RENAULT
La vie, avec passion

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Section Extraction from Numerical Simulations of Proving Ground Data

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Agenda

1. Introduction
2. "OK-Measure" development with nCode
3. Numerical simulation quality control
4. Conclusion

Intro to François QUIN, Project Leader in numerical simulation for reliability & durability at Renault Group

- Graduated both in Mathematics and Physics, I have been asked to accelerate numerical transformation of tests for vehicle reliability and durability for Renault Group.

  - RENAULT GROUP provide 6 brands worldwide for 3,8 million vehicles in 2019.
  - Vehicle Test Department is responsible for global vehicle validation except Power Unit internal management.
  - Reliability & Durability Service provides on-bench endurance result and proving ground records.

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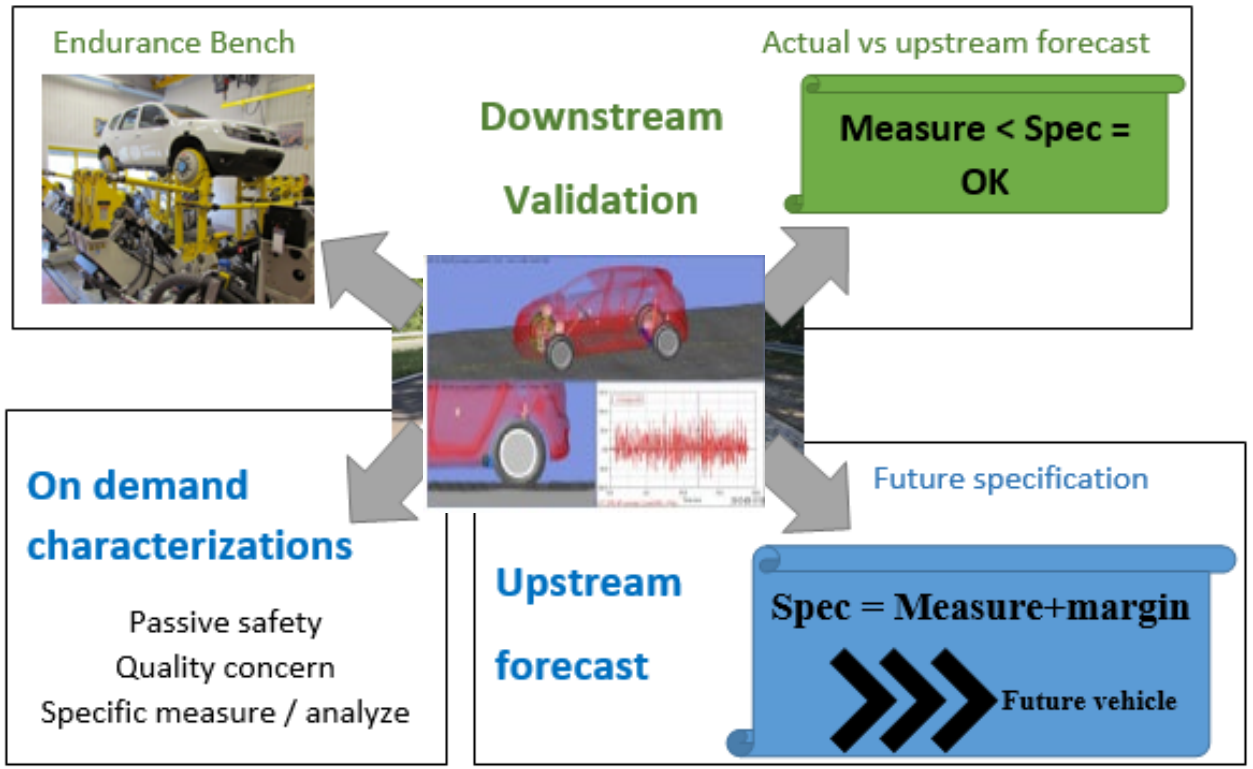
Quality for Numerical Simulation Project

- 25 years ago, Renault shifted from full on-ground driving durability validation to on-bench simulation with on-ground measurement. From months of driving on proving grounds we've kept only few hours to acquire signals to repeat on benches.

