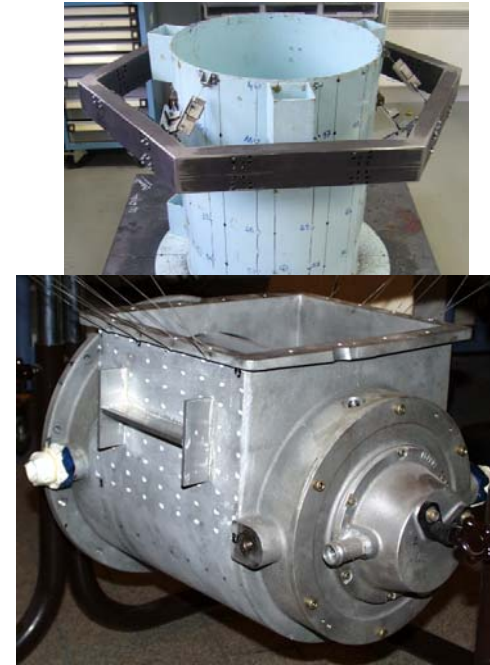
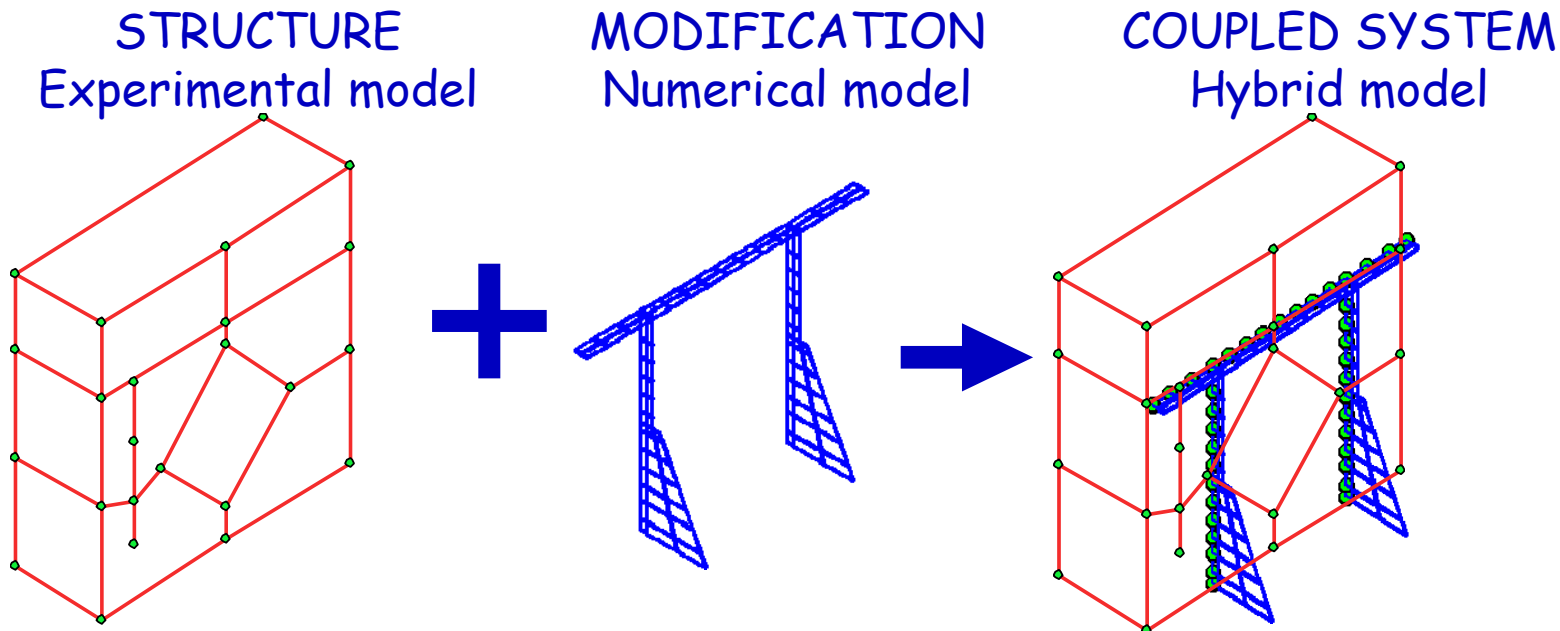


