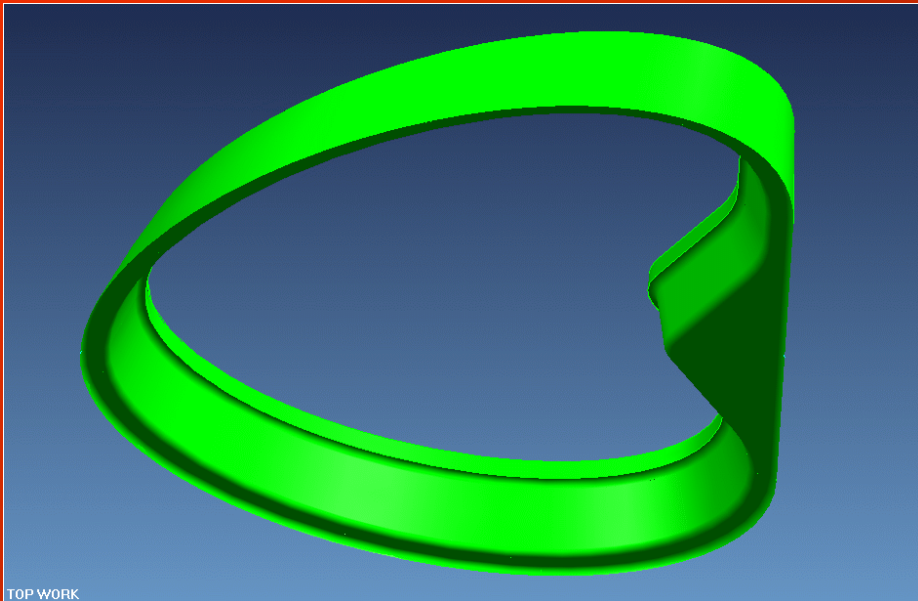
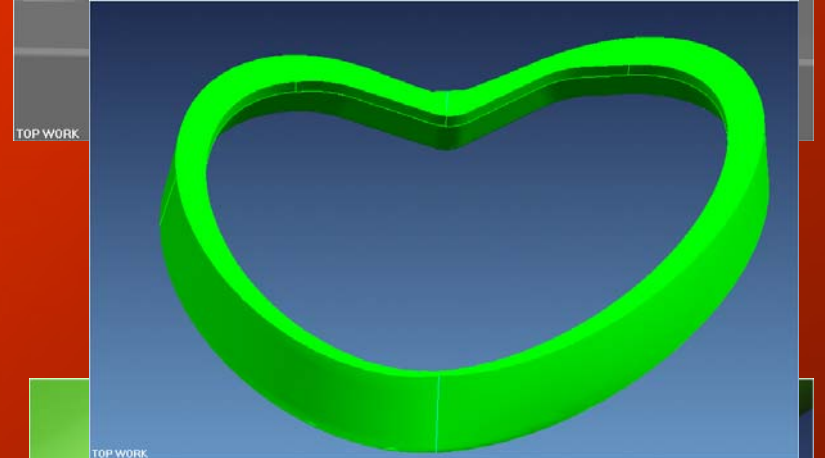
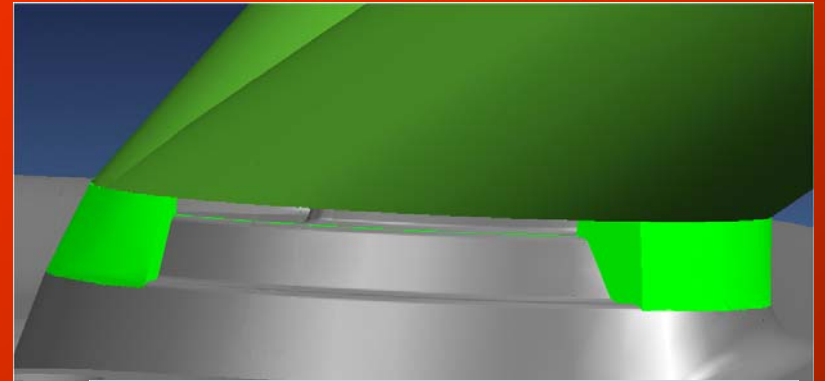
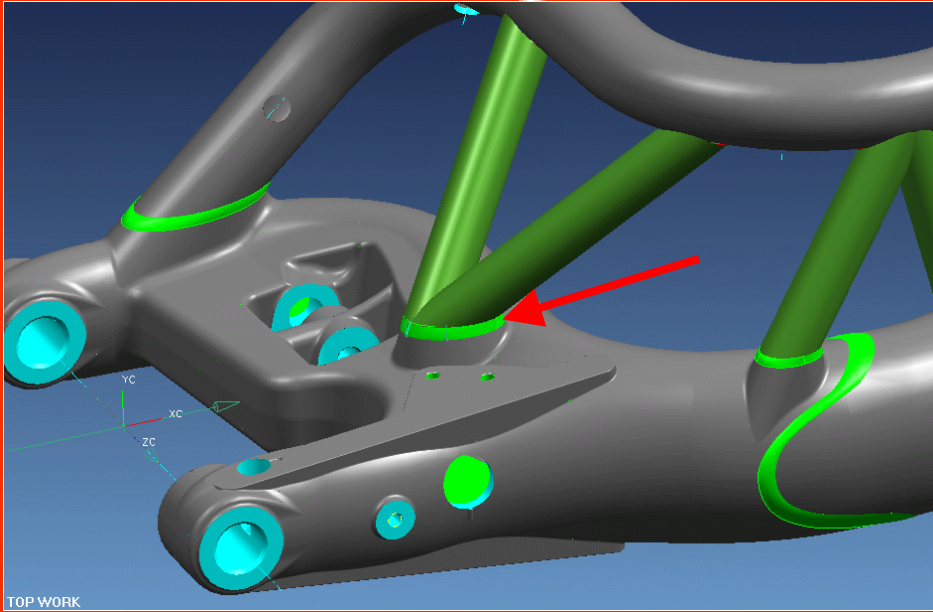


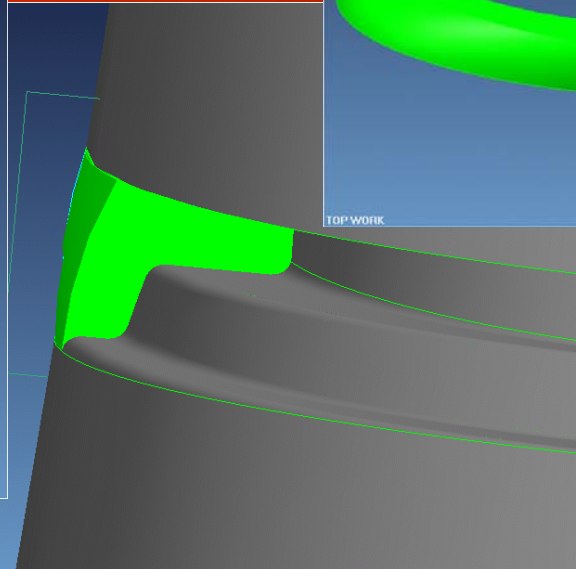
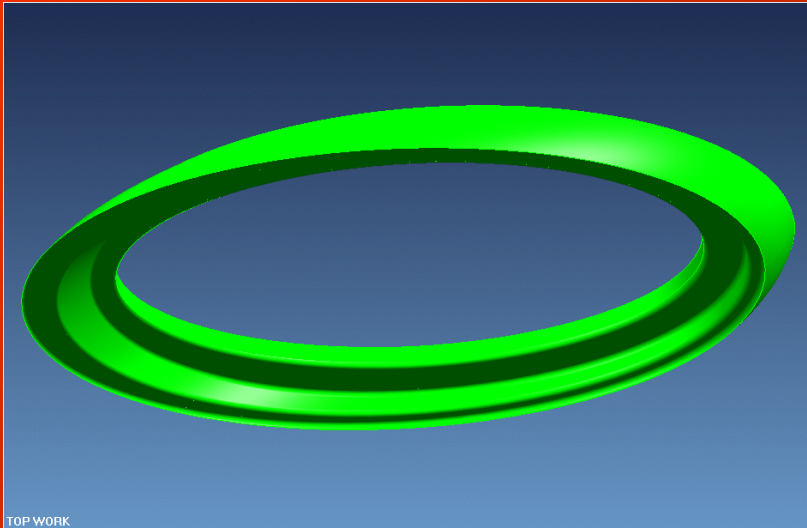
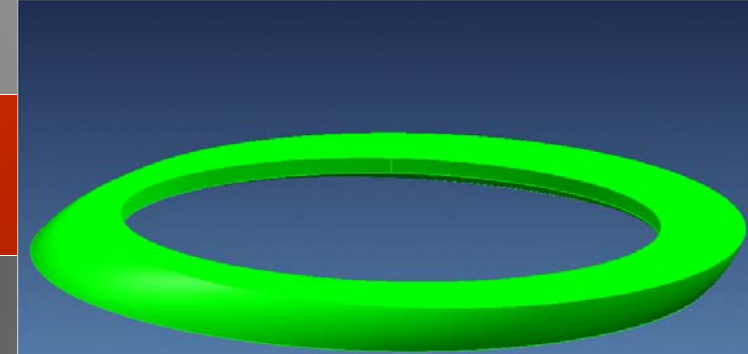
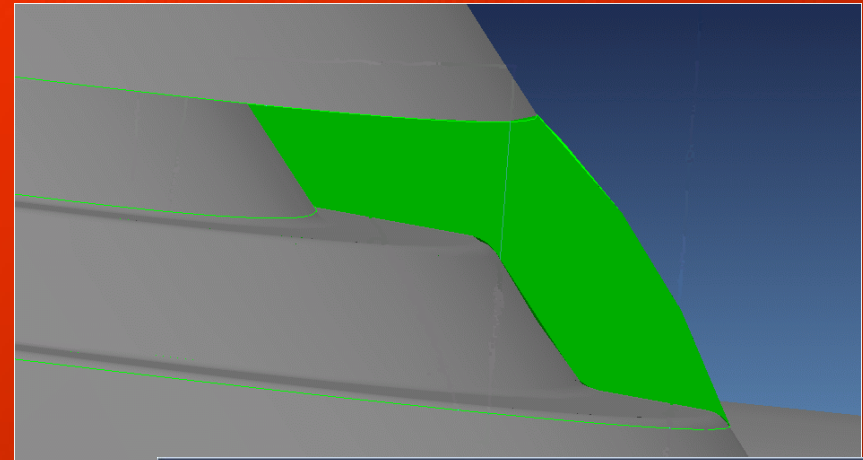
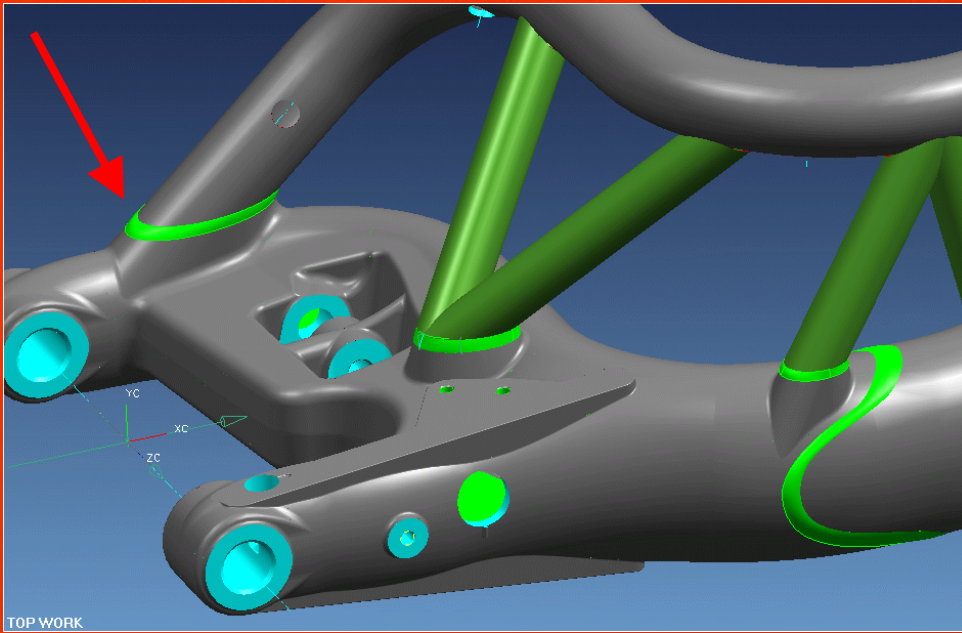
TOP WORK



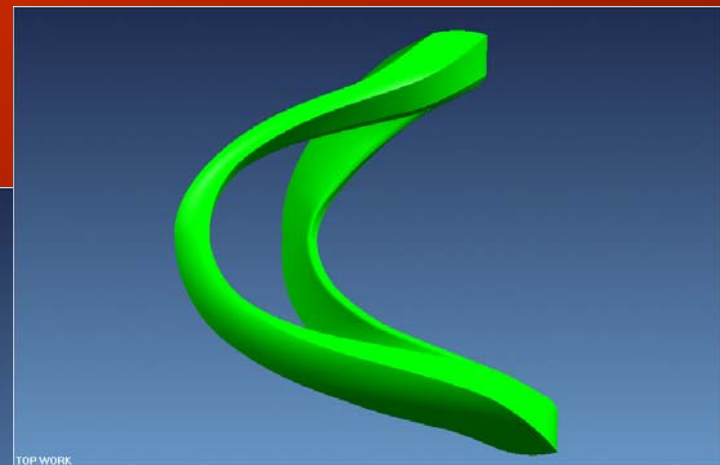
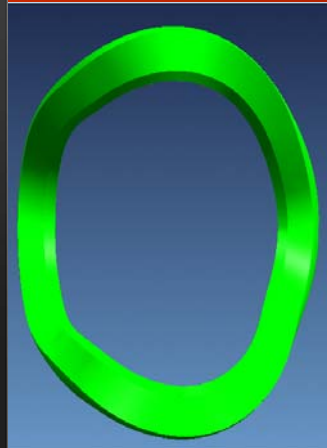
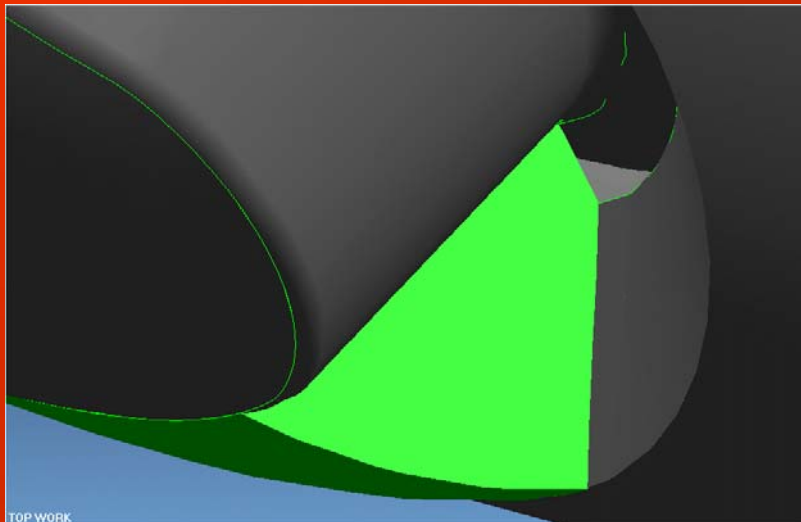
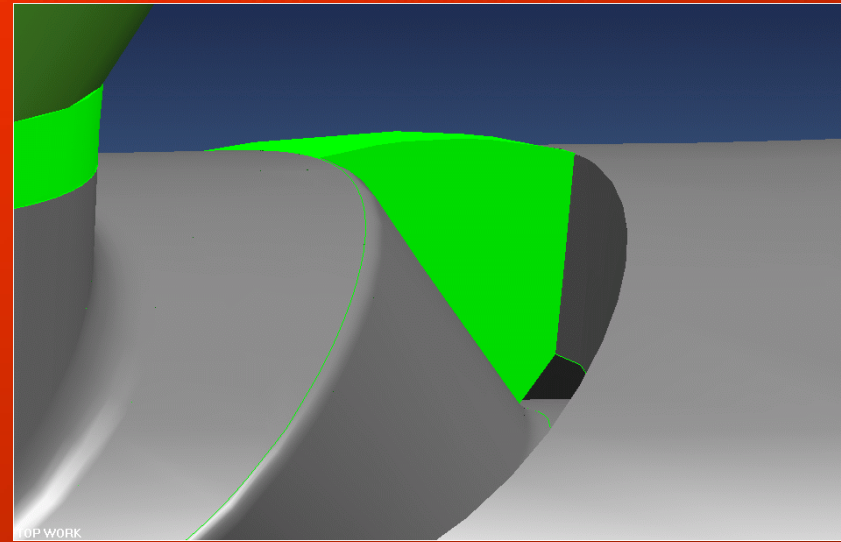
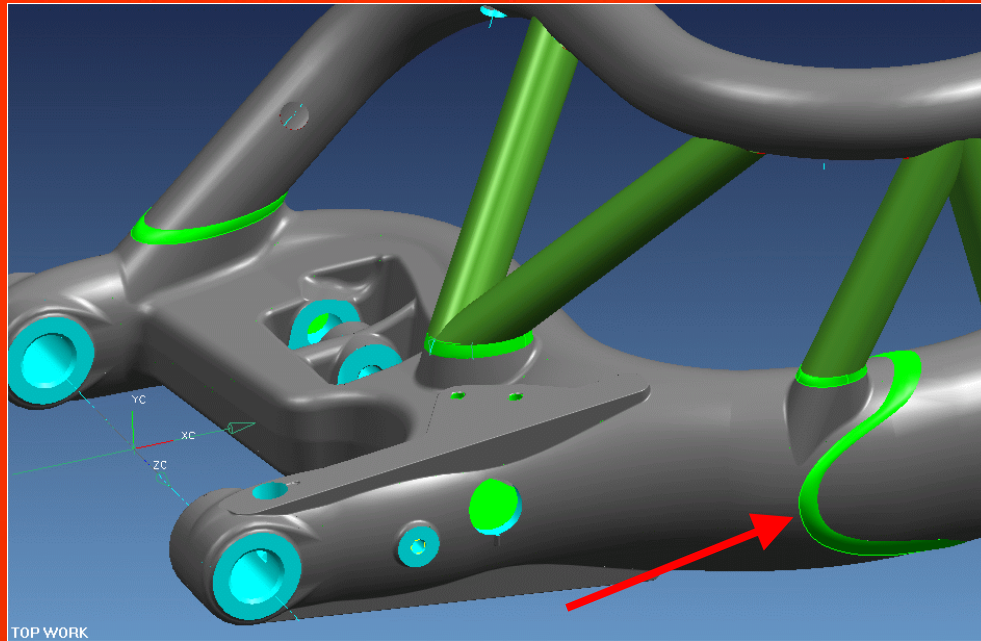
TOP WORK







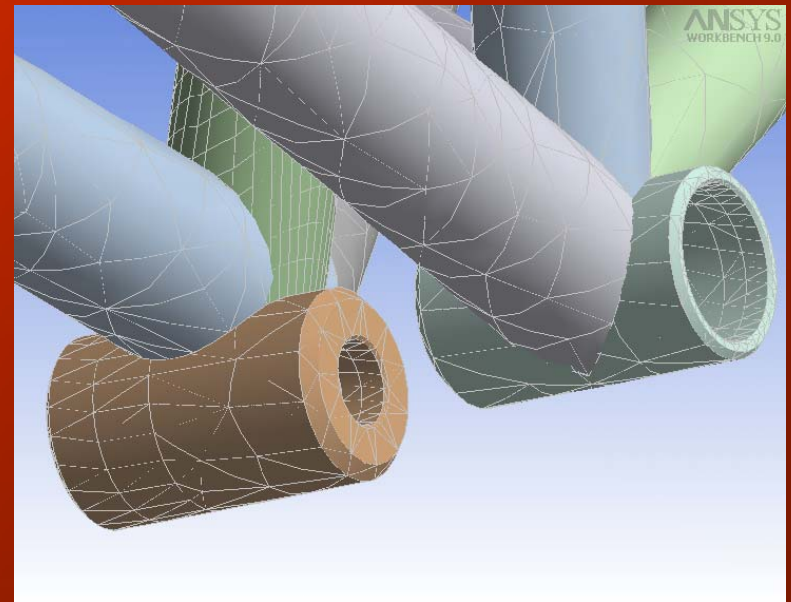
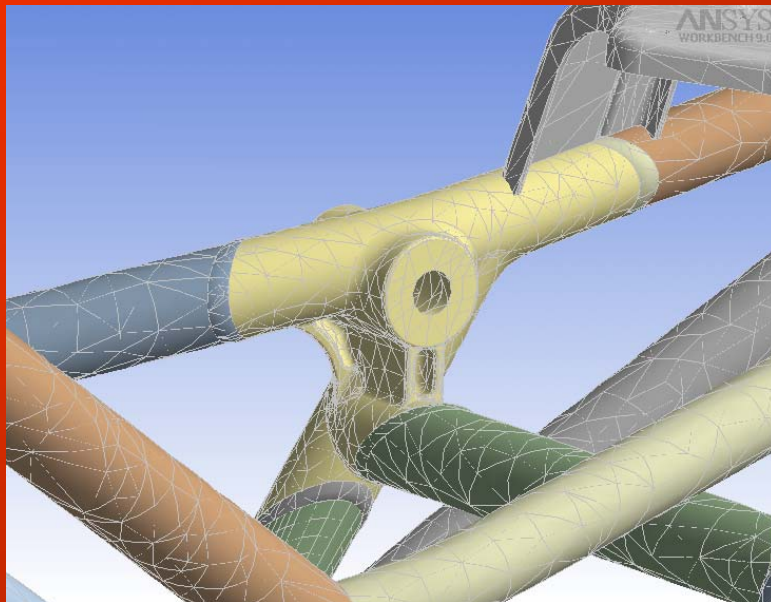
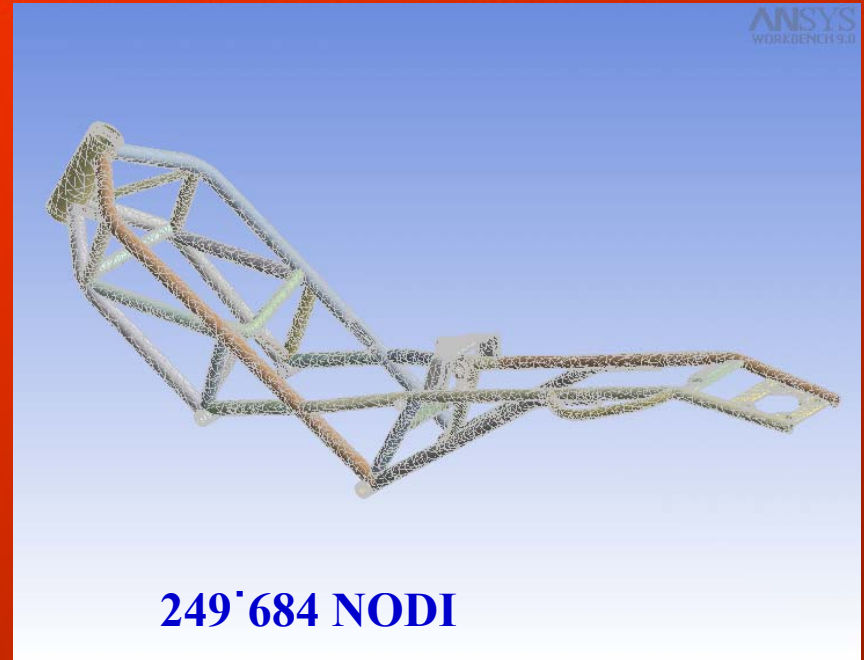
TOP WORK





LE VERIFICHE DI RESISTENZA





Carico a perno 3: 2400.56 N

Vincolo fisso

Carico a perno: 11475.1 N

Carico a perno 2: 11475.1 N

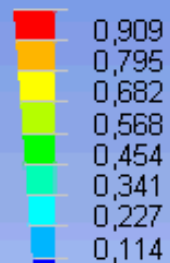
0.000 0.156 0.311 0.467 (m)



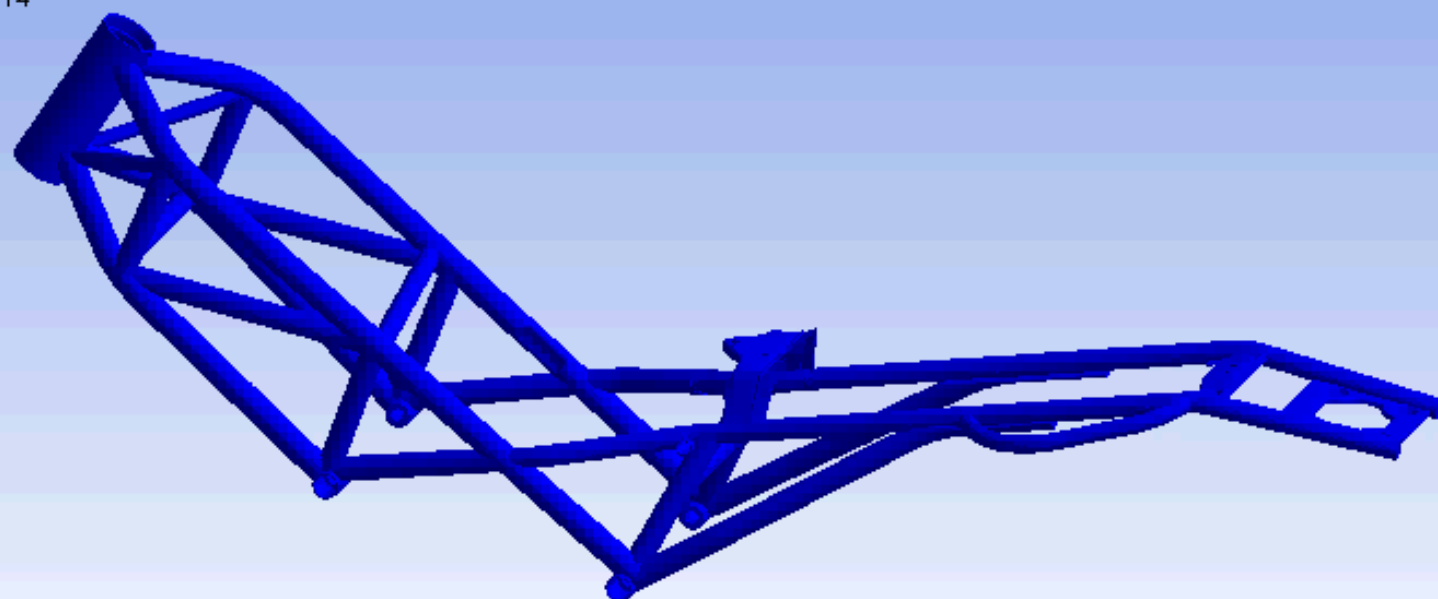
Sollecitazione equivalente (von Mises)

