



Noise Challenges in hydraulic transmissions

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Who am I ?



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Summary

1. Problem statement
2. Test & Measurement challenges
3. Computational challenges
4. Conclusions

01

PROBLEM STATEMENT



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NOISE RELATED TO AGRICULTURE MACHINERY



- ▶ FRANCE : Noise related to agriculture activity falls in the « **neighborhood noise** » regulations.
 - Based on noise Emergence
 - More restrictive during night work → 3 dB(A) Emergence

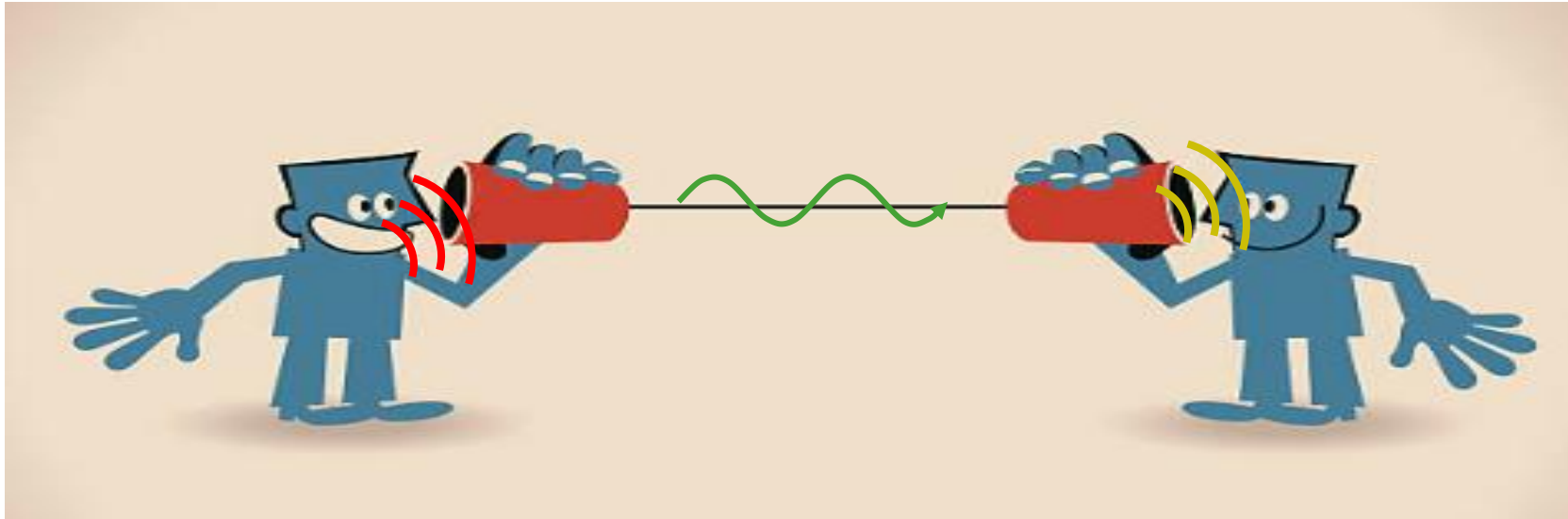
- ▶ ACOUSTIC standards and regulations : **more and more restrictive**
 - European Directives under revisions

HYDROSTATIC TRANSMISSION



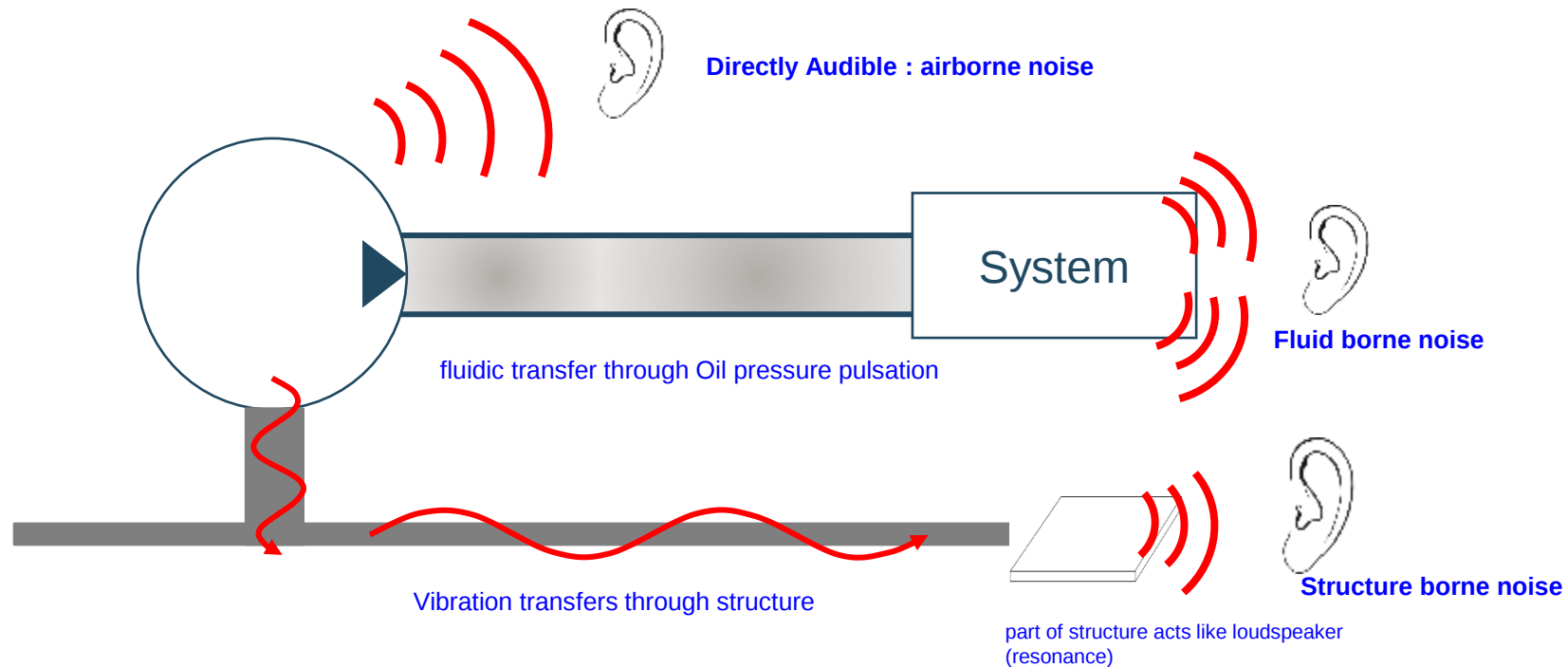
In hydraulic transmissions in agricultural machinery : pumps are usually the most audible sources