# Combining test and approximate models in experimental sub-structuring

Etienne Balmes, *SDTools, Arts et Metiers ParisTech*  
Mathieu Corus, *EDF, Ecole Centrale Paris*

**IMAC 28, Jacksonville**

# Structural Dynamic Modification



Industry where machines are purchased so that SDM is used for **problem shooting** when no **model is available**

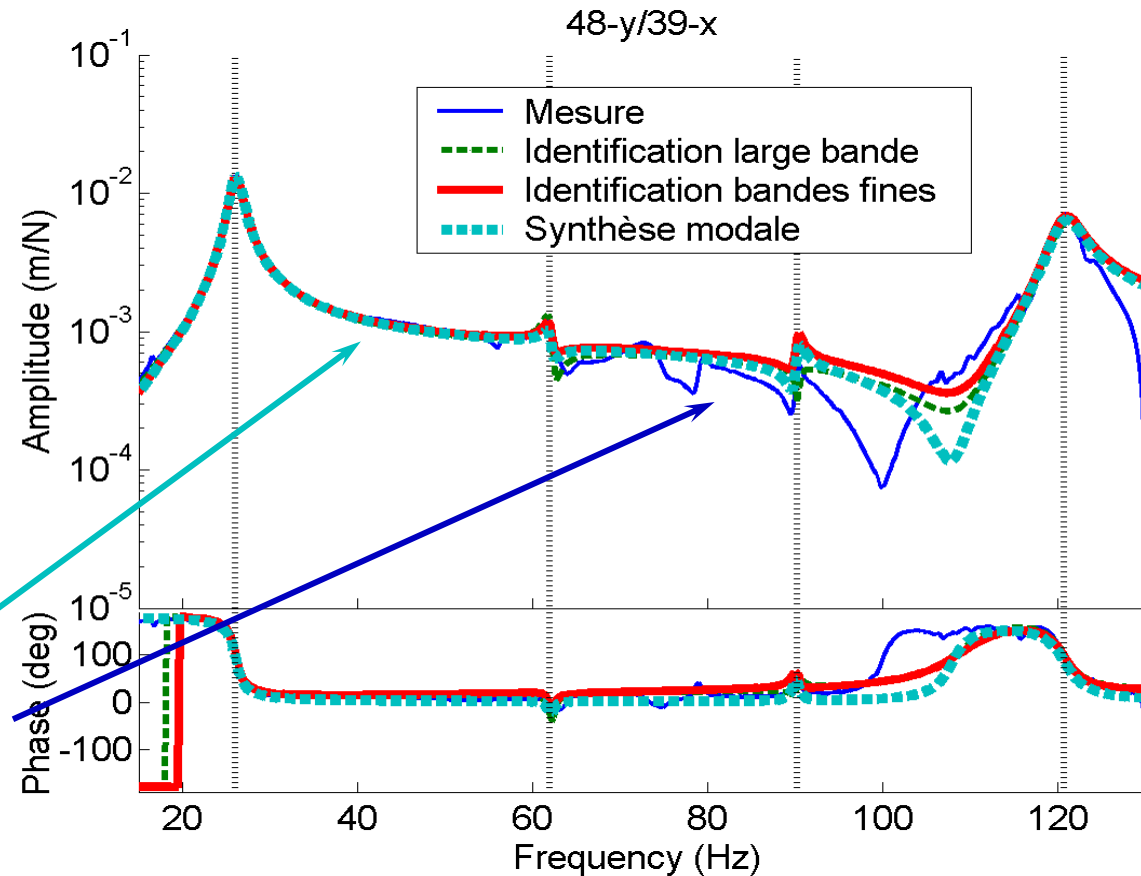
Our focus problems

- Sensors & interface are not coincident
- The number of interface DOFs is larger than N sensor
- Measurements are inexact