X 1e9 Pa

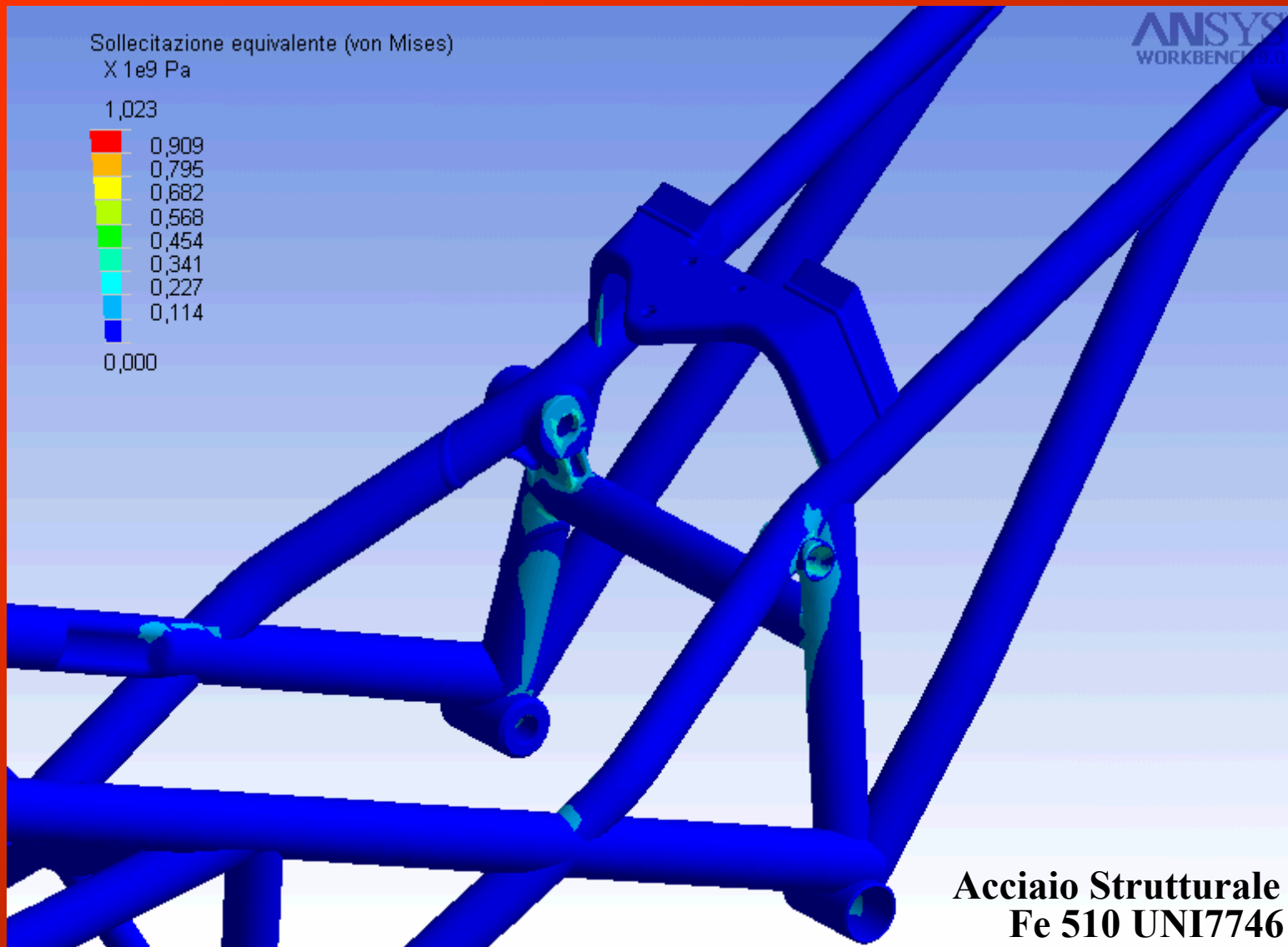
1,023



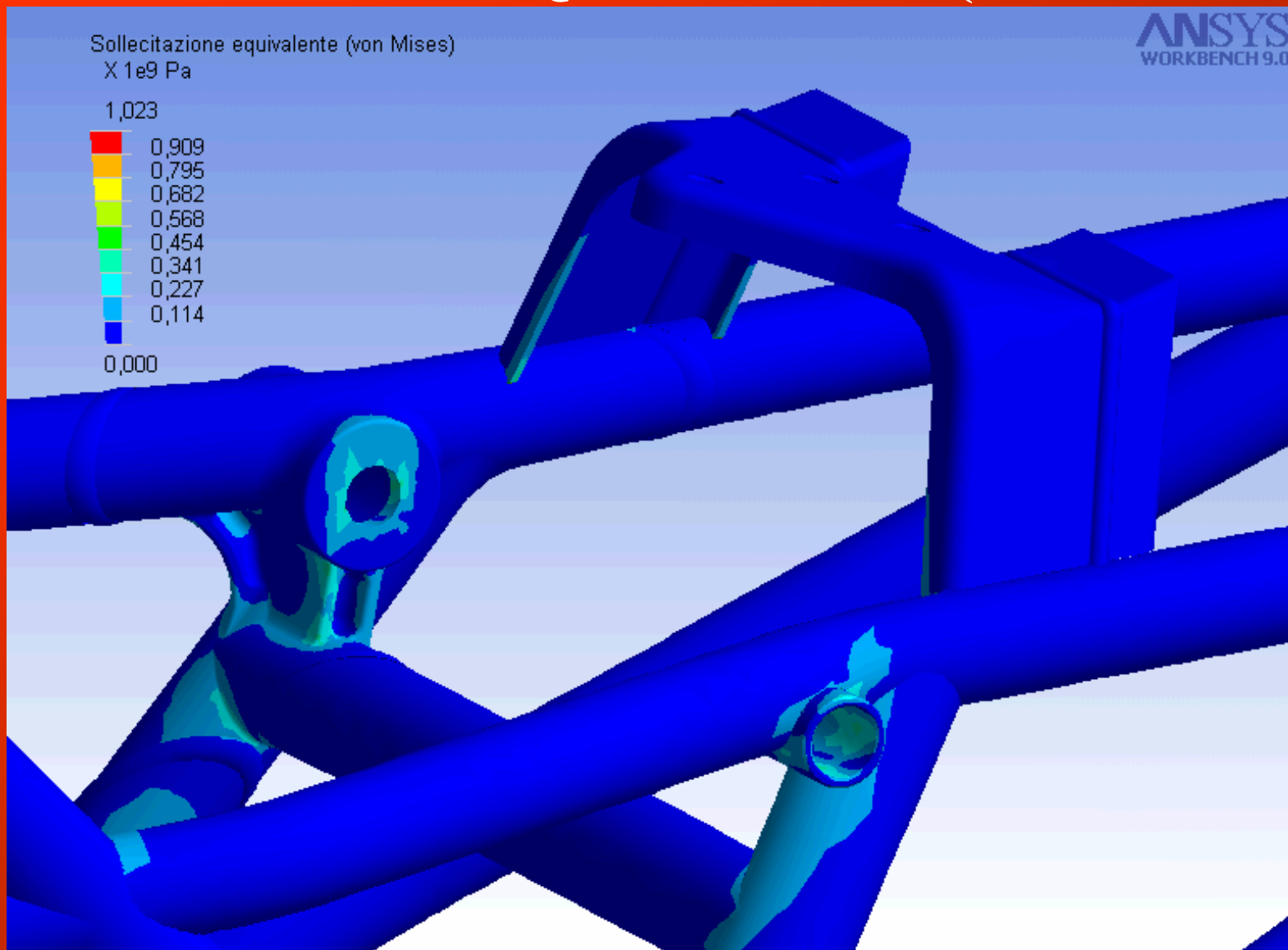
0,000



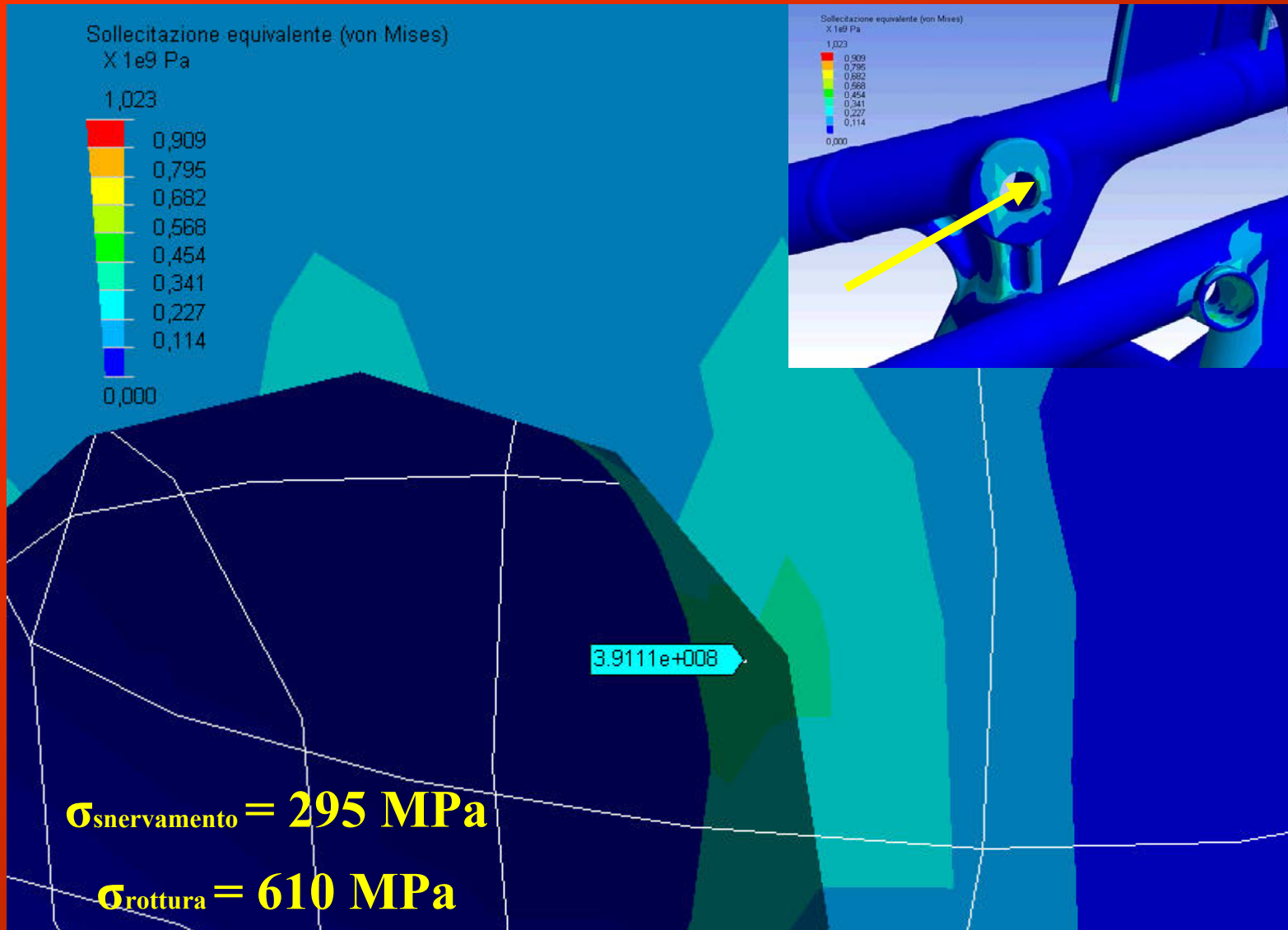
SOLLECITAZIONE EQUIVALENTE (VON MISES)



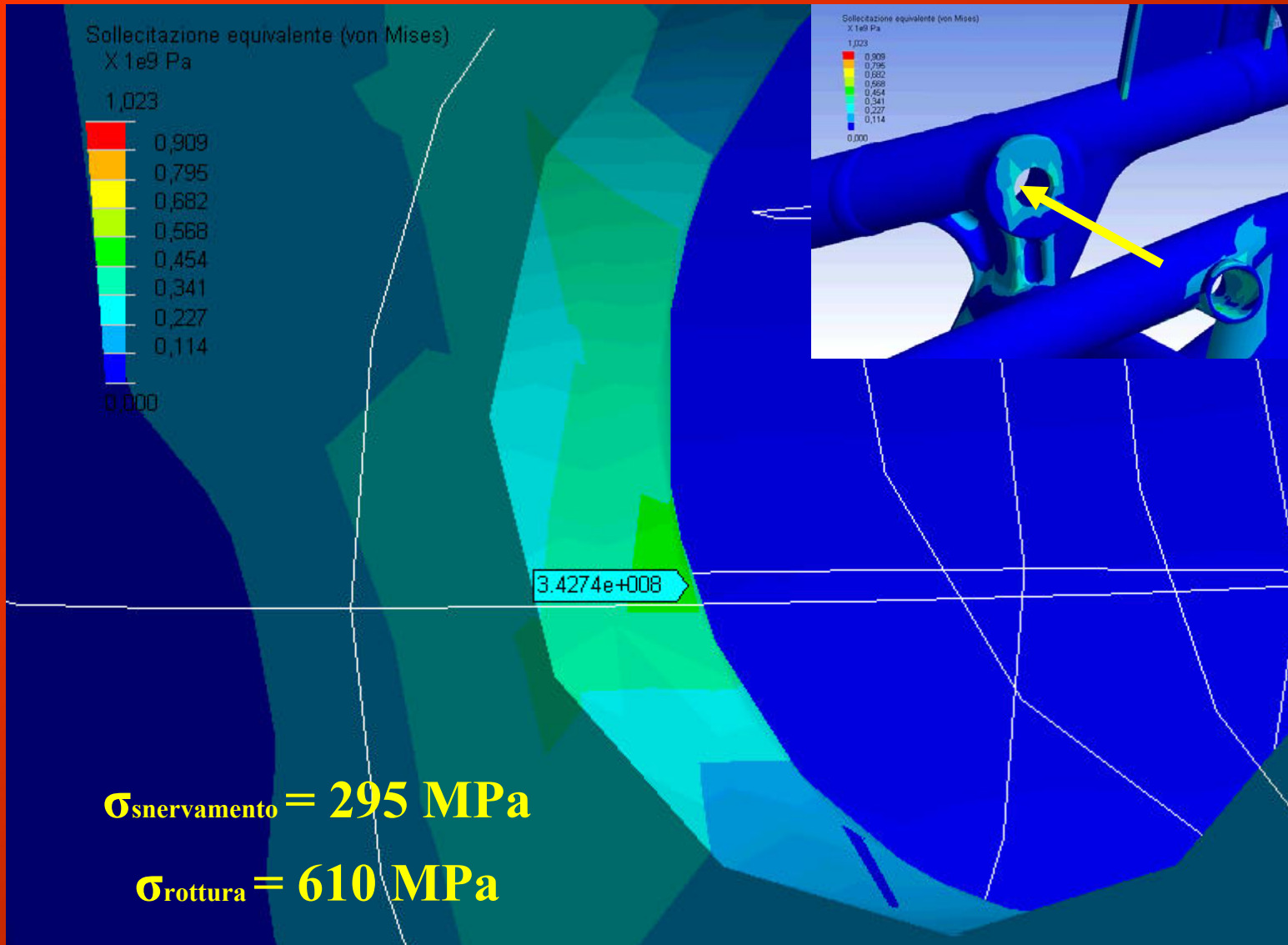
SOLLECITAZIONE EQUIVALENTE (VON MISES)



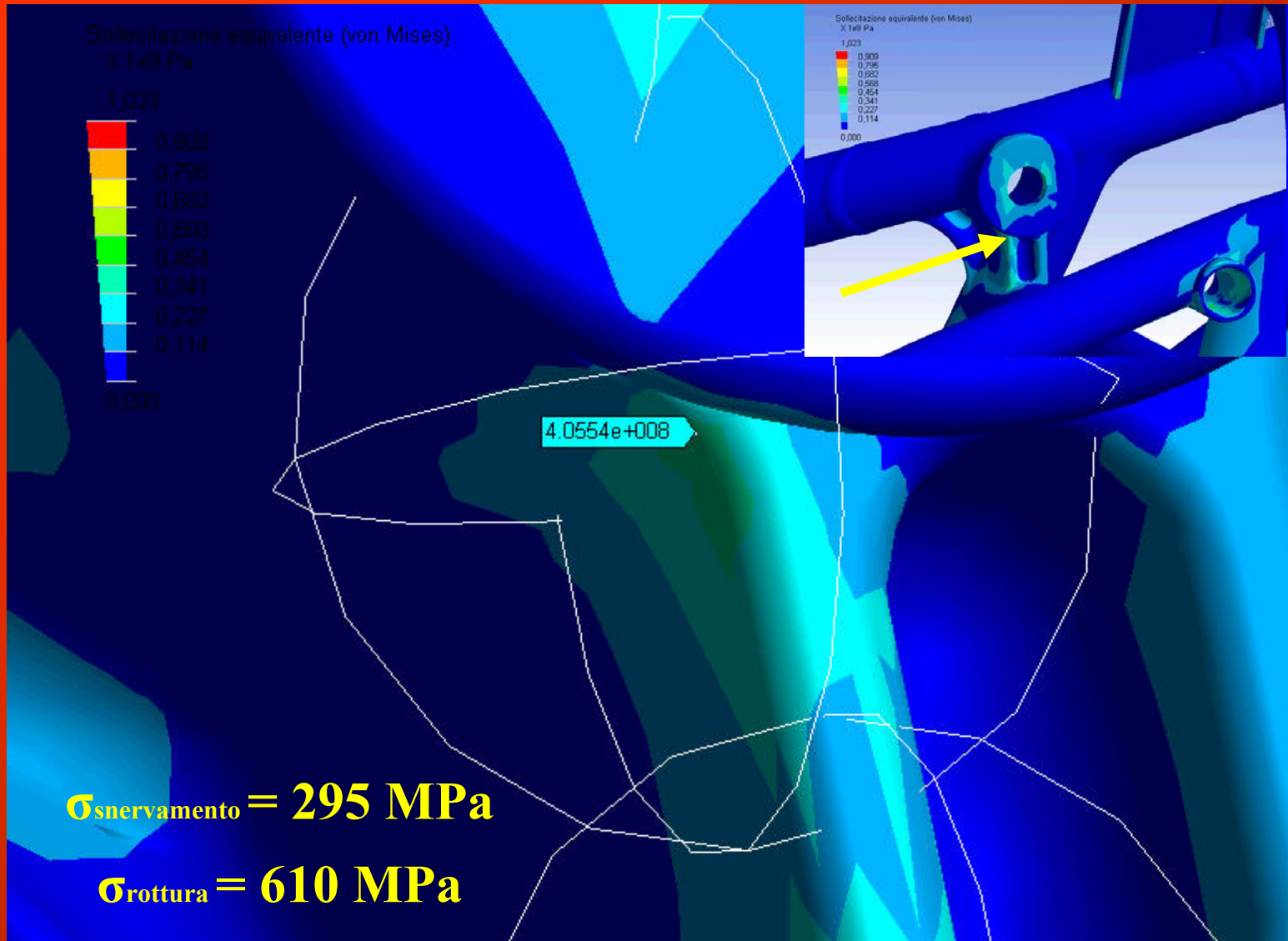
SOLLECITAZIONE EQUIVALENTE (VON MISES)



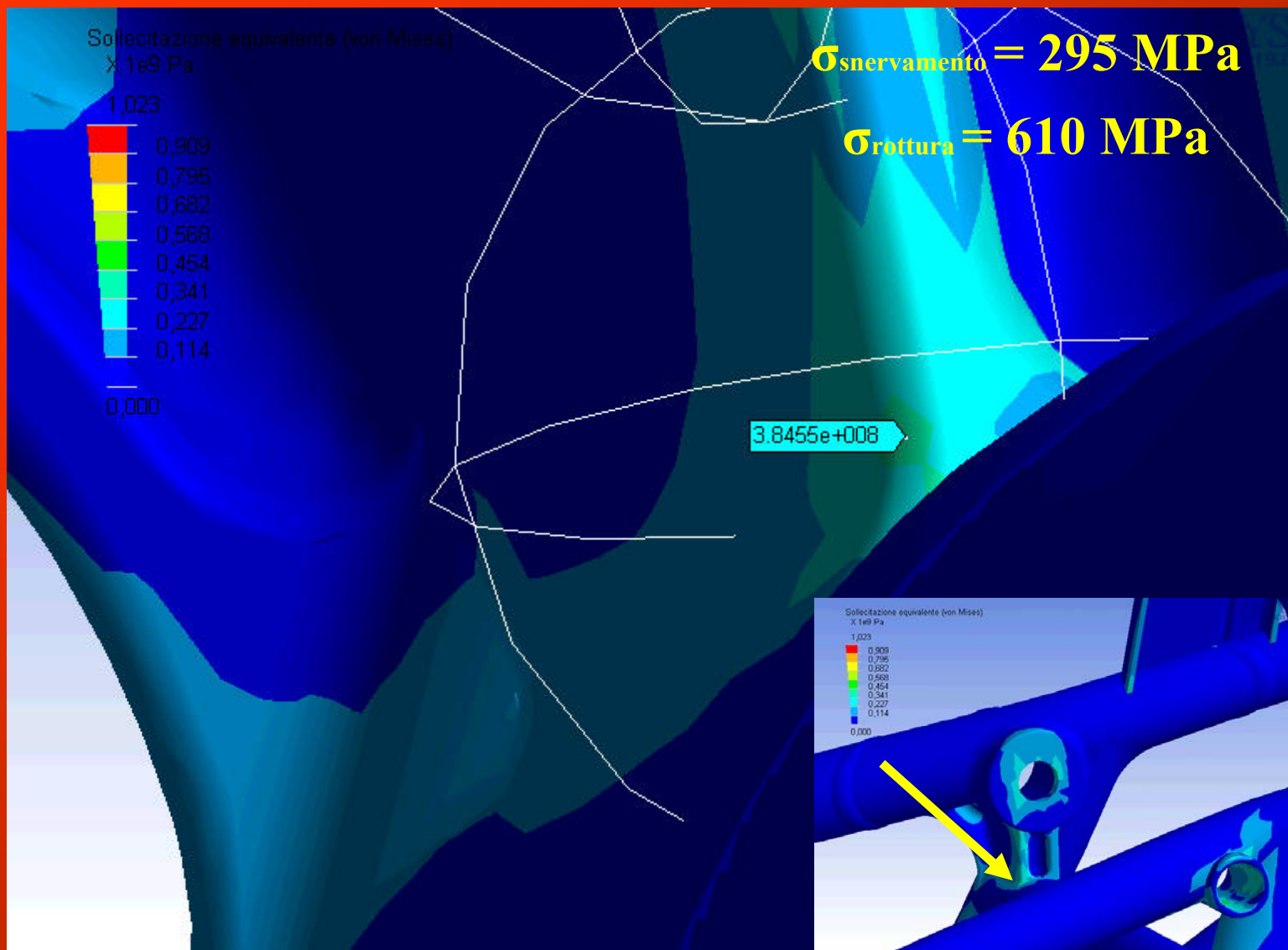
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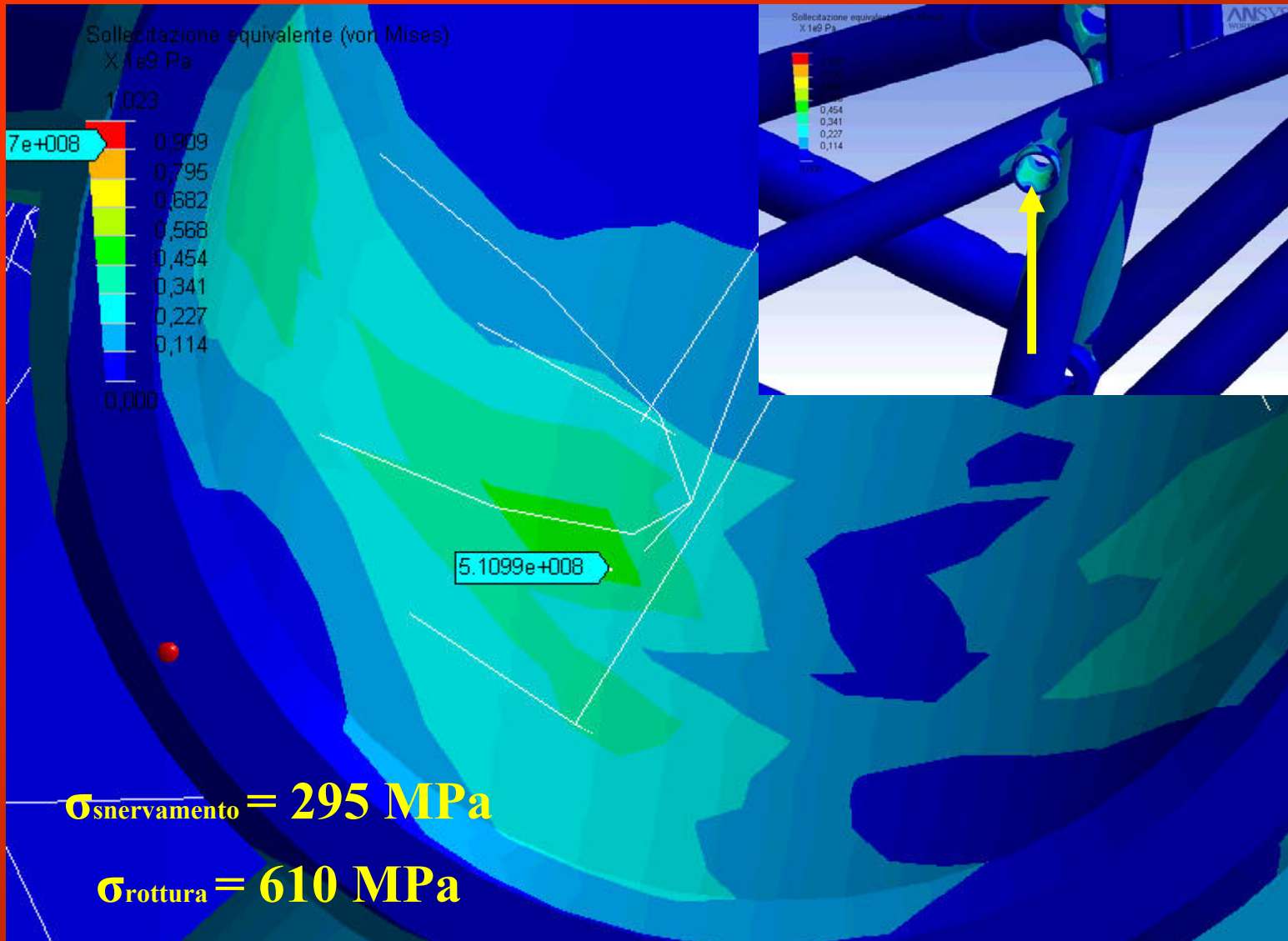
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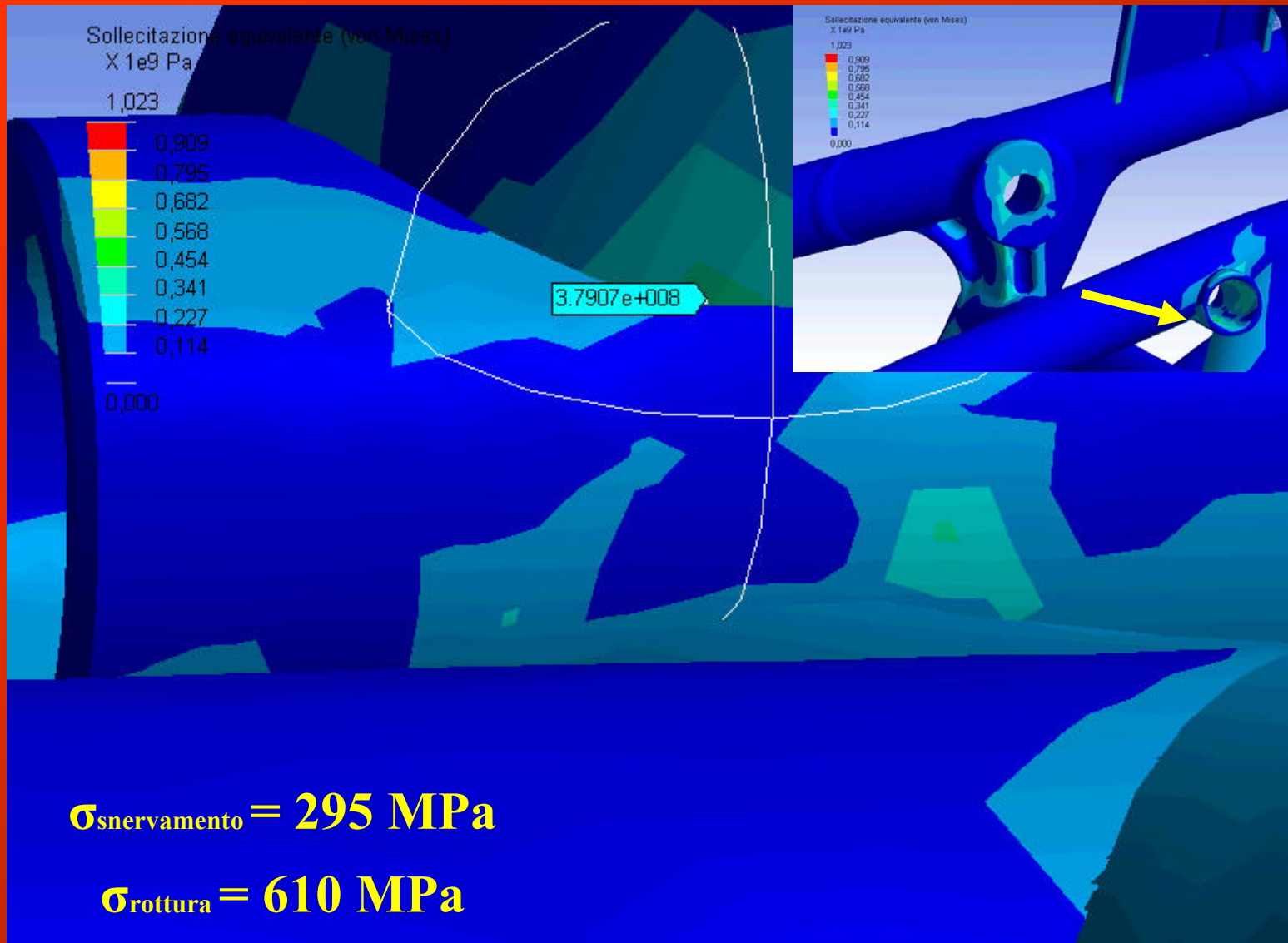
SOLLECITAZIONE EQUIVALENTE (VON MISES)