VIBRO-ACOUSTIC SCHEME



NOISE IS SYSTEM RELATED

VIBRO-ACOUSTIC SCHEME



NOISE IS SYSTEM RELATED

Noise Challenges in hydraulic transmissions



NOISE IS SYSTEM RELATED

02

MEASUREMENT CHALLENGE



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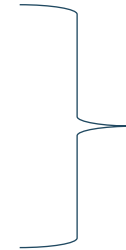
Measurements challenge

- NVH characteristics depend on the environment
 - ▶ AIRBORNE → Air pressure pulsation (noise)
 - ▶ STRUCTURE BORNE → Vibration
 - ▶ FLUID BORNE → Pressure pulsation

MEASUREMENT ON BENCH $\neq$ MEASUREMENT ON FINAL MACHINE

Needs :

- ▶ Determine **INTRINSIC** characteristics
- ▶ Determine **measurement methodologies**
- ▶ Use those characteristics to determine **full system behavior**



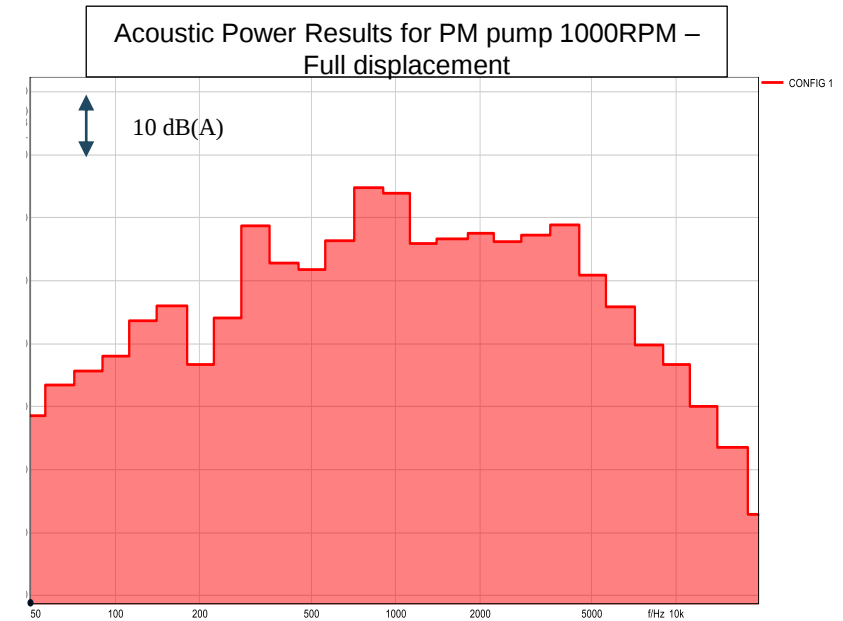
ISO standard exist !!