# Why/how we use modal based CMS

- Our tests have to be short : only a few input locations are available
  - ⇒ use of reciprocity is necessary
  - ⇒ modes is the only approach
- Need simple coupling
  - ⇒ use normal modes
- High amplitude modes pollute identification quality of low modes
  - ⇒ use narrowband identification
- CMS = synthesis of transfer over wide band without residual terms
  - ⇒ validate coherence of synthesis and test

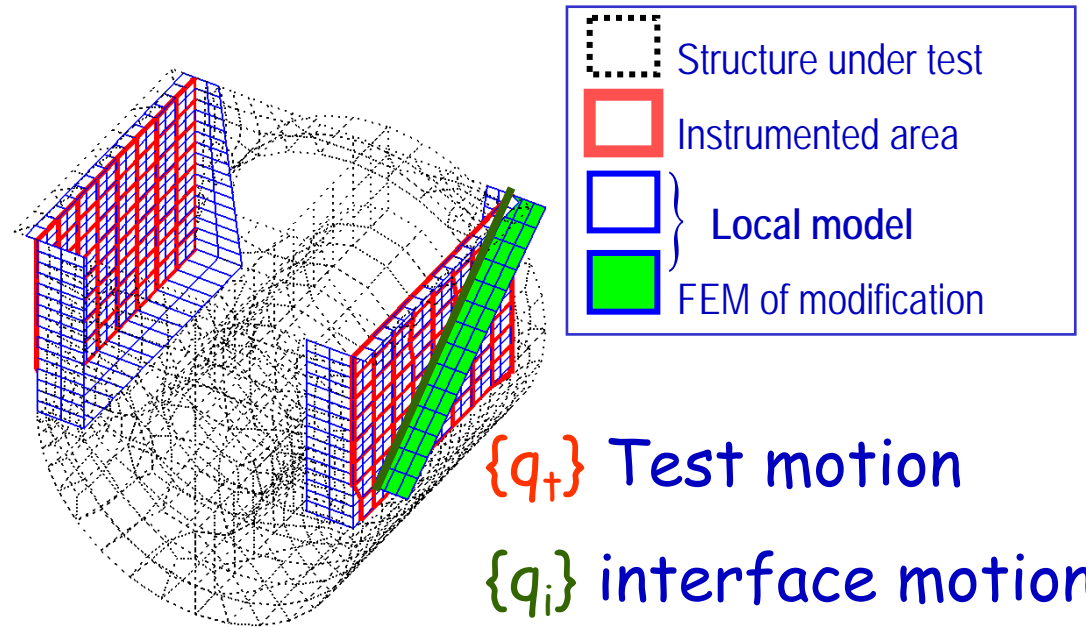


$$\sum_{j \in \text{identified}} \left( \frac{[R_j]}{s - \lambda_j} + \frac{[\bar{R}_j]}{s - \bar{\lambda}_j} \right) + [E(s)]$$

Idea: identification is a process that **smoothes inconsistencies** typically found in FRF measurements :  
it can be a better representation of the tested structure