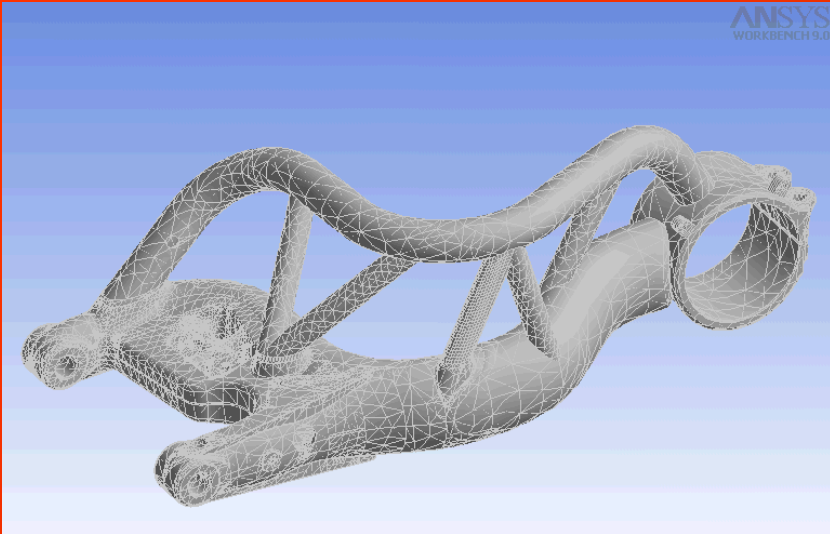


SOLLECITAZIONE EQUIVALENTE (VON MISES)

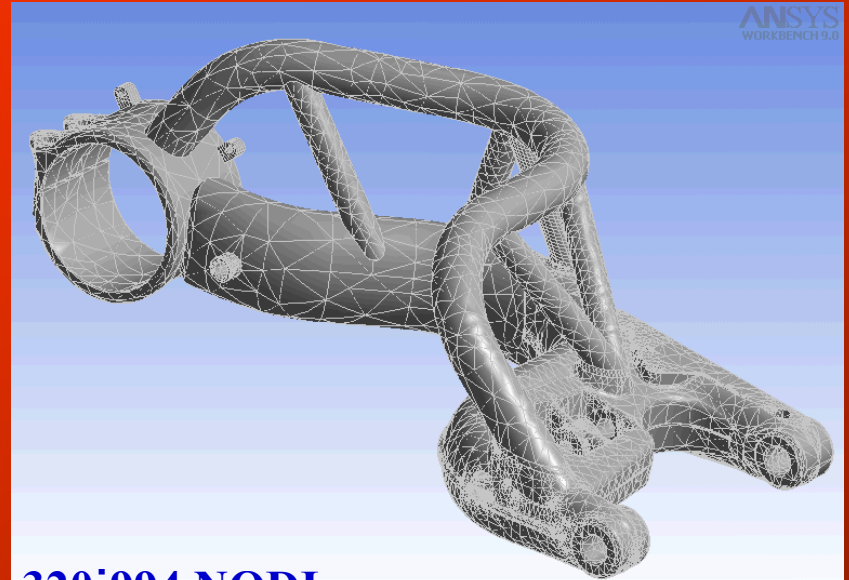


SOLLECITAZIONE EQUIVALENTE (VON MISES)

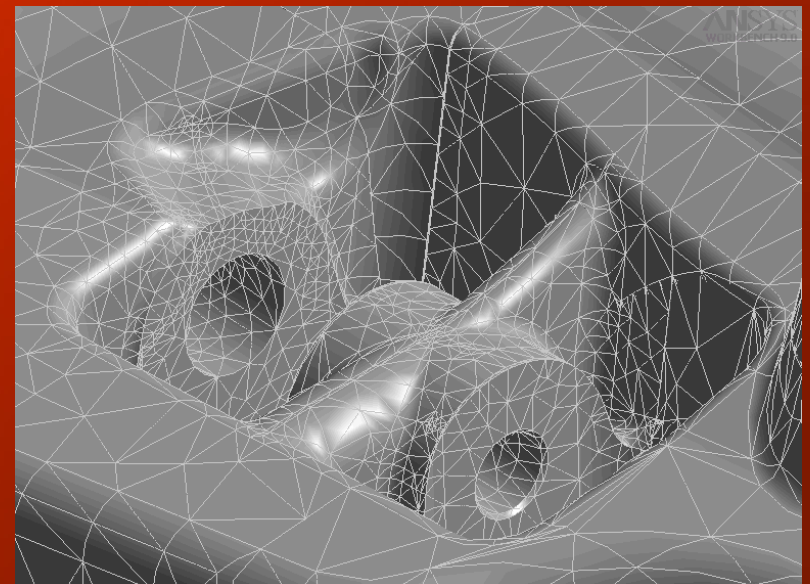
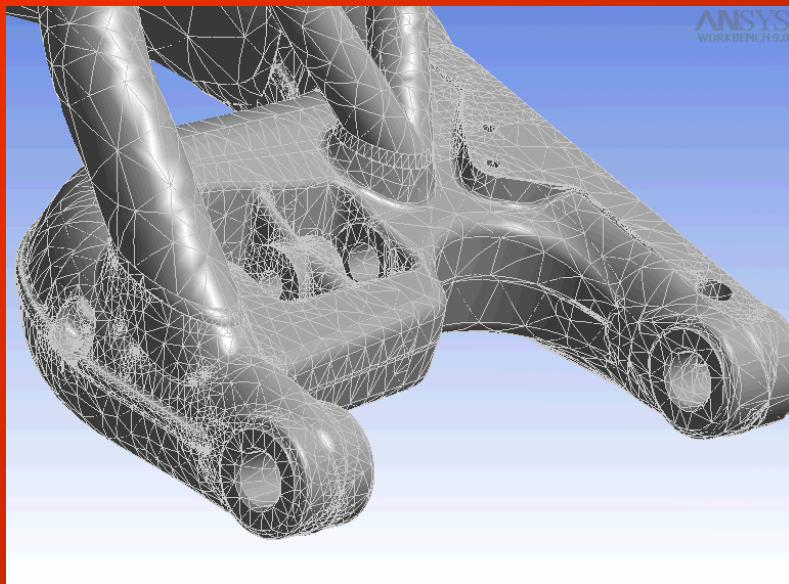


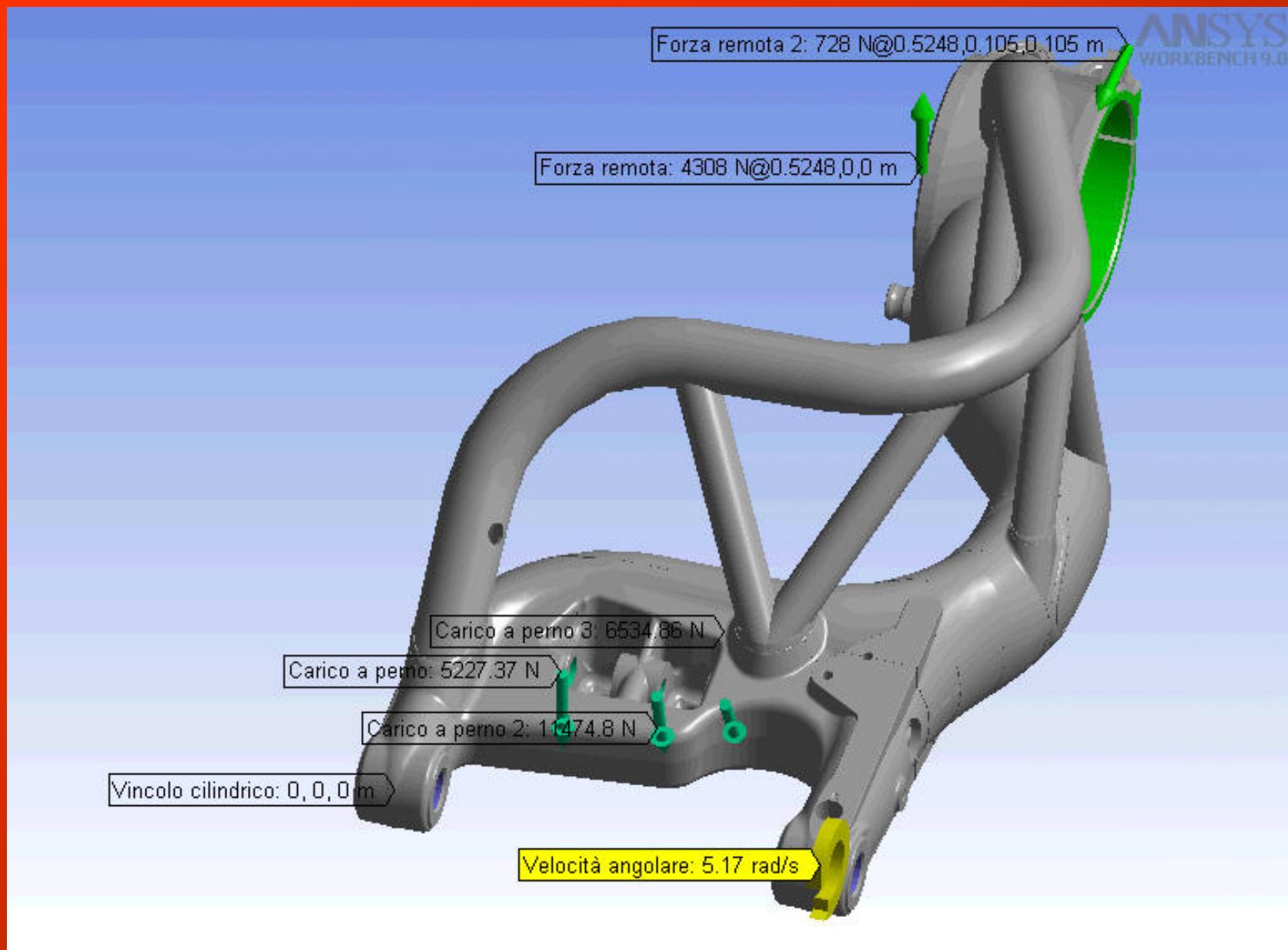


186'969 ELEMENTI

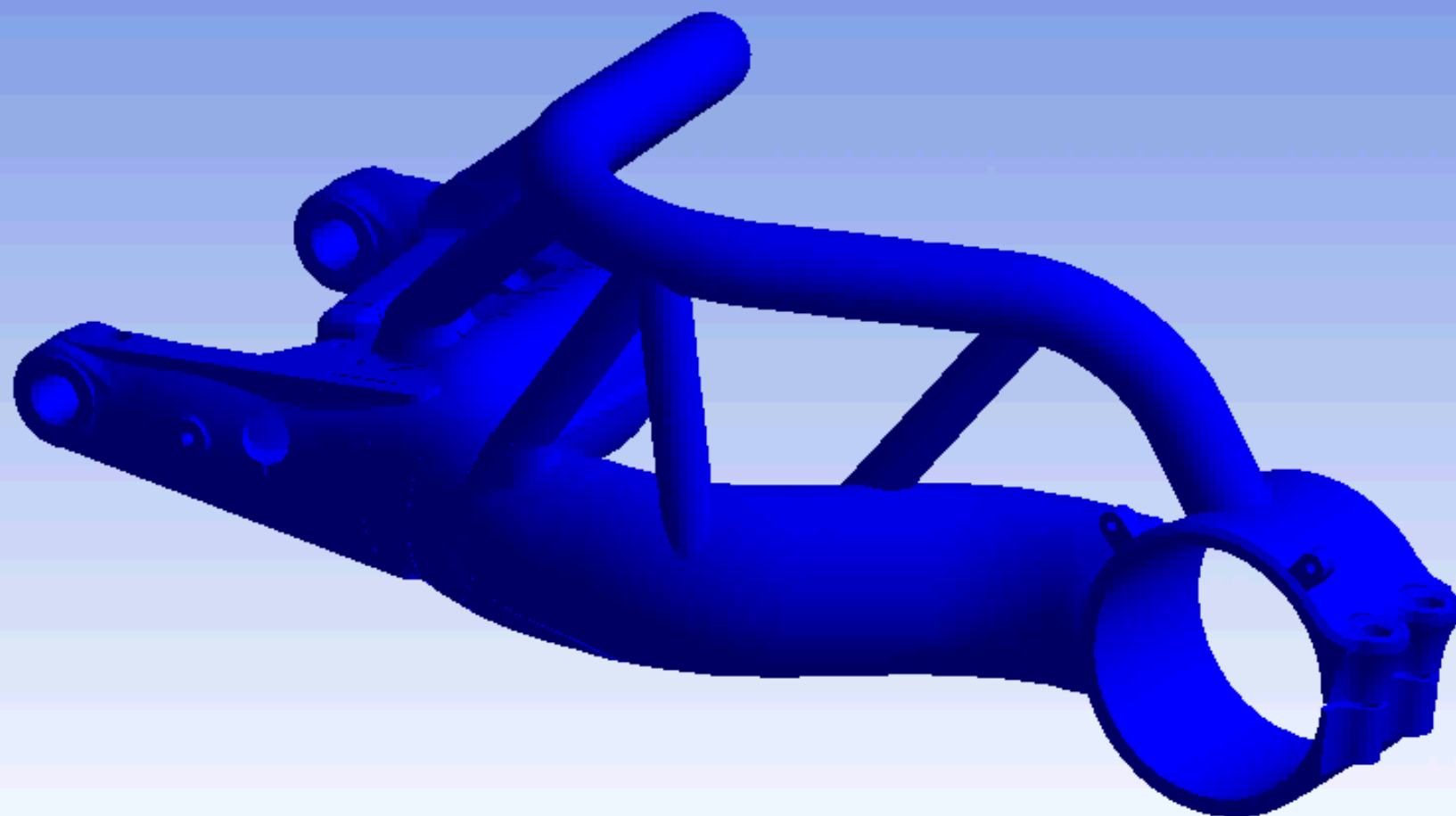


320'994 NODI

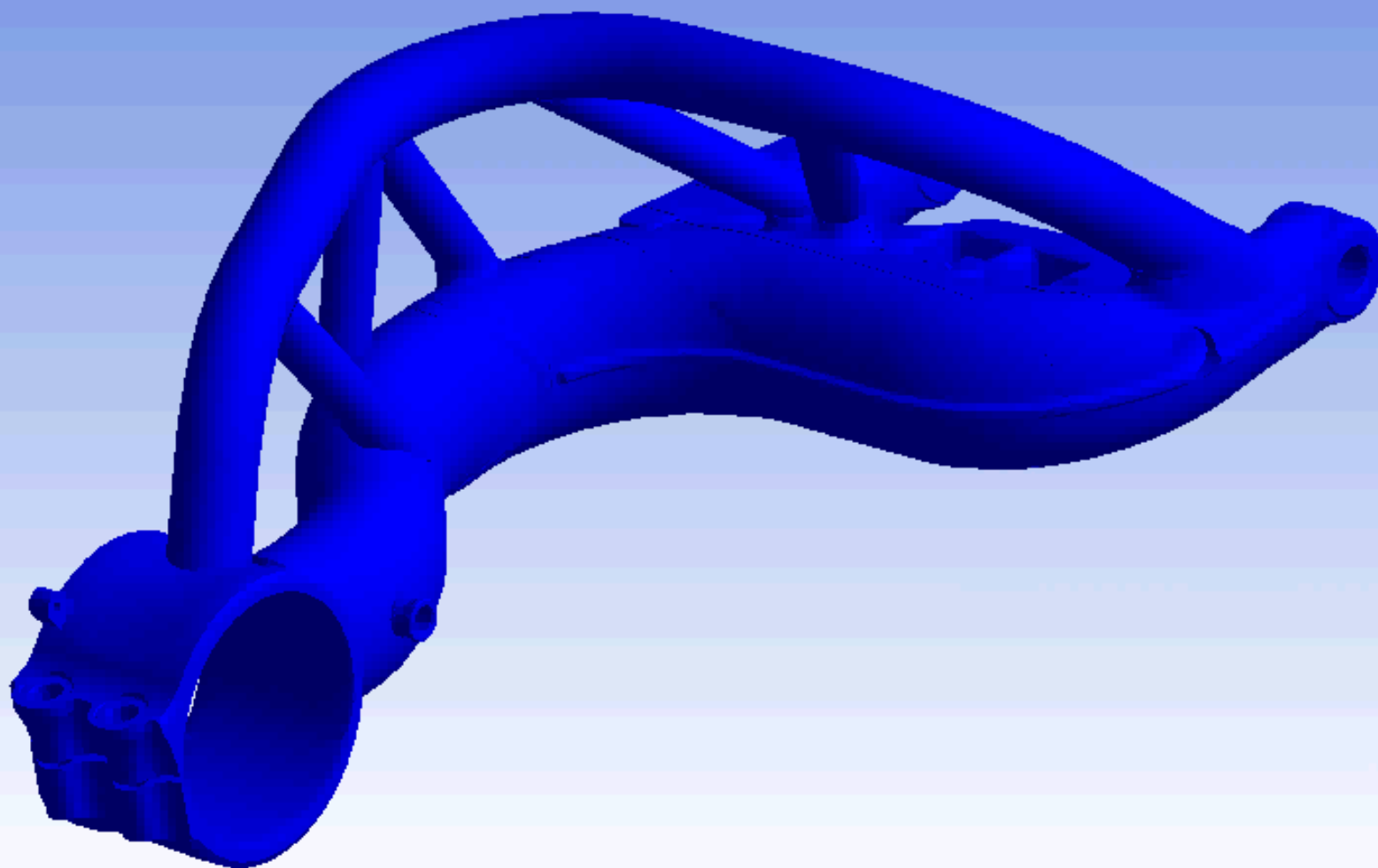




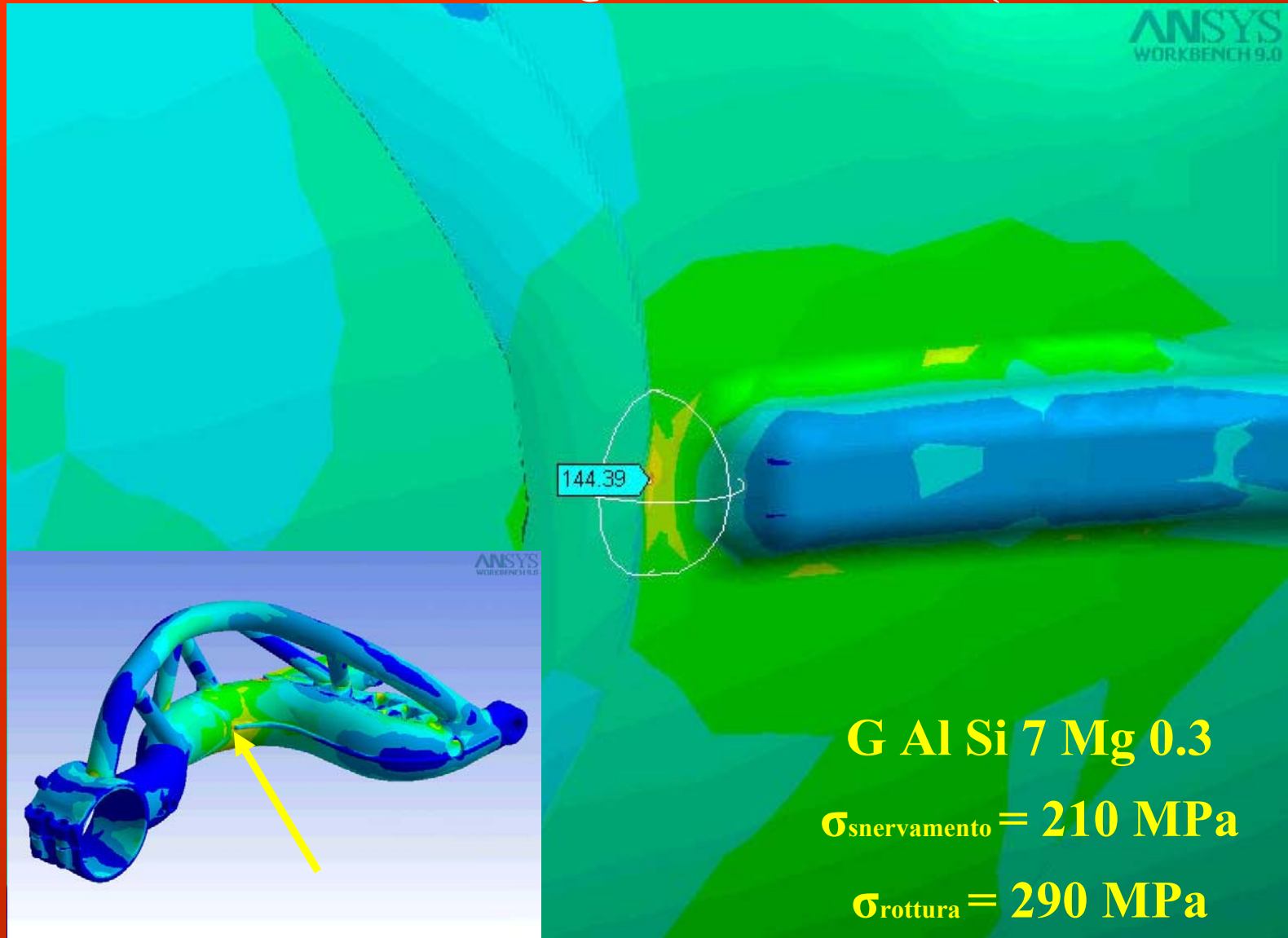
ANSYS
WORKBENCH 9.0



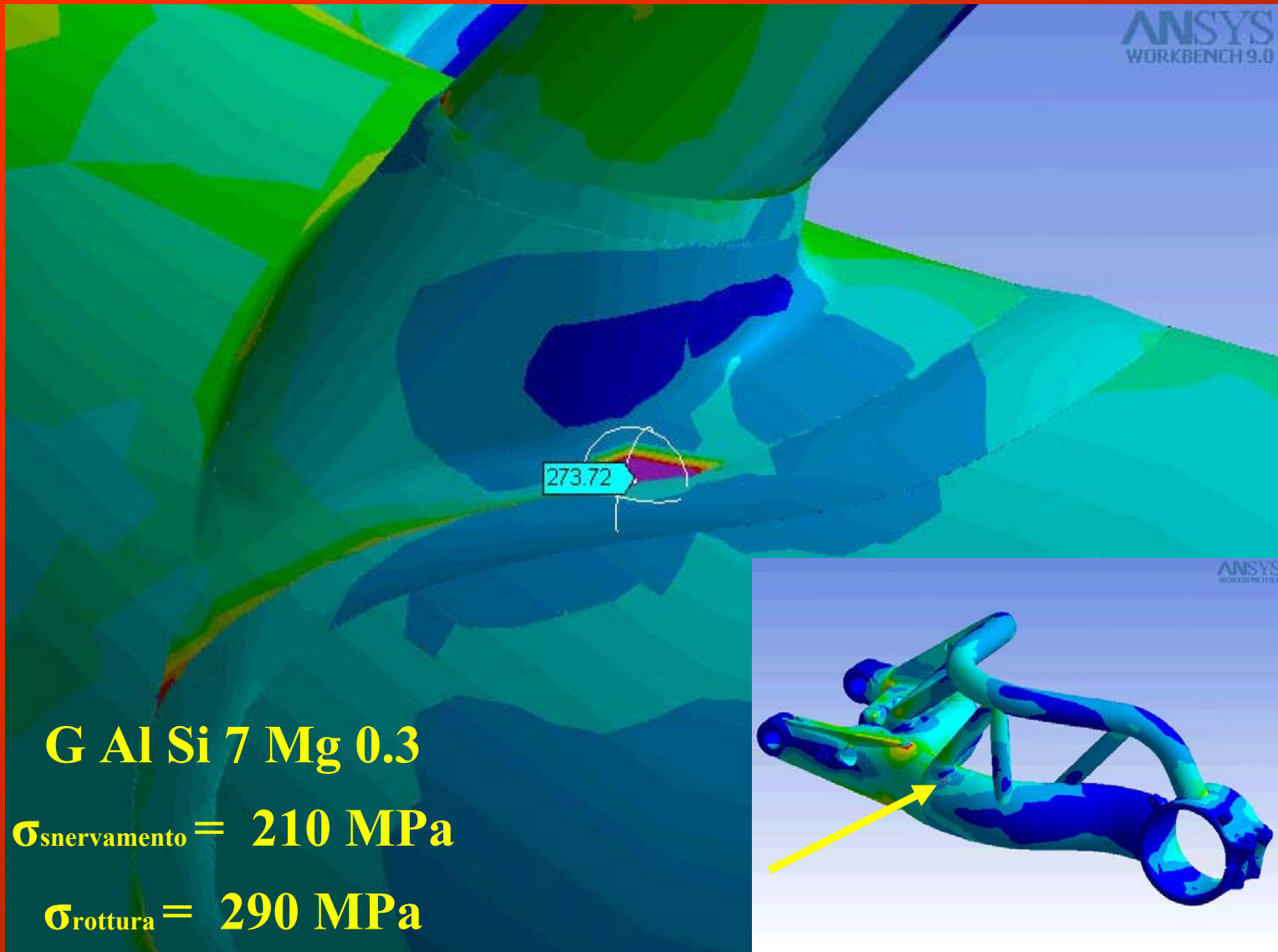
ANSYS
WORKBENCH 9.0



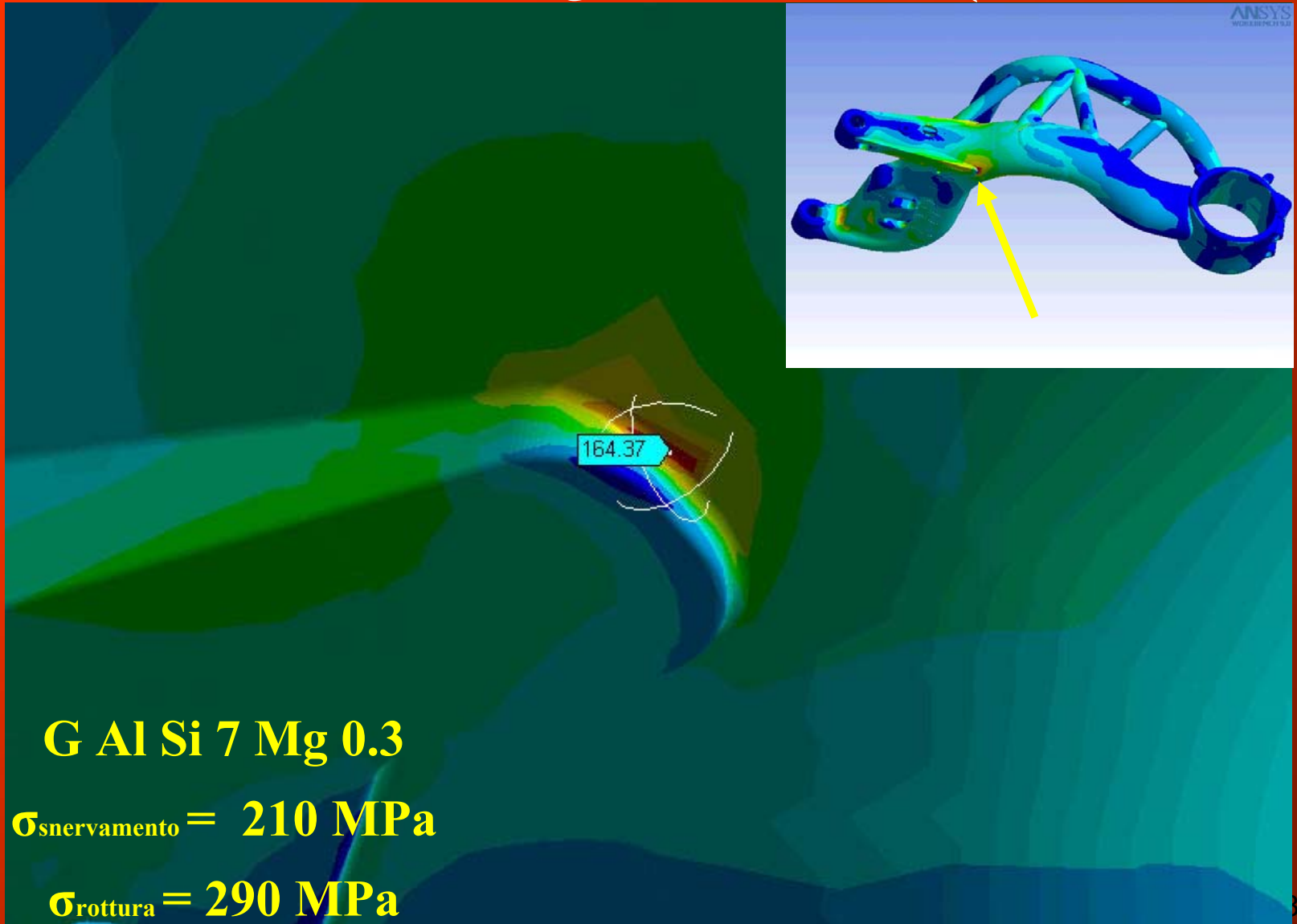
SOLLECITAZIONE EQUIVALENTE (VON MISES)