- Now Renault progressively frees itself from ground to go to the cloud, replacing measurement by numerical simulation of driving.

- **Once OCM (OK-Measure) had ensured physical measurement quality, we've been asked to extend the use of automated quality check to numerical simulation.**



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Summary

Challenge

Users were both asking for fast deployment, easy evolution and strong maintainability.

A good example is given by new needs brought by numerical simulation that come along with several computing-related troubles we hadn't heard before in Proving Ground Measurement teams.

Solution

We've firstly done a fast development with ready-to-use glyphs from nCode.

Once functional design has been fully validated by some months of use, we processed to change internal methods to a more easy-to-maintain solution with explicit and commented python code combined with nCode glyphs.

Benefit

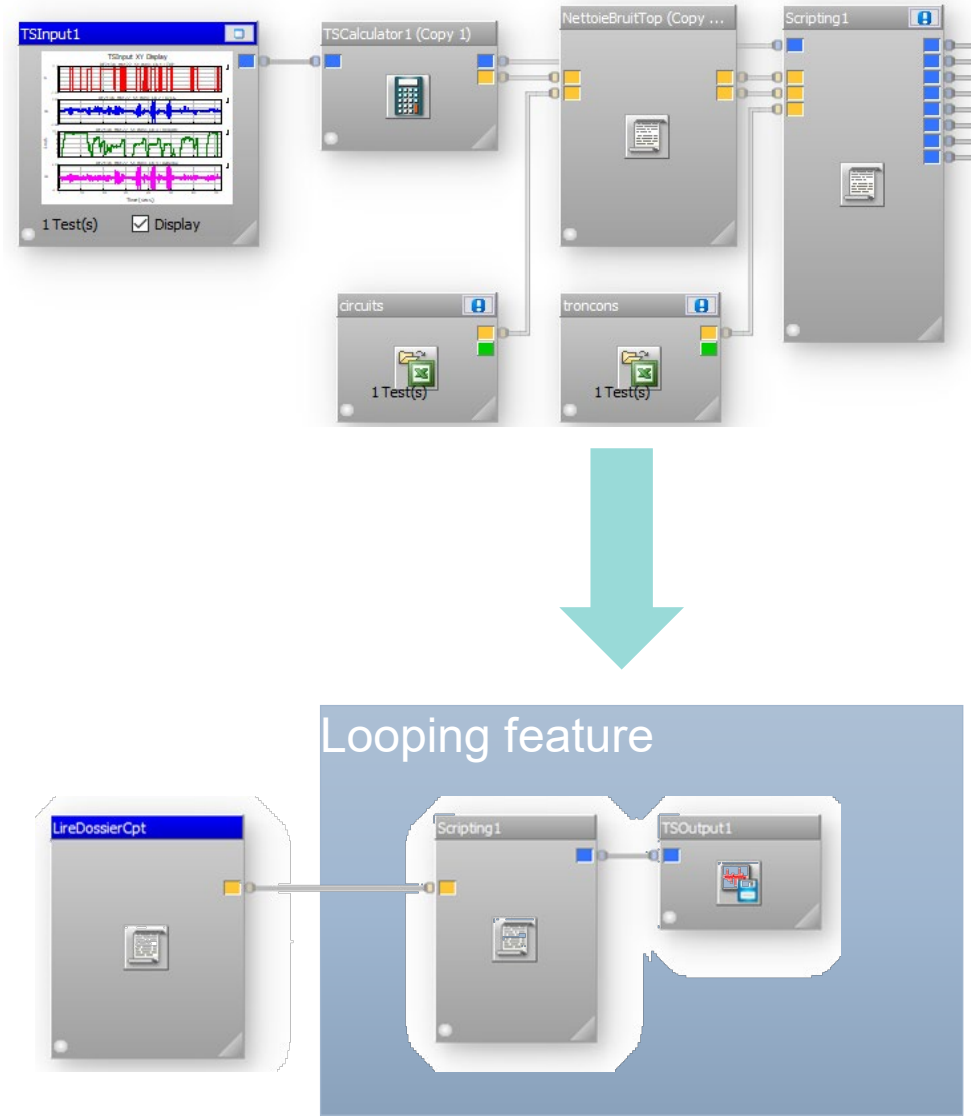
It gave to measurement team a good reputation in several services which align themselves (some of them have done, some are still ongoing) to our methods and standard to profit from OK-M quality tool.

For example, numerical simulation team were requested to adopt our signal naming and unit standards to be enabled in bench feeding.

Using nCode GlyphWorks for OK-M

- We've made the OK-M system very easy to adapt by using human-readable excel files and maintainable due to python scripting.

- It was a first step of development we've gone through and today we're able to use more integrated scripting using CSV files.

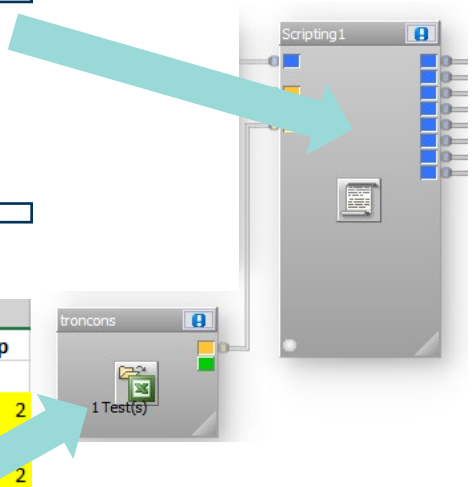


From simple xls to data-based xls on csv

0 excel-input whatever would be the numer of excel files to load

- At first, we've set an Excel-Input glyph and two standards lines of code to get a table with all data about sections.

```
6   circuits = es.GetInputMultiColumn(1)
7
8
9
10
11
12
13
14
15
16
17  ListeCircuits = circuits.GetTable(0,0)
```



	C	E	F	G
1	troncon	numTOPS1	timeTroncon	PretrigTop
2	string	double	double	Double
3	1ch	1	12	2
4	1pl	5	27	
5	1ger	6	7	2
6	1be	8	23	2
7	1fr	11	23	2
8	1es	14	23	2
9	1gb	15	7	2
10	1ne	16	10	2

- It's fast and understandable for few inputs

- We went to two files : one formatted xls referring to one python-readable csv.

Formated xls ***calling*** *csv database*

	C	E	F	G
1	troncon	numTOPS1	timeTroncon	PretrigTop
2	string	double	double	Double
3	1ch	1	12	
4	1pl	='Circuits_tr	27	
5	1ger	oncons -	7	
6	1be	adaptated -	23	
7	1fr	data.csv'!E4	23	
8	1es	14	23	
9	1gb	15	7	
10	1ne	16	10	
11	2psud	1	12	
12	2pv	15	27	
13	2bds	6	7	

	C	E	F	G
1	troncon	numTOPS1	timeTroncon	PretrigTop
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8	1es	14	23	
9	1gb	15	7	
10	1ne	16	10	
11	2psud	1	12	
12	2pv	15	27	
13	2bds	6	7	

- And 5 times more code, fitted to data

```
46    troncon.append(open(monRepertoire + '/' + fichiers[i], 'r').readlines()[6:])
47
48  # gestion de la non rededondance parfois de la lere ligne d'adams
49  Longueur = len(troncon[0])
50  for i in range(len(fichiers)):
51     Variable = len(troncon[i])
52     if Variable < Longueur :
53        Longueur = Variable
54
55  #Jonction des donnees en un seul tableau (fusion a t constant puis decoupe de chaque ligne)
56  Concat = []
57  for j in range(Longueur):
58  #  for j in range(len(troncon[0])):
59     Concat.append("")
60     for i in range(len(troncon)):
61        Concat[j] = Concat[j] + troncon[i][j]
62     Concat[j] = Concat[j].split()
```


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From simple xls to data-based xls on csv

Benefits of progressive development

- First implementation very easy to adapt during program development with glyph-based-language.
- ***Progressive transferring to python code with simultaneous support of these features by nCode and its ability to link them.***

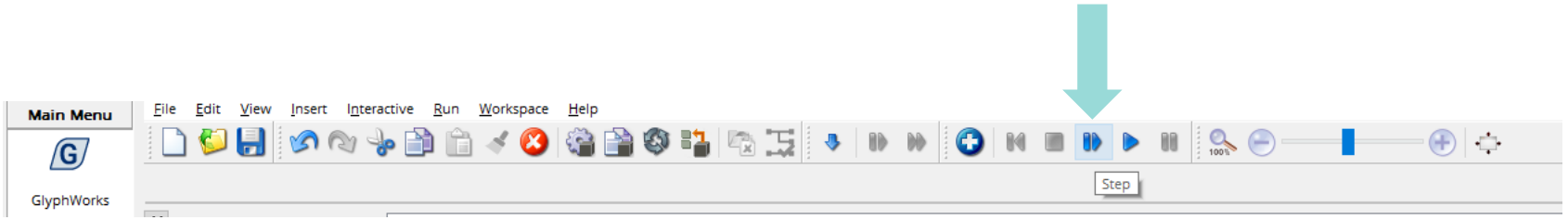
Benefits of python scripting solution

- Simpler process view gathering all functions in code with 0 “excel-input” glyph whatever would be the number of excel files to load.
- Possible to isolate the load function as a subfunction called wherever you want with single line.
- Between 2 and 5 seconds for each avoided Excel-Input.

From direct execution to looping

- For treatment development purpose, glyphs are very easy-to-use and it gives you a clear view of each steps.

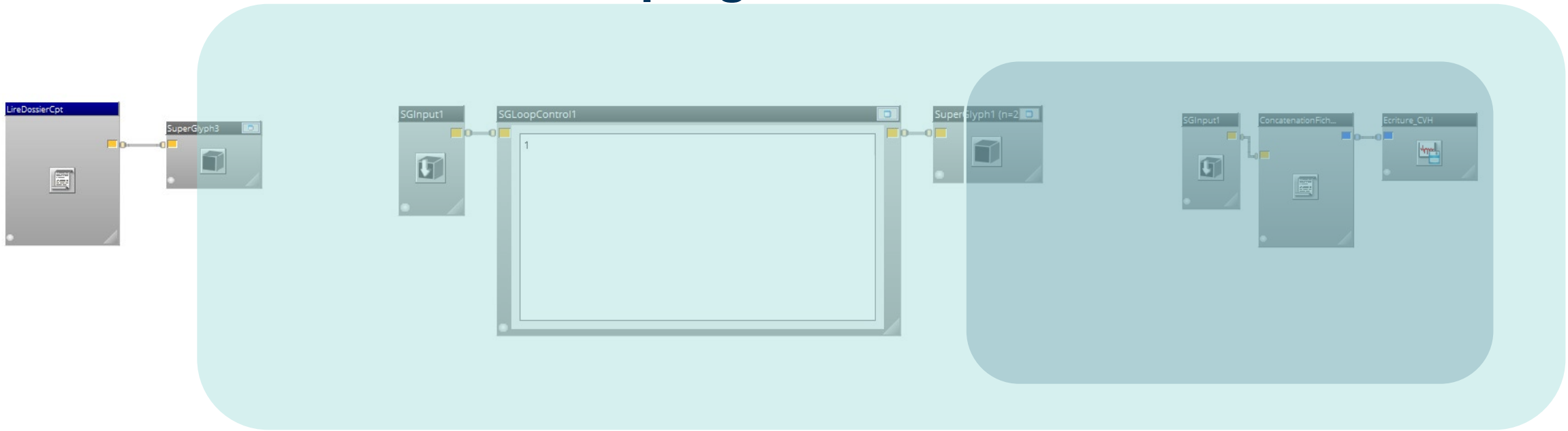
- It’s emphasized by the step execution feature which stop execution after each glyph.