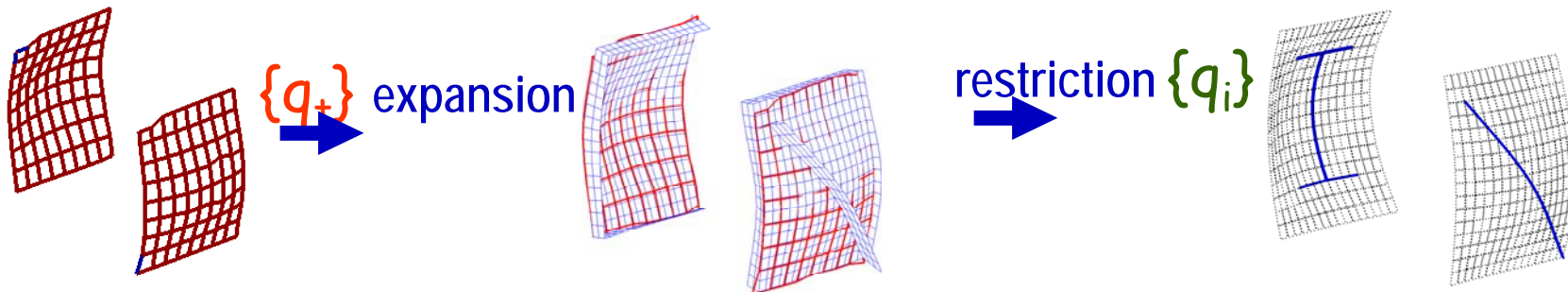
# Expanding interface motion

Idea 2 : a non-updated partial FEM model can be used to fill in unmeasured **spatial information**



One assumes subspace expansion possible  $\{q_i\} = [T_{it}] \{q_+\}$

- Incompatibility : local model used for kinematics
- Measurement errors : regularization needed

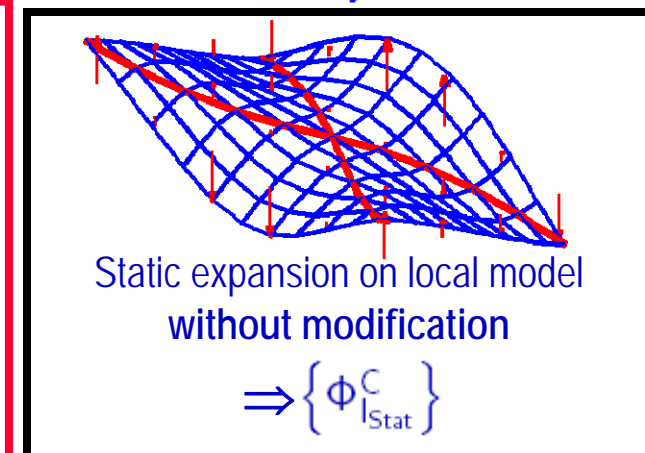
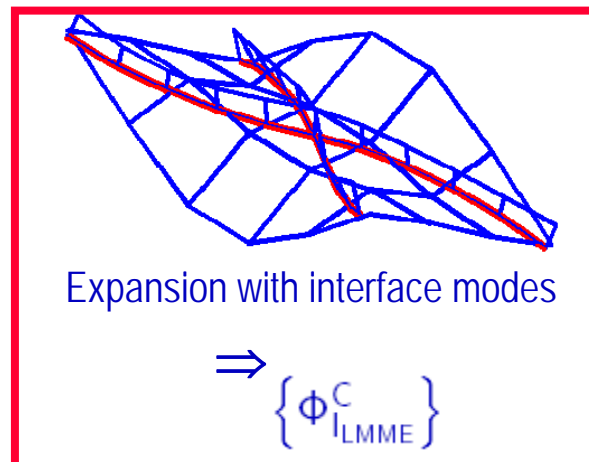
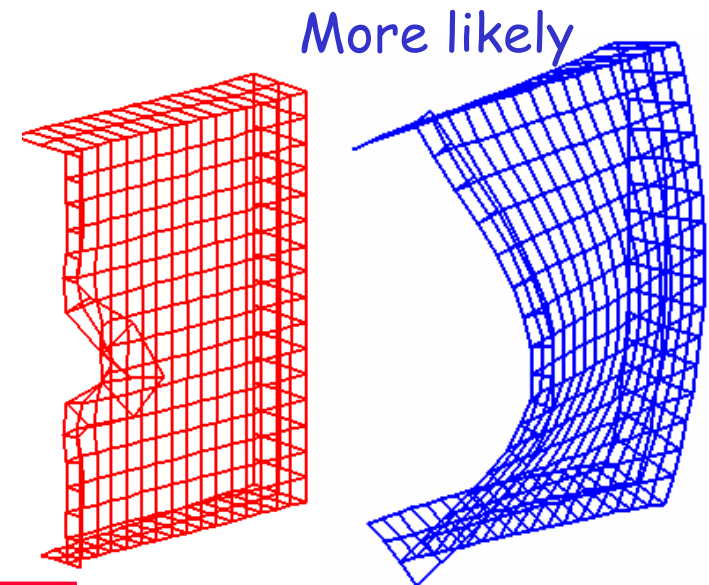


# CMS with estimated interface motion

$$\begin{bmatrix} [Z_{CC}^M] & [Z_{CI}^M] ([T_{It}] [\Phi_t]) \\ ([T_{It}] [\Phi_t])^T [Z_{IC}^M] & ([T_{It}] [\Phi_t])^T [Z_{II}^M] ([T_{It}] [\Phi_t]) + \left( -(\omega^C)^2 [Id] + [\Omega_t]^2 \right) \end{bmatrix} \begin{Bmatrix} \{\phi_C^C\} \\ \{\phi_t^C\} \end{Bmatrix} = \begin{Bmatrix} \{0\} \\ \{0\} \end{Bmatrix}$$

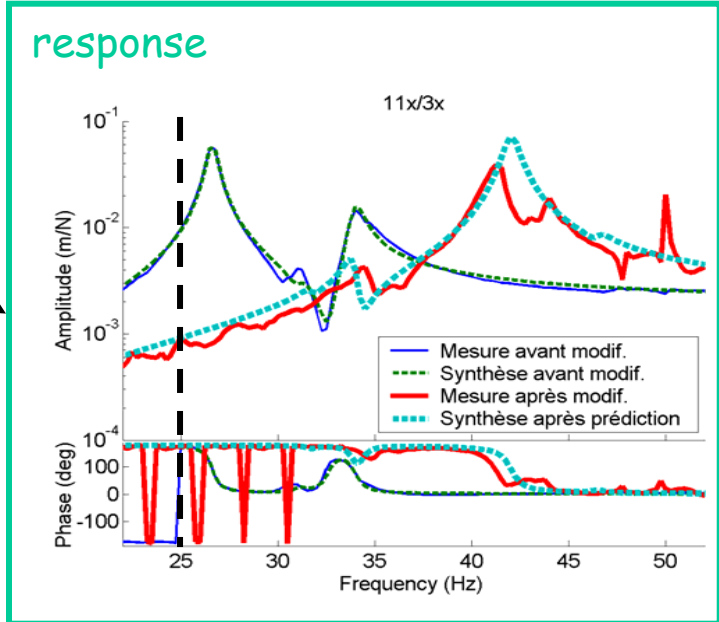
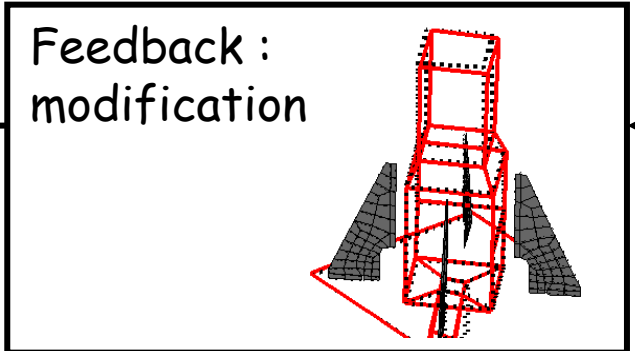
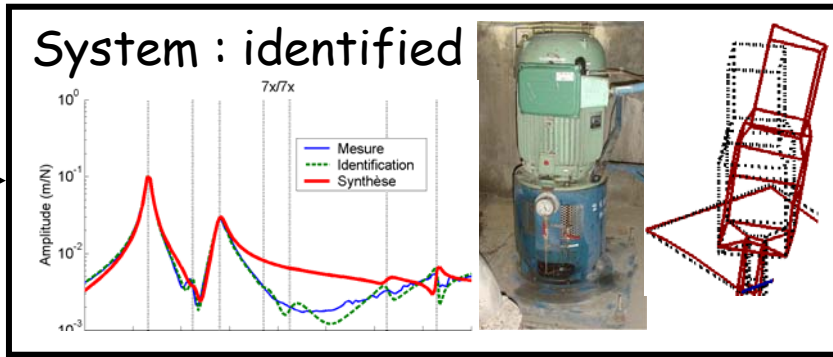
Subtleties that improve results

- Account for presence of modification
- Choose subspace
- Retain solution where all methods coincide best

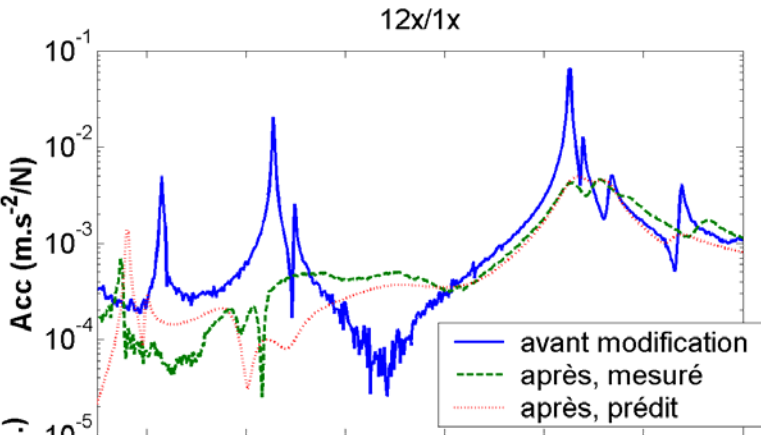
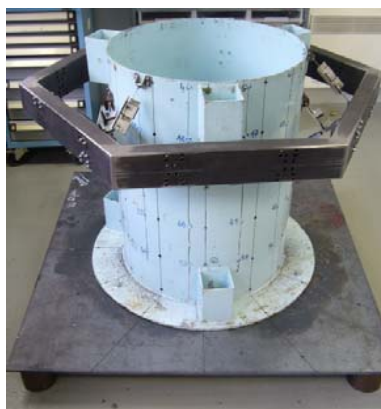


# It works (when properly applied)

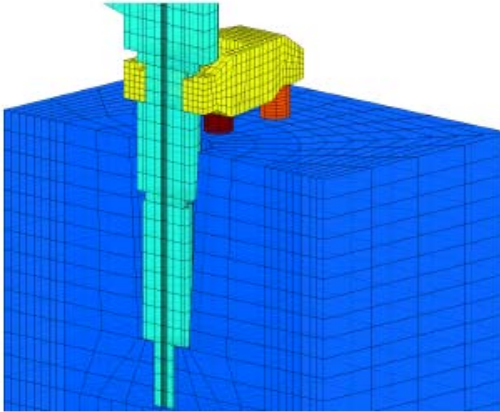
In



- Handles distributed mass, stiffness or damping modifications
- Restricted to low frequency global modes



# Our current work



- Apply our CMS methodology
- Estimate operational loads (Corus ... IMAC 2008)
  - Use **known test block** and **target object** to obtain modes + static
  - Use measurements on block to estimate displacement & load  $f_0, u_0$
  - Estimate generalized  $f$  load in equilibrium for object only
  - Couple **experimental model** of object with **real structure**