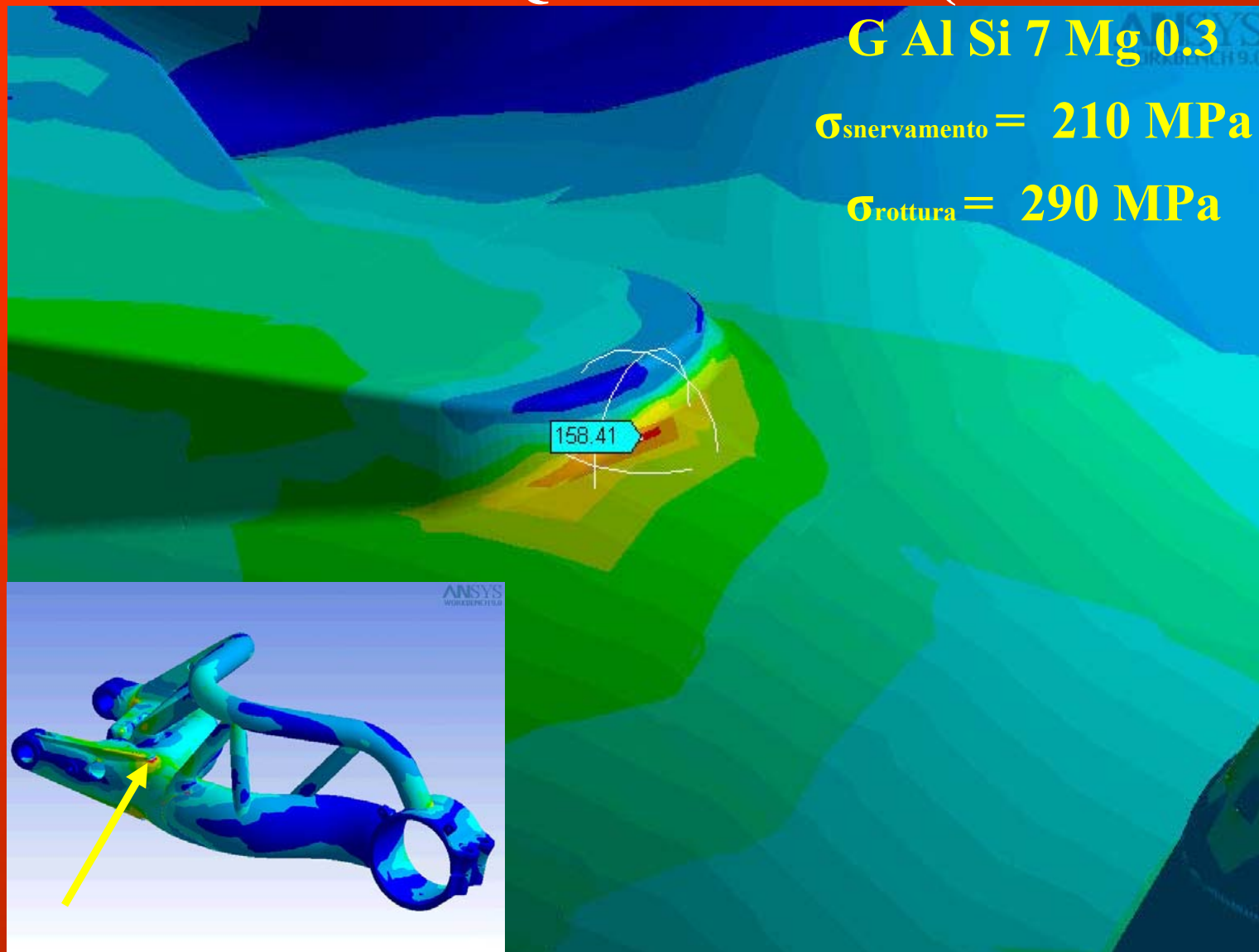
SOLLECITAZIONE EQUIVALENTE (VON MISES)



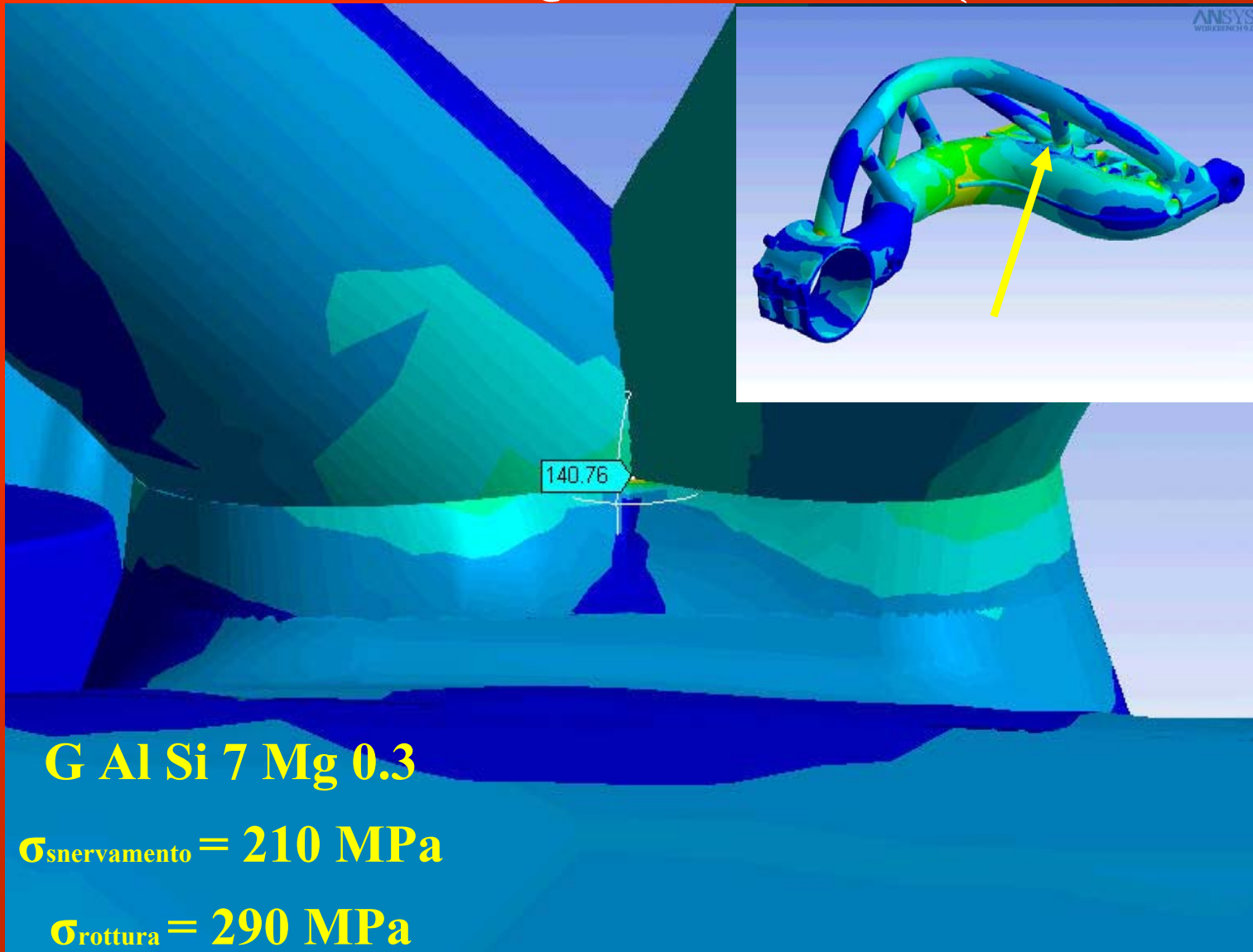
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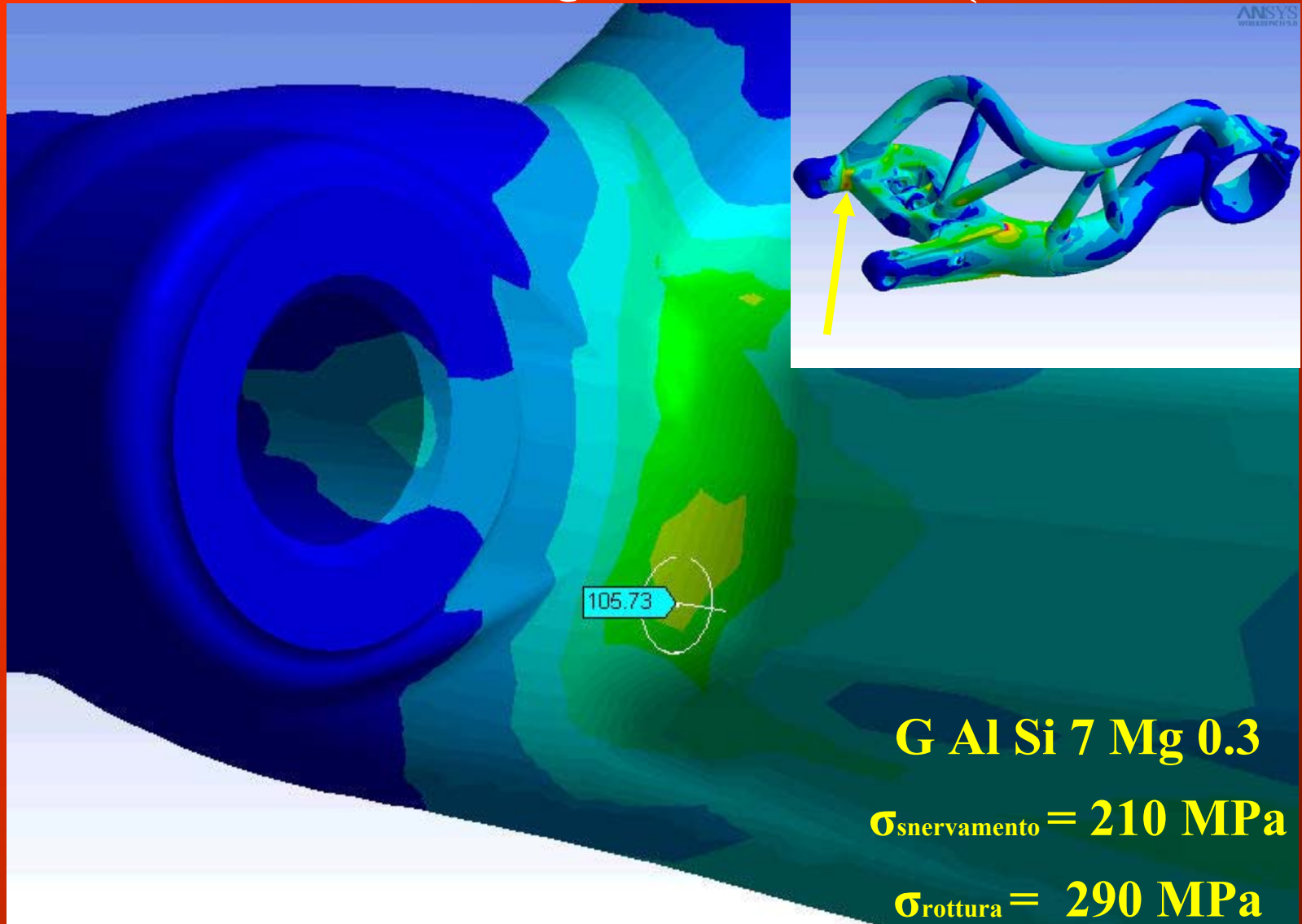
SOLLECITAZIONE EQUIVALENTE (VON MISES)



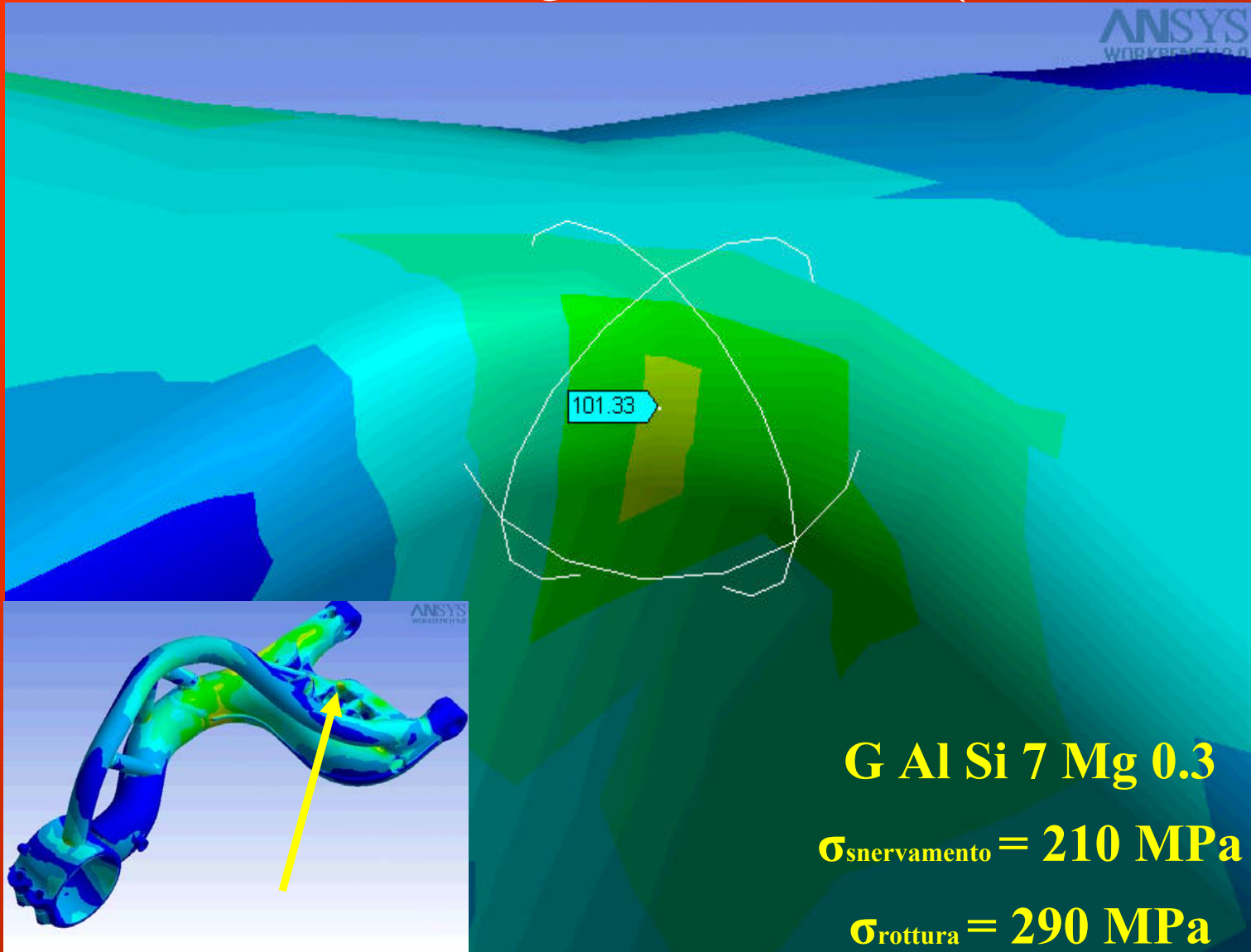
SOLLECITAZIONE EQUIVALENTE (VON MISES)



SOLLECITAZIONE EQUIVALENTE (VON MISES)



SOLLECITAZIONE EQUIVALENTE (VON MISES)

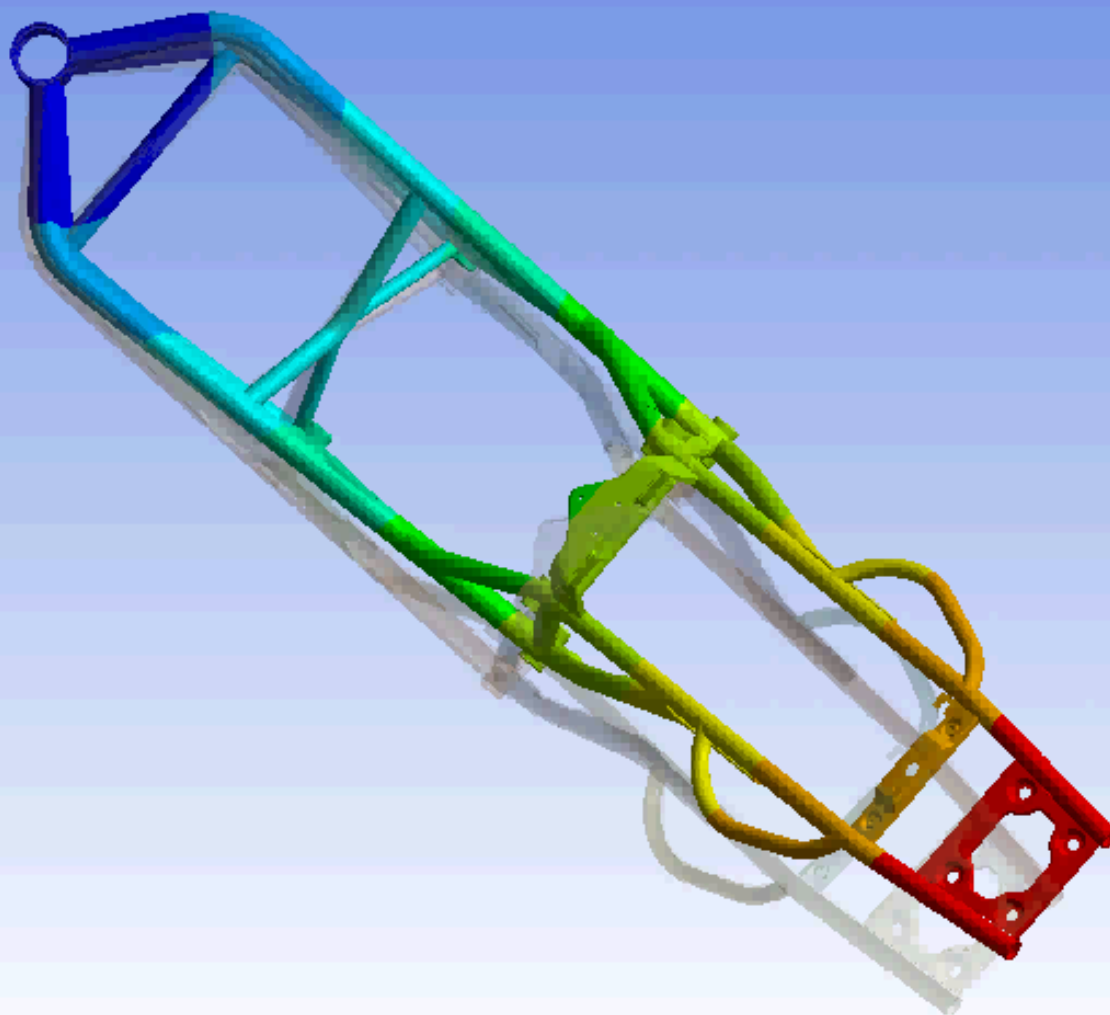
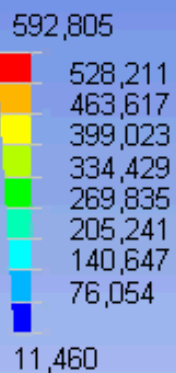