GOAL : EASE SUPPLIER - INTEGRATOR DIALOG

AIRBORNE NOISE

Measurement methodology widely used over industries

- ▶ **INTRINSIC characteristics : Acoustic Power (L_w)**
- ▶ Several Standards, using different measurement equipment
 - ISO 3740 series → Controlled environment and microphones positions
 - ISO 9614 → Intensity probes, less controlled environment
- ▶ **Challenge for hydraulic pumps and motors : mounting setup**
 - Need to avoid noise from pipes and connections
 - Need to avoid vibrations transfer to support
 - Specific guidance for hydraulic systems ISO4412

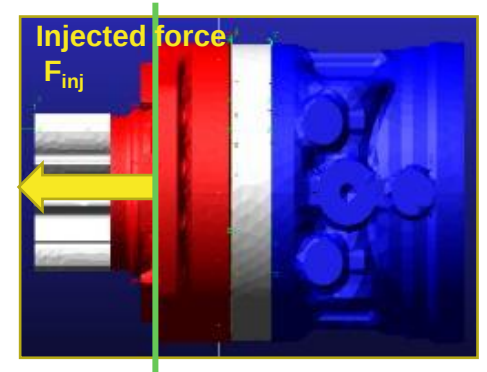


STRUCTURE BORNE NOISE

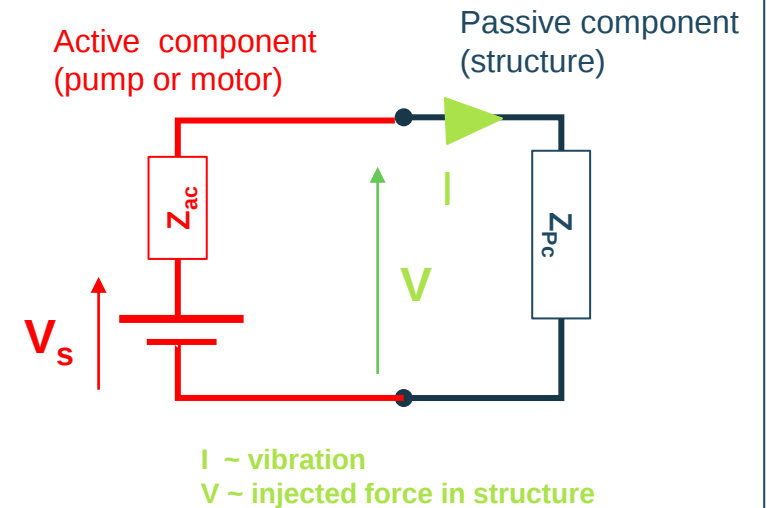
Measurements Methodology start to be used in automotive – Expert domain

- ▶ INTRINSIC characteristics : **Blocked Force** and **Impedances**
- ▶ Standards :
 - **ISO 21955** : Transposition methodology from test bench to final structure
 - **ISO 20270** : « In situ Measurements »
- ▶ **Challenge :**
 - **COMPLEX**
 - Lots of accelerometers and/or dynamic force sensors
 - Capabilities for Impact tests, FRF
 - Specific post processing software
 - Pipes ?
- ▶ Impedances to be determined also on passive side → OEM
- ▶ Under development at Poclairn

Allow vibration prediction in any part of the structure



Electrical analogy (ISO 21955)



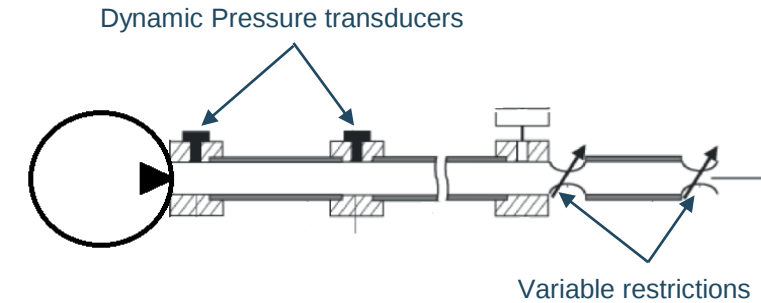
FLUID BORNE NOISE

Measurements Methodology in Expertise domain

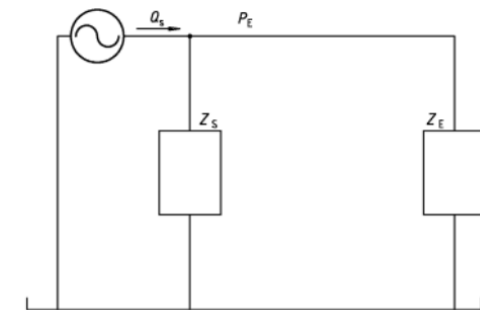
- ▶ **INTRINSIC characteristics : Source pressure pulsation and Impedances of components**
- ▶ Standards :
 - **ISO 15086** : Determination of fluid-borne noise characteristics
 - **ISO 10767** : Determination of pressure ripple levels
- ▶ **Challenge :**
 - Require a **specific bench** & specific hydraulic circuit
 - **Dynamic pressure measurements** capabilities
 - Specific **post processing** knowledge
- ▶ Impedances on passive elements necessary

Allow pressure pulsation prediction in any part of the system

ISO 10767 setup example



Circuit impedance representation (ISO 10767)