- The lone feature I found not very easy is the looping feature. It needs 2 levels of embedding with production of a table with the looping values beforehand…

From direct execution to looping

Glyph solution



Python solution

- for i in range(len(fichiers))

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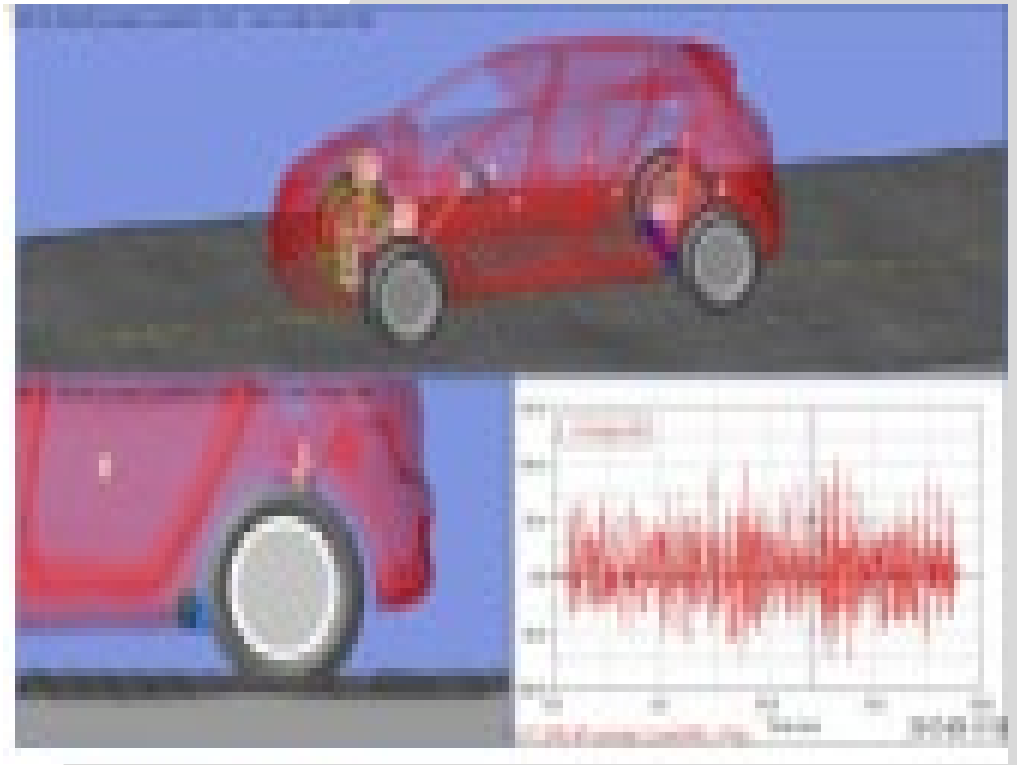
Numerical simulation quality control

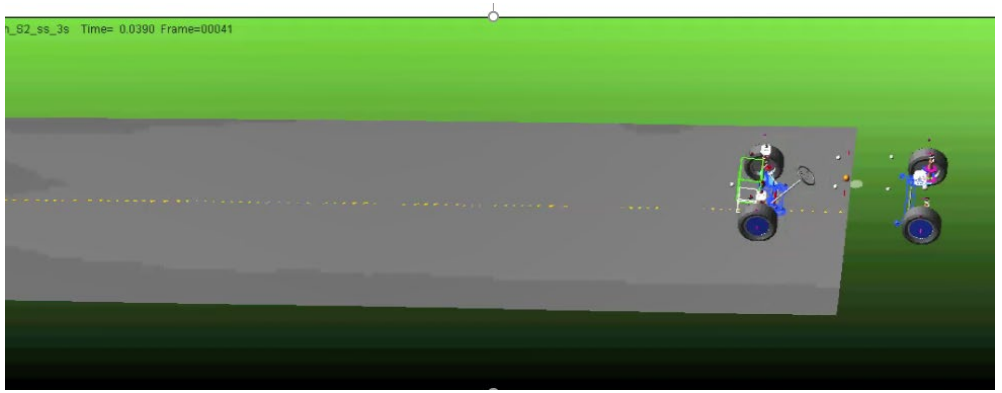
- Presentation of riding numerical simulation for durability tests
- Section extraction for numerical simulation
- Control of computing crash
- Control of computing divergence



