INNOVATIVE MODELING CAPABILITIES IN VIRTUAL.LAB IN VIEW OF CROSS ATTRIBUTE SIMULATION

AUTHORS:

Tom Van Langenhove, LMS International
Cedric Canadas, LMS International
Nick Tzannetakis, LMS International
Christophe Liefooghe, LMS International

CORRESPONDENCE:

Tom Van Langenhove
LMS International
Interleuvenlaan 68, Researchpark Z1
3001 Leuven, Belgium
+32 16 384 200
+32 16 384 350
Email: Tom.vanlangenhove@lmsintl.com

ABSTRACT

To meet the challenge to support the development of an ever increasing number of vehicle models and variants with an optimal quality in the constantly decreasing resource and time requirements, companies are forced to increase the integration amongst and impact of the different simulation disciplines in the core vehicle design and engineering process. A proposed methodology is offered by LMS through the LMS Virtual.Lab Software suite proposing an integrated platform for body, chassis, engine and full vehicle engineering. Through its integration in Dassault Systemes PLM and Simulia solutions it tightly links multi-attribute simulation with vehicle design.

Innovative assembly and modelling capabilities enable a unique bridge between the different vehicle attribute domains, being noise & vibration, durability, strength and crash/impact. The definition of a generic assembly, which can be even defined directly on the design model represented by CAD together with multi-solver modelling information, and a multi-solver pre/post environment seamlessly integrating leