The algebraic system associated to RB solution modes is obtained by projection of the departing discretized operators, assembled with conventional discretization techniques (finite elements, finite volumes, etc.). If the RB solution basis size is small and sufficient to represent the solution, the resulting matrices are often smaller by several orders of magnitude.

In the context of a fixed mesh, the assembly and projection steps take place once and for all. On the contrary, if the mesh moves in time, these steps need to take place for every time step. Hence, despite the size reduction of the linear system, there is still a considerable overhead during its assembly. To overcome it, the (M)DEIM system approximation technique is introduced. To use (M)DEIM, the operator is expressed as a linear combination of operator modes (collateral basis); whose coefficients are obtaiend from an empirical interpolation method applied over the evaluation of a restricted set of operator entries. Since an ad-hoc basis is identified for the solution and each of the algebraic operators, the combination of these two techniques defines an hyper reduced order model (HROM).

The methodology is purely algebraic, with a non-intrusive property that should allow its implementation on existing solvers. We have obtained RB solution and operator bases; to approximate the operators projection unto the reduced space without explicitly assembling and projecting the original FOM operator. The resulting HROM bases can be truncated to resolve for a determined error threshold with respect to the conventional model. Building the collateral basis increases the cost of the offline stage, but it allows a perfect offline-online split: no FOM operators are used during the online run. For the operators, the offline stage is carried out separately from the FOM simulation, so that a wider parameter range can be spanned.