MODI DI VIBRARE DEL TELAIO

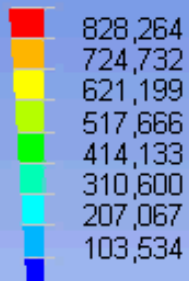


1° modo nell'intervallo (12.1879 Hz)

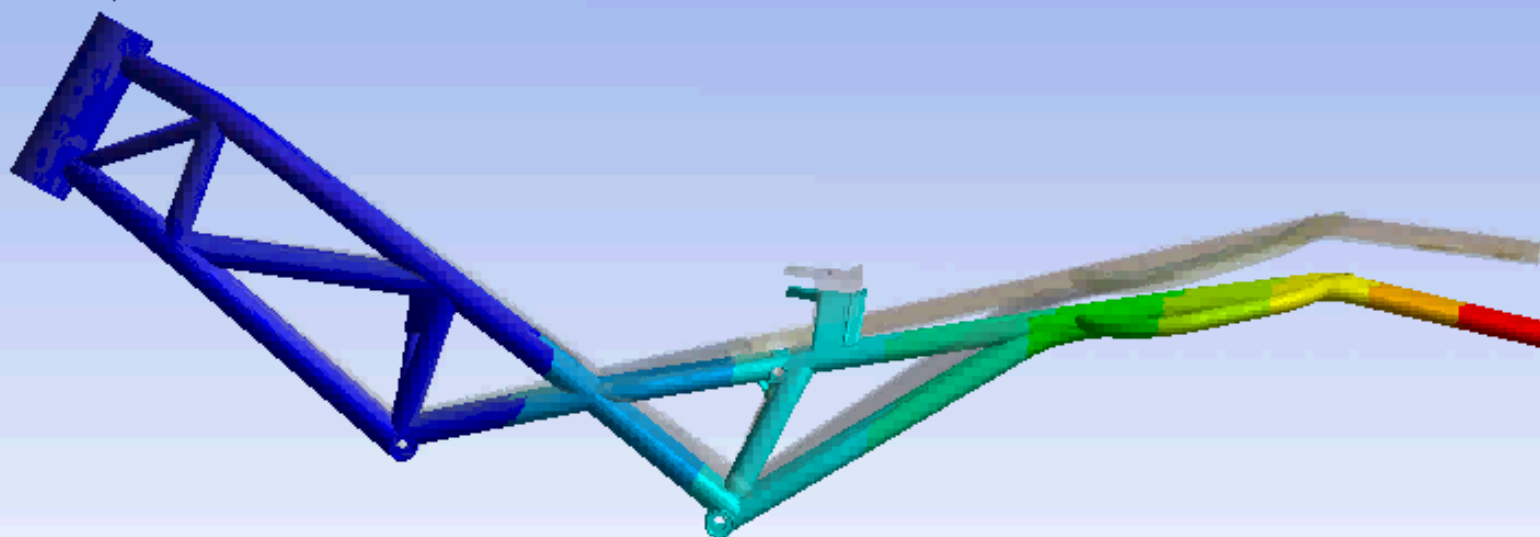


2° modo nell'intervallo (36.3408 Hz)

931,797

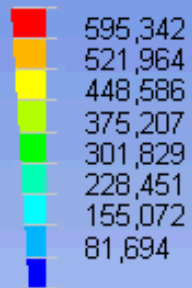


0,001

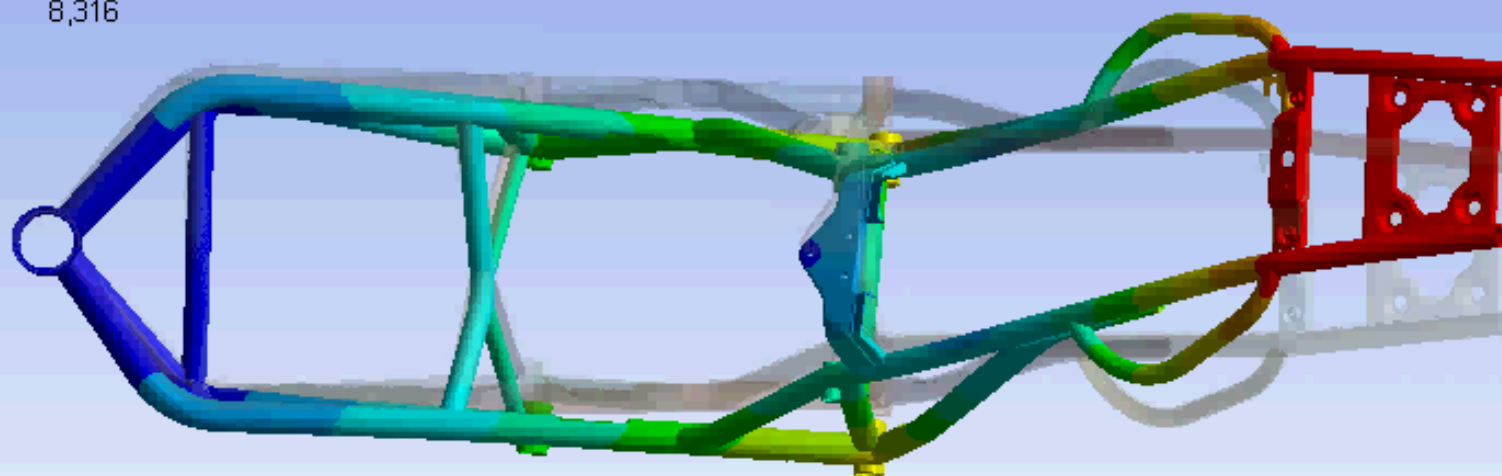


3° modo nell'intervallo (85.7443 Hz)

668,720



8,316



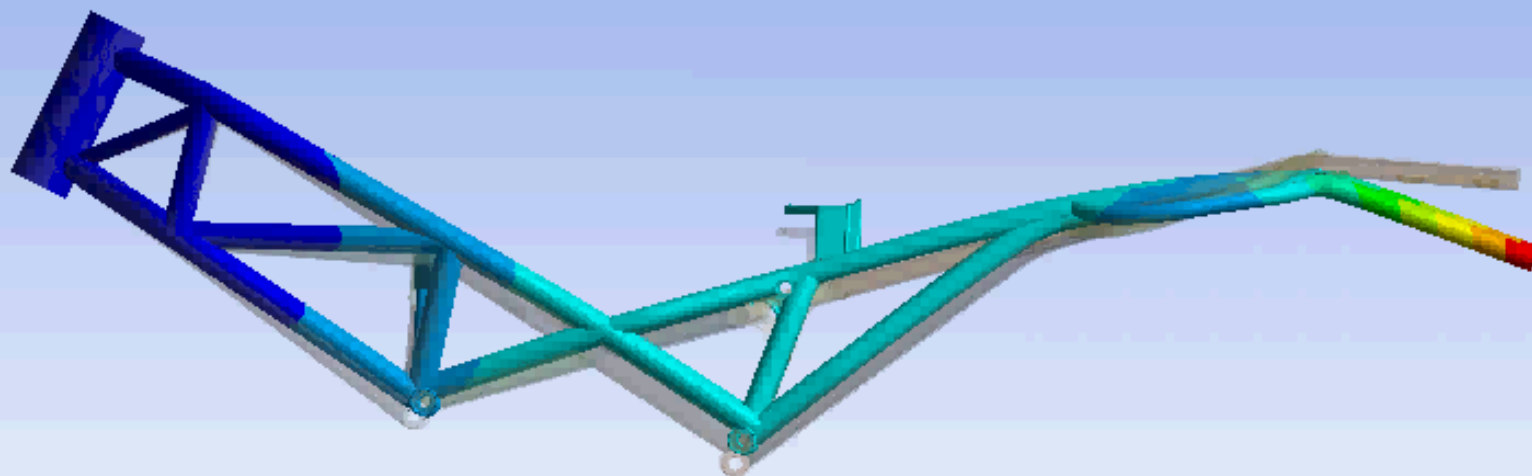
4° modo nell'intervallo (98.8894 Hz)

X 1e3

1,150



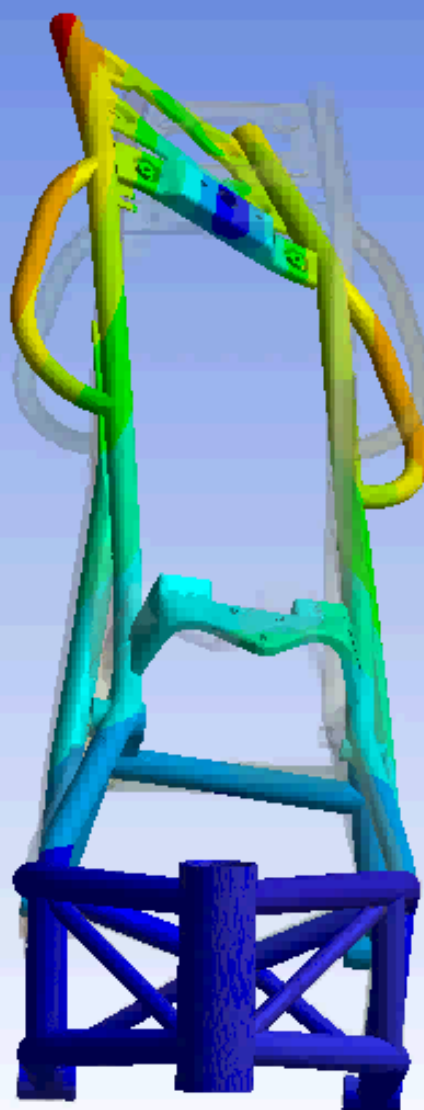
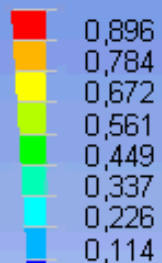
0,000



5° modo nell'intervallo (111.162 Hz)

X 1e3

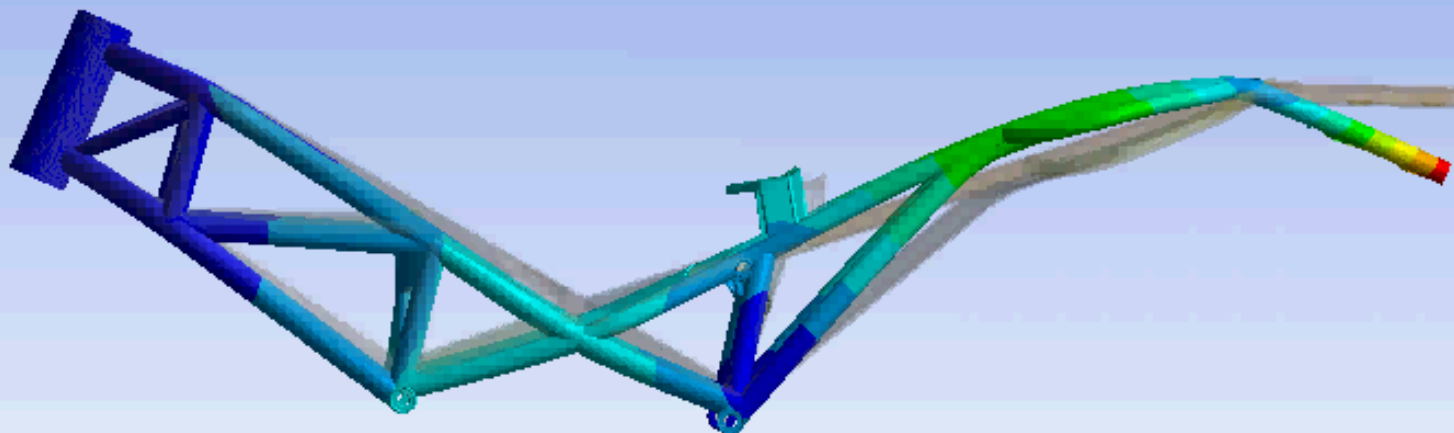
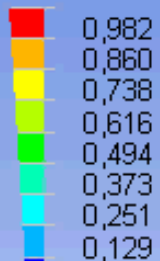
1,007



6° modo nell'intervallo (175.92 Hz)

X 1e3

1,103

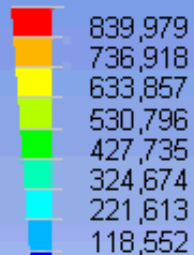




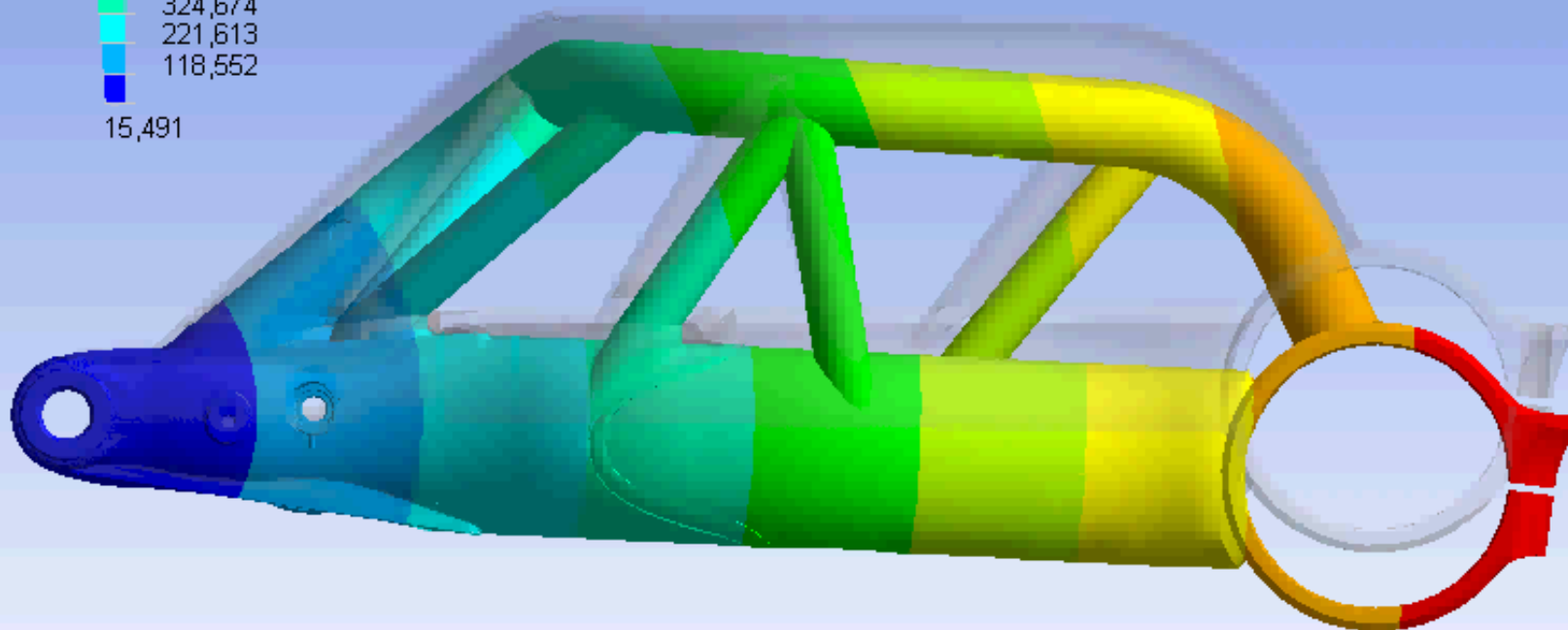
**MODI DI VIBRARE DEL
FORCELLONE**

1° modo nell'intervallo (15.4287 Hz)