Presentation of riding numerical simulation for durability tests

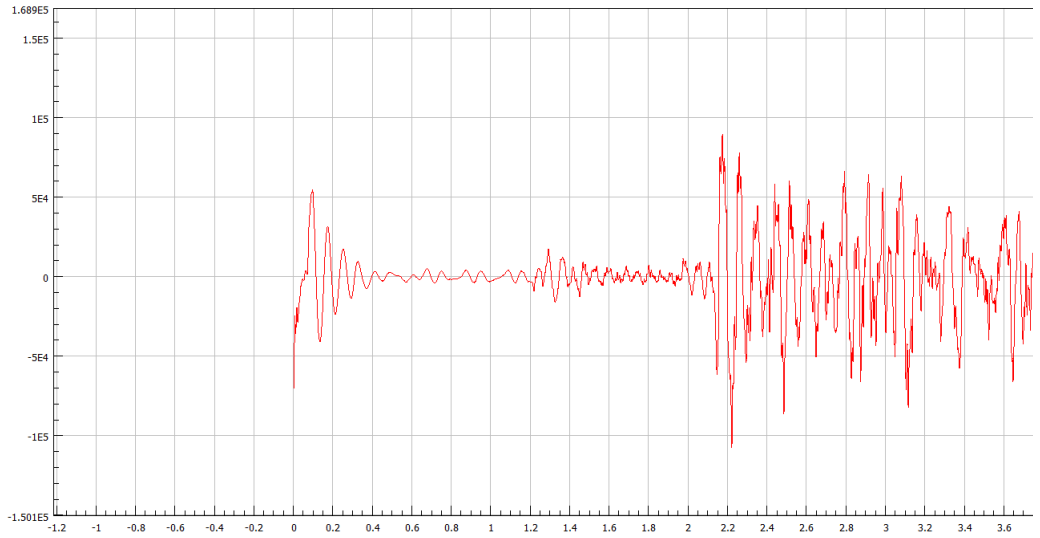
- Digitalized road with coordinates

Each section of proving ground is given with its specific riding parameters (trajectory, speed). The coordinates are given with longitudinal and orthogonal values.



- Gravity settling

The car is dropped on the road as 4 wheels and the modelling of each component is working to settle the car on right height according to their properties. It gives some decreasing sinusoidal movement of the body.