$Q_s \rightarrow$ pulsating flow
 $P \rightarrow$ Pulsating pressure

03

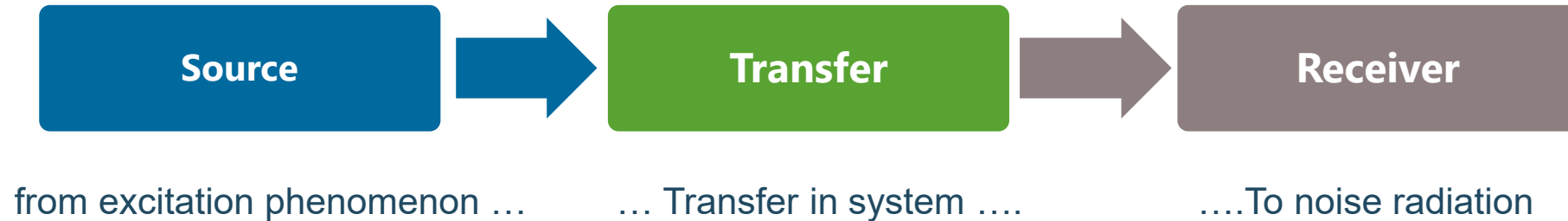
COMPUTATIONAL CHALLENGE



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SIMULATION CHAIN

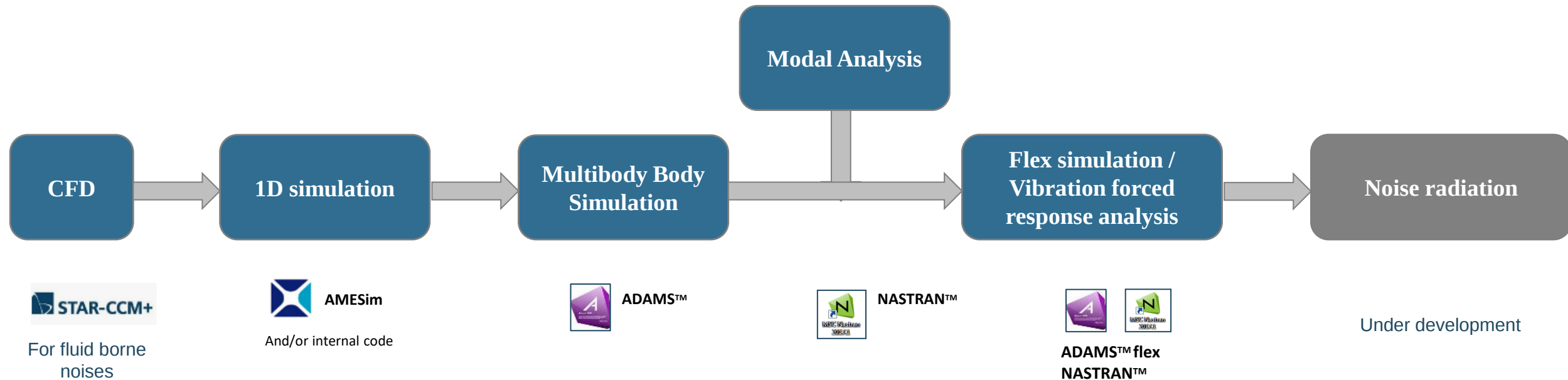
- ▶ Source of noise is multiphysic !



- ▶ Different physics → Different softwares

SIMULATION CHAIN

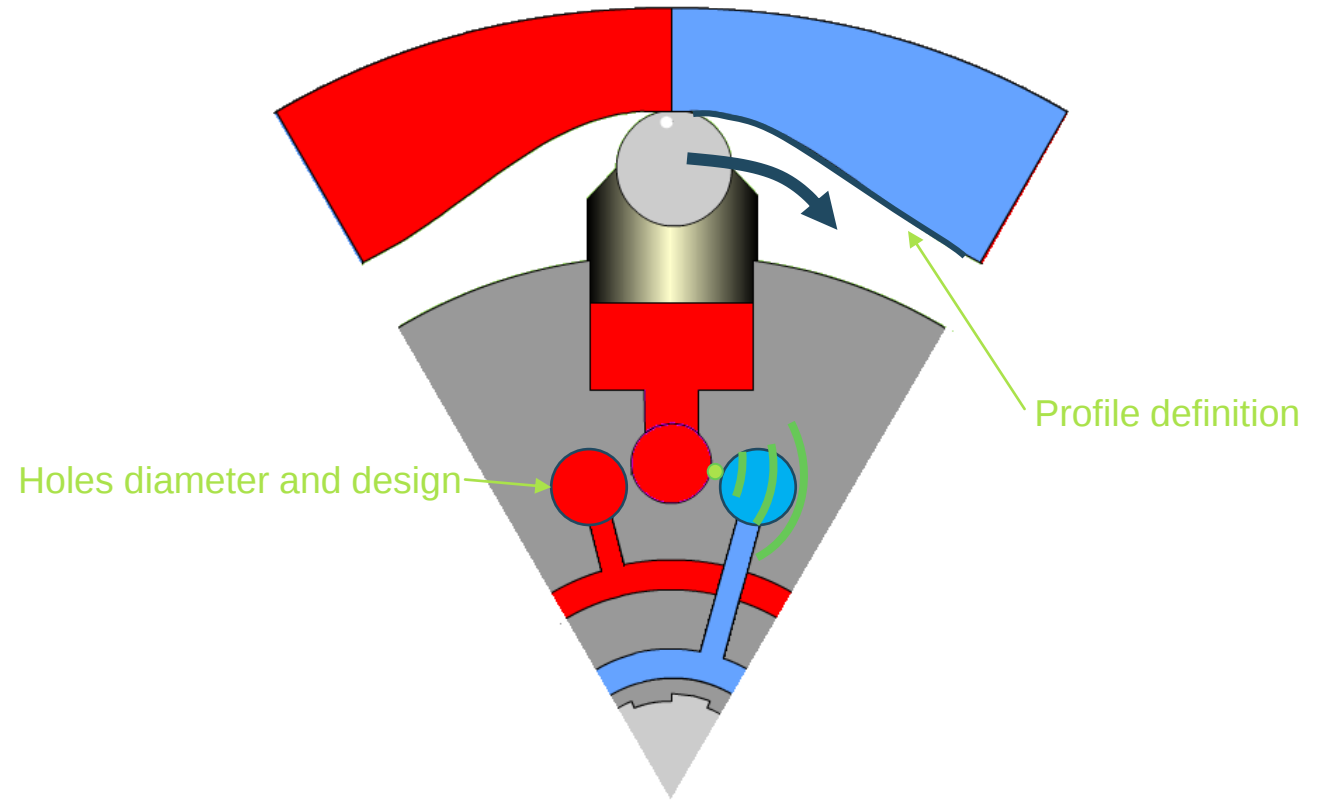
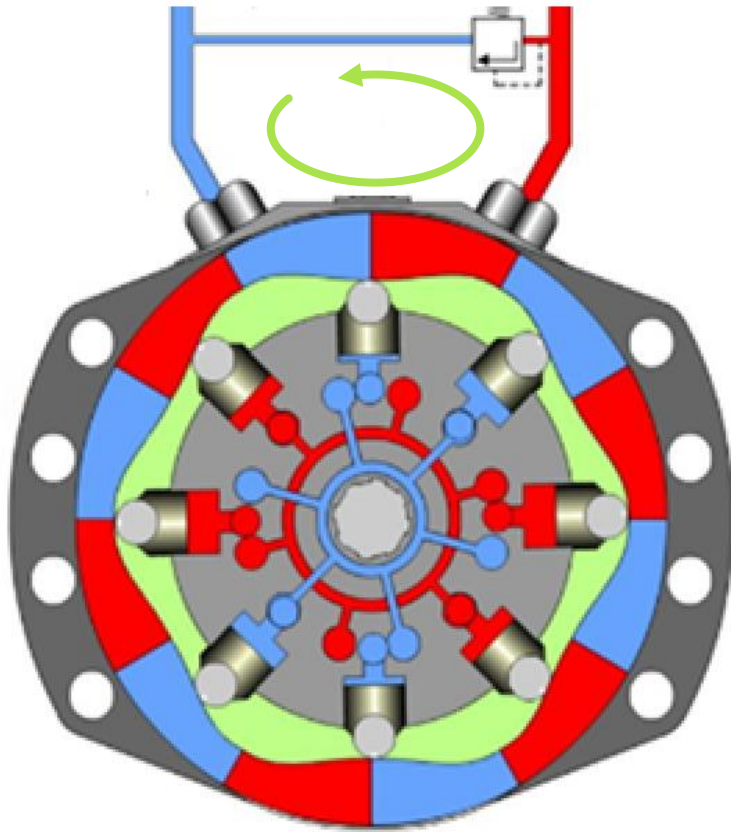
FMBD methodology (Flex Multi Body Dynamics)



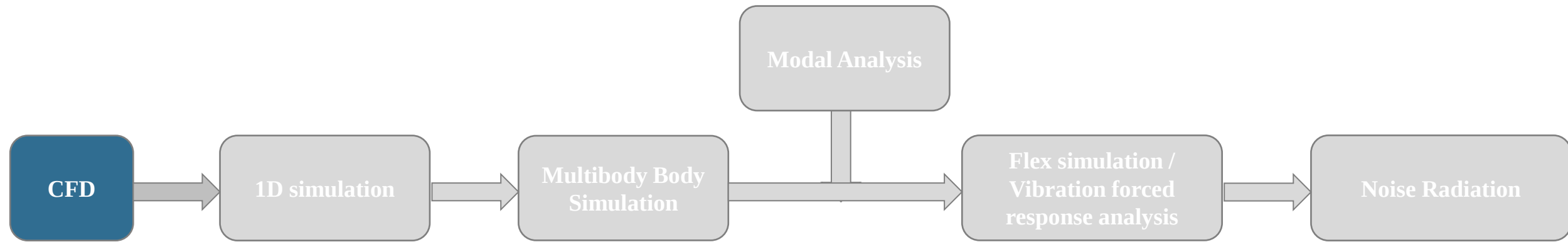
Different physics → Different softwares

Example of Motor NVH simulation

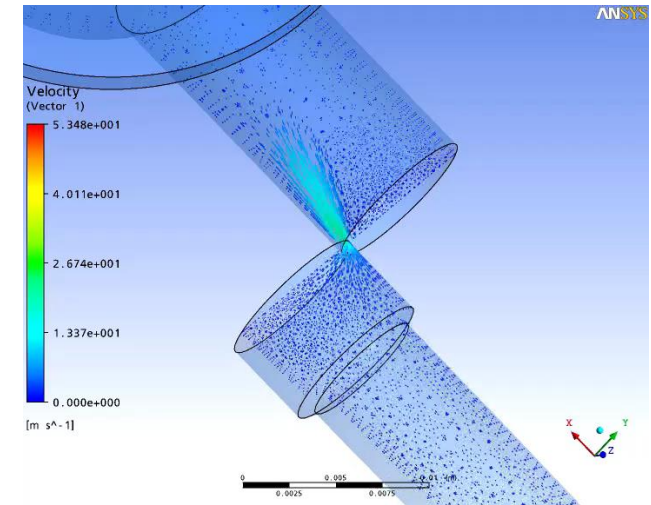
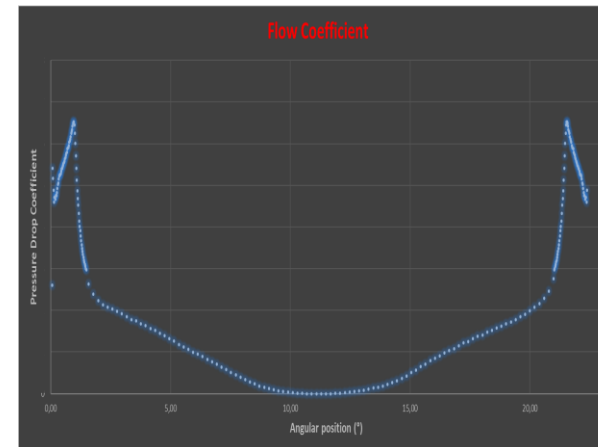
SOURCE of Noise : commutation HP/BP



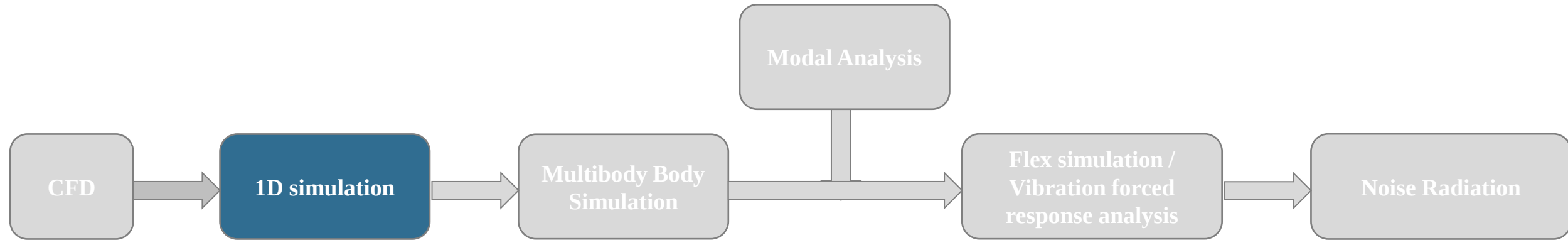
SIMULATION CHAIN



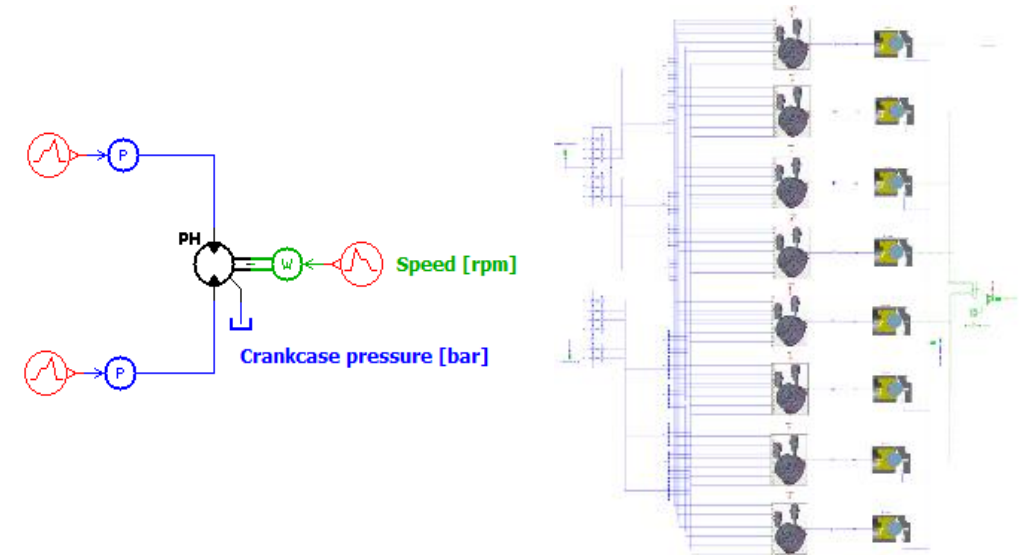
- ▶ Steady State simulation at different opening steps
- ▶ Calculation of pressure drop in channel during commutations



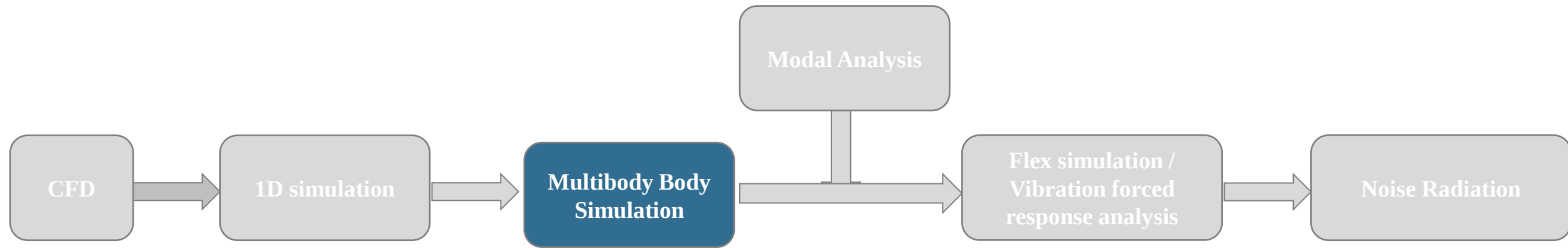
SIMULATION CHAIN



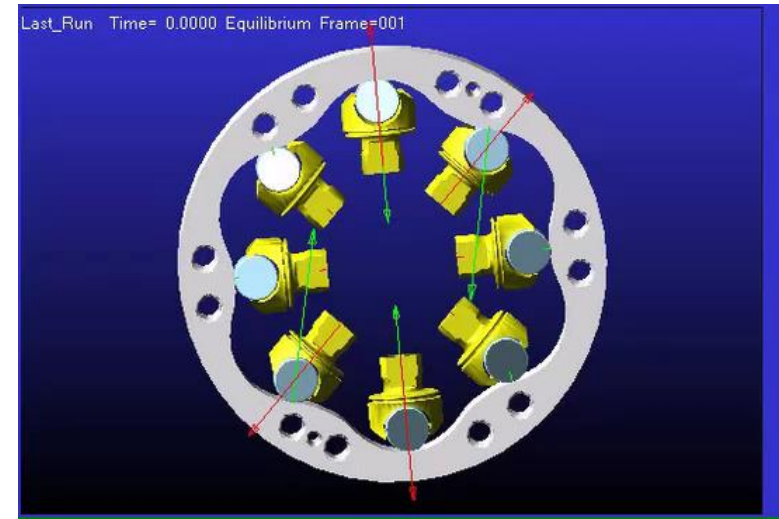
- ▶ Use pressure drop in 1 channel and calculate time pressure fluctuation at all pistons
- ▶ Other parameters included : frictions, thermal effects....
- ▶ **Pressure fluctuation in cylinder → Force fluctuation under piston**



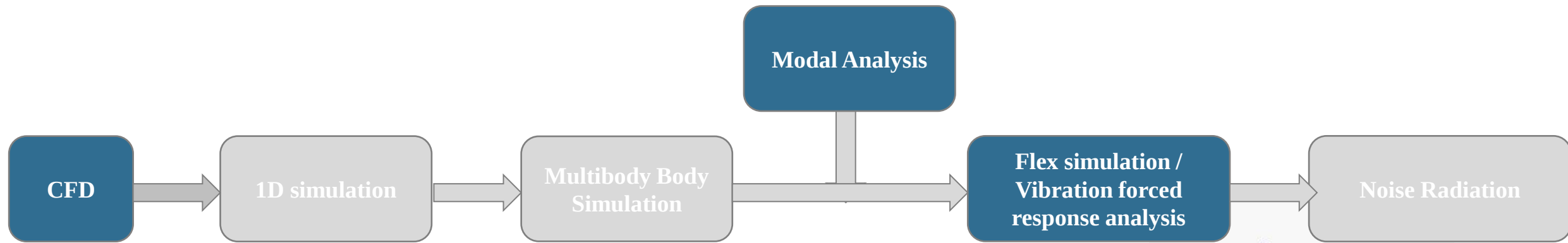
SIMULATION CHAIN



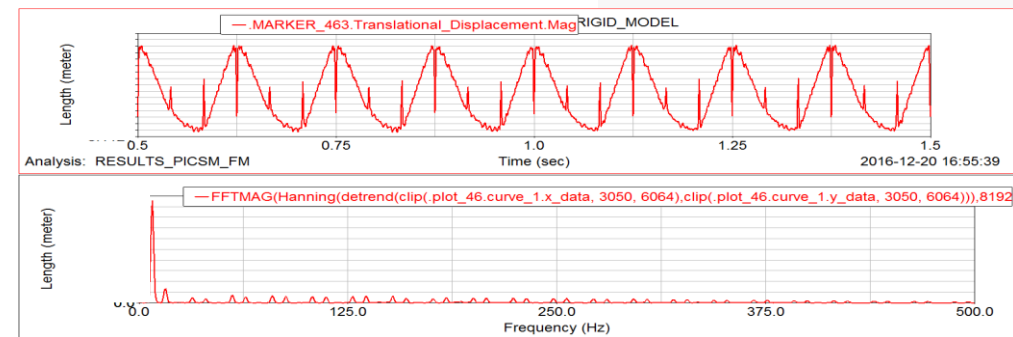
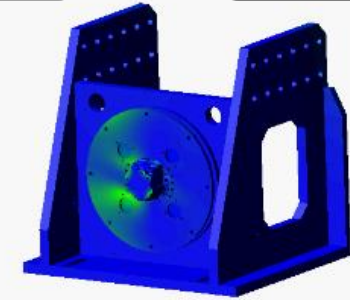
- ▶ Rigid Body simulation of hydrobase **kinematic**
- ▶ Computation of **forces applied on the structure** by the pistons



SIMULATION CHAIN



- ▶ Modal base calculation using modal analysis
- ▶ **Structural response of Motor + bench structure**
- ▶ Results of vibration structure needs to be improved.
- ▶ Noise radiation as final step !



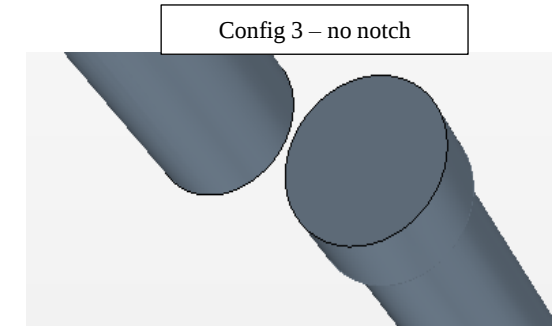
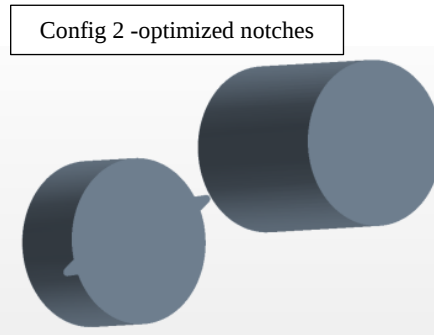
DESIGNS COMPARISONS USING SIMULATION

► Optimization of interface designs :

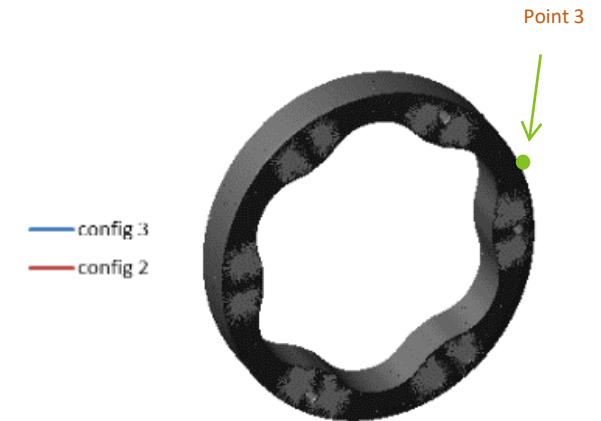
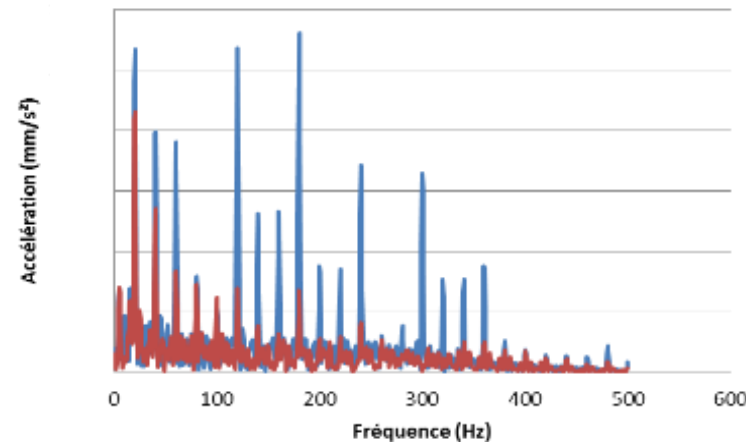
- Notches designs
- Holes sizes
- ...

► Trends can be found

► Compromise with performance requirements



Accélération came point 3



04

CONCLUSION



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CONCLUSIONS



- ▶ **Noise is system related**
- ▶ **Dialog necessary between component suppliers and OEM**
 - Early in Machine Development
- ▶ NVH Specifications and qualifications must include **intrinsic characteristics**
 - For **airborne, structure borne** and **Fluid-borne** noises

- ▶ Test & Measurements : **Methodologies exists**
- ▶ Computation from source to noise radiation
 - Multiphysics
 - Complex to put in place



QUESTIONS & ANSWERS