943,040



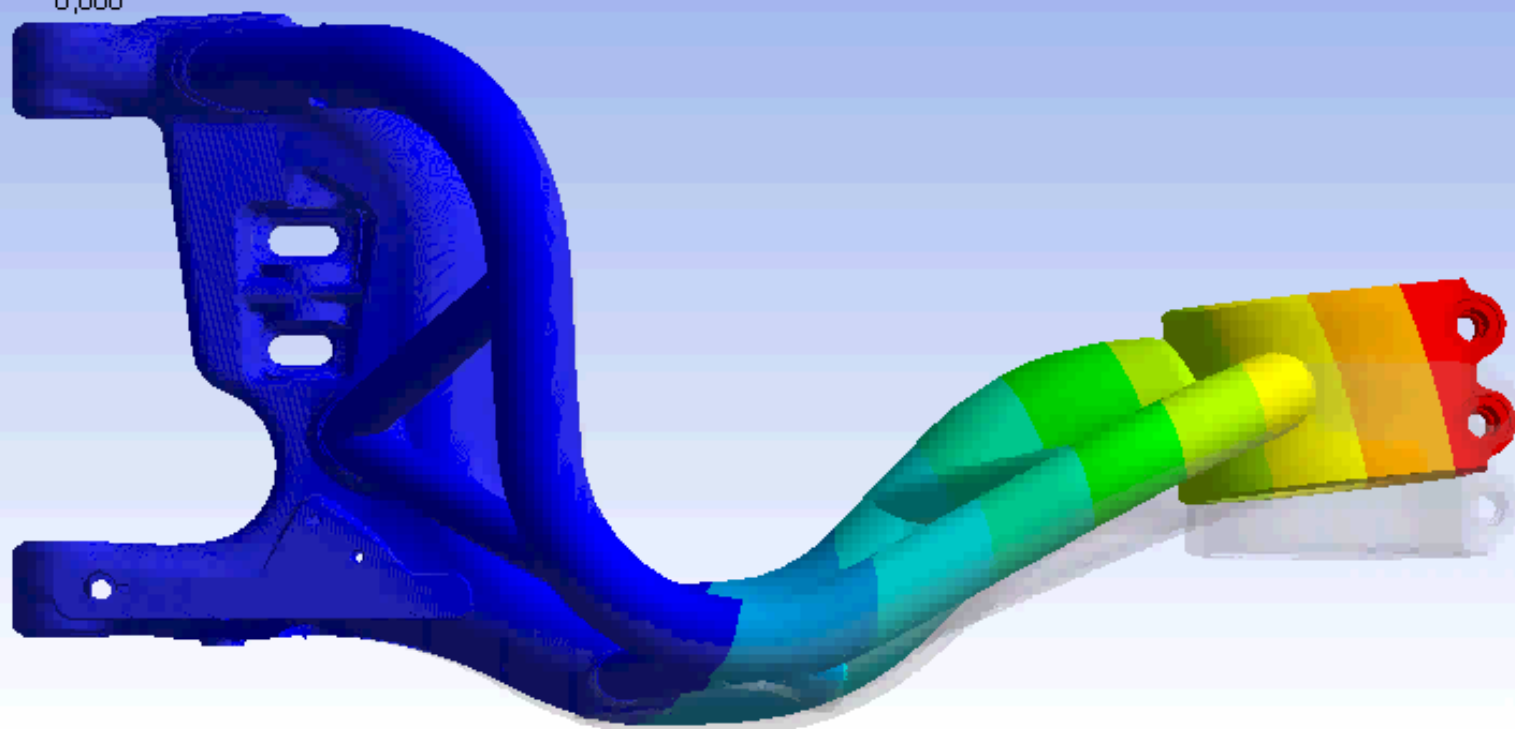
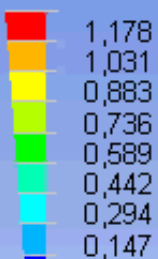
15,491



2° modo nell'intervallo (163.541 Hz)

X 1e3

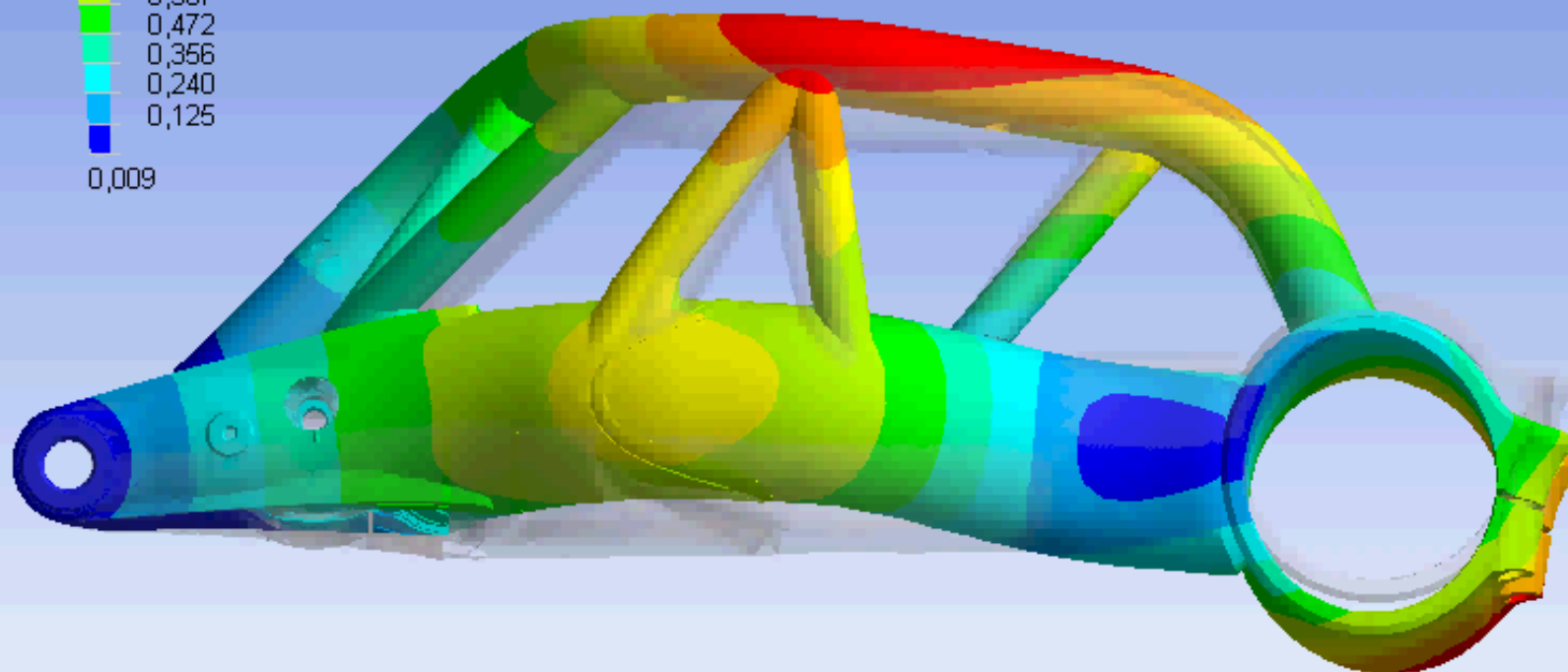
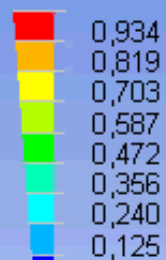
1,325



3° modo nell'intervallo (487.345 Hz)

X 1e3

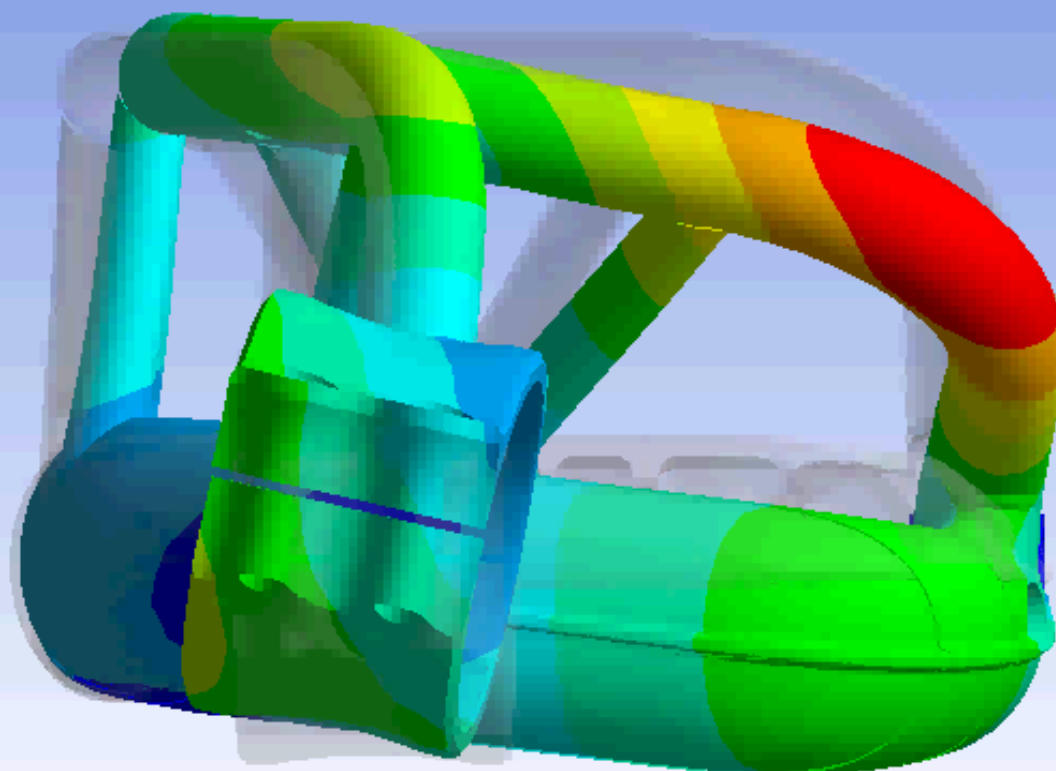
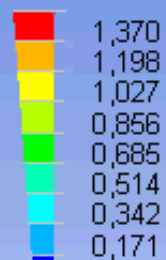
1,050



4° modo nell'intervallo (595.583 Hz)

X 1e3

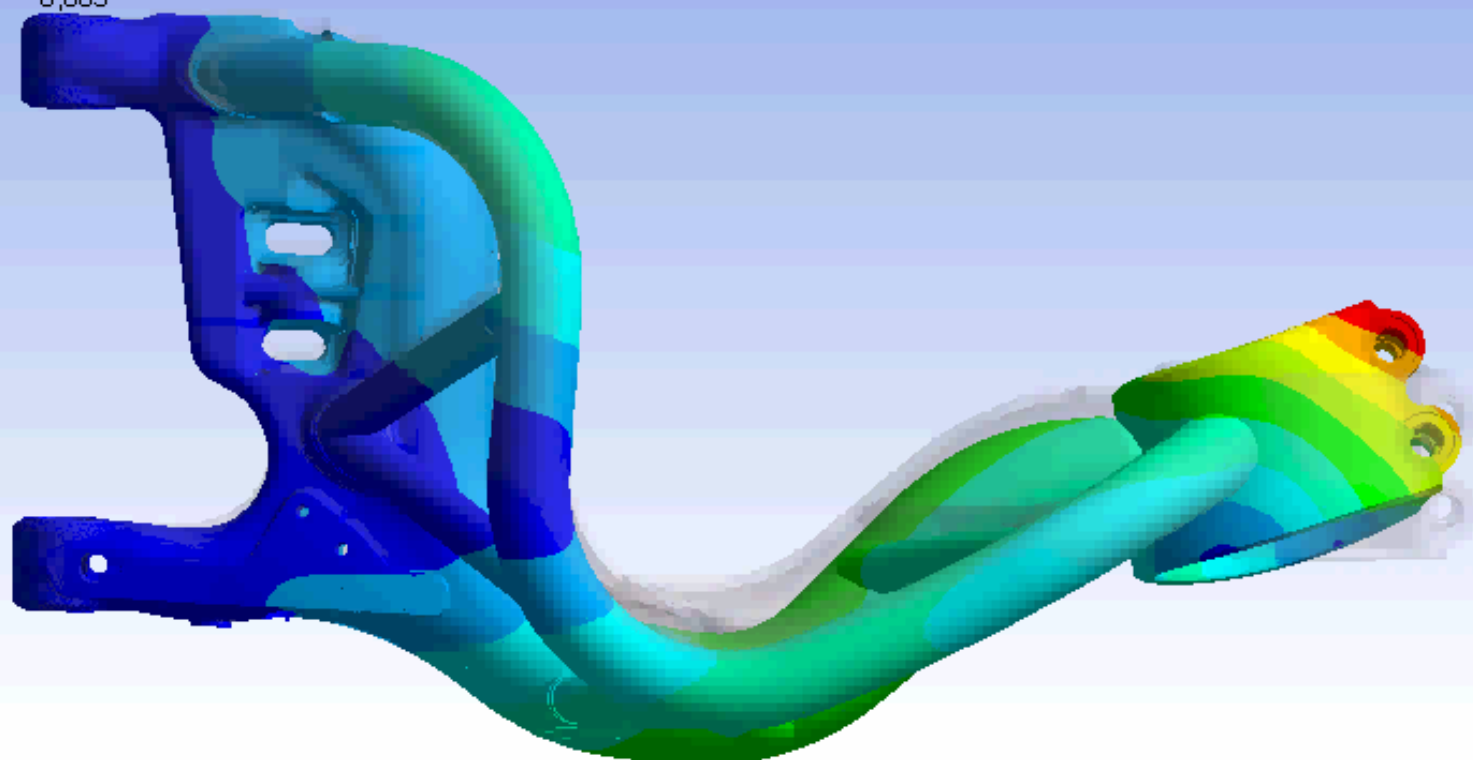
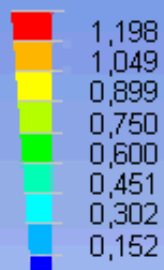
1,541



5° modo nell'intervallo (778.841 Hz)

X 1e3

1,347



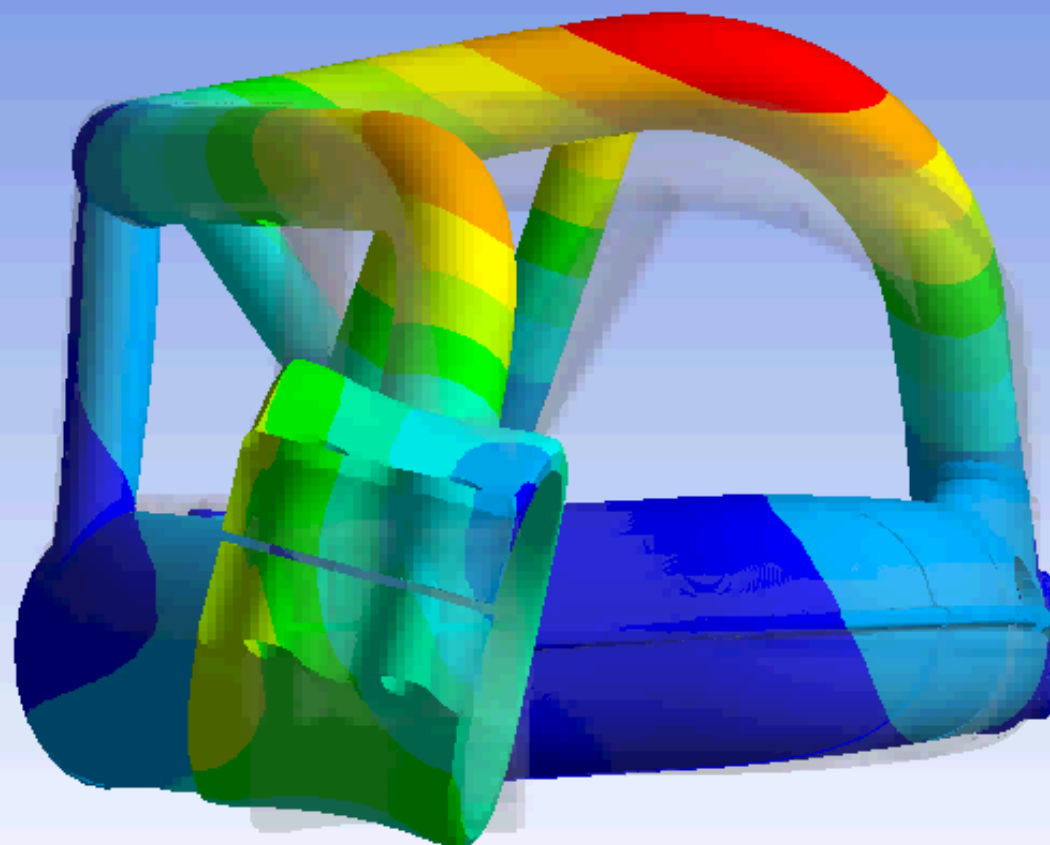
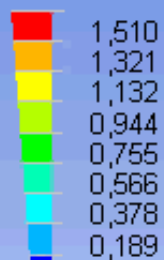
ANSYS
WORKBENCH 9.0



6° modo nell'intervallo (813.184 Hz)

X 1e3

1,698



ANSYS
WORKBENCH 9.0



RINGRAZIAMENTI

Prof BARTOLOZZI Giorgio

Prof PIANCASTELLI Luca

Ing CASSANI Stefano

Dir Produz Veicolo Ducati Ing FORNI Andrea

Dir Reparto Esperienze Ing GESI Andrea

**Tutto la Staff di Ingegneri e Tecnici del Reparto
Esperienze Veicolo Ducati**

Il Driver CONCORDIA Mario