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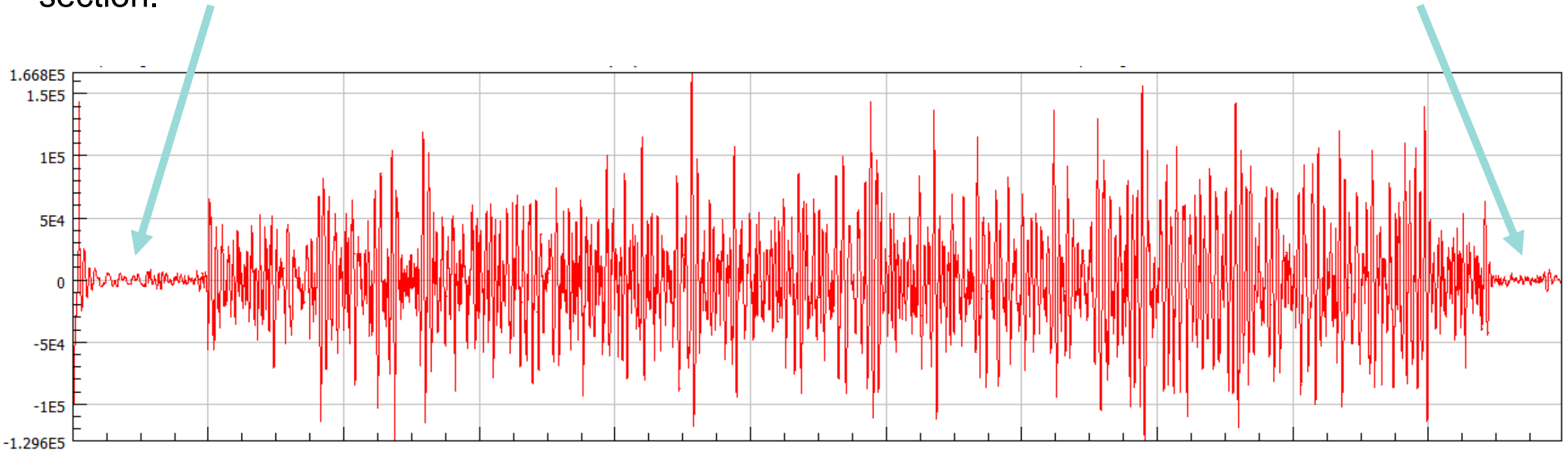
Presentation of riding numerical simulation for durability tests

- Incoming addition

To ensure gravity settling is done before to reach the section to record, an incoming addition of right road is added to digitalized section.

- Outgoing addition

To allow simulation to continue up to the rear wheels got off the section, a similar right road addition is made after the section.



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Section extraction for numerical simulation

- One section in each file

While in large record on proving ground one needs to found several sections in one record. In numerical simulation, the cutting has been made beforehand. This allow less memory consumption during simulation.

- Furnished coordinates

Start and end points of section are obviously well known in coordinates and numerical simulation can record them. Thus the section extraction is possible at any precision requested.

- Method for section extraction

As I remind you, these simulation feed durability benches. Bench mechanic asks for small delay from excitation start to full power so beginning of each section is defined with a coordinate pre-trigger related to speed. A similar function with length of the car is used for ending of sections.

→ The section extraction is no longer a big challenge but is still needed.

Control of computing crash

- Presentation of the problem

Driving numerical simulation is a complex computing work with some crash hazards. With our current simulation solution we found that some crashes brought the simulation files to be closed “as it” at the time of crash. It gives us a shorter file.

- Method fitting

The section extraction was fed with excel files in which we found the standard length of each section. We just had to use this information in a different way. We develop a test function on nCode metadata to check that each file has requested length.

→ **Control of computing crash is very easy and reliable.**

Control of computing divergence

- Presentation of the problem

For same causes of complexity as for computer crash, computing divergence appends and gives absurd values such as 200kN on vertical force on wheels. Being determinist, same driving numerical simulation always diverges in the same way.

- Solution seeking

As for differential equation, initial parameters define a lot on the whole computing. So we've proposed to numerical simulation team to do two simulations on each section with different incoming addition length.

- Final control method

These different driving allow us to check constituency of computing after section extraction to fit start time.

→ With a bit of mathematic mindset, computing divergence is well-checked

Conclusion

Development

Glyph developing was first used to enable fast implementation of straight processes with easy debugging.

To fasten the process execution and to enable easy loops, the code was afterwards progressively translated to python code.

Numerical Simulation

The numerical simulation have different features to check from physical records. But the previously developed tool brought a good structure to add specific numerical checking functions.

These additions were also implemented by same development progressive way.

Focus on nCode choice

nCode solution choice was made upon its allowance to mix python and glyph processes. It allows to check each function implementation with full process during the translation from glyph to python.


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Do you have a question for the Presenter? Visit the Guest Speakers Virtual booth within the next hour for an interactive Q&A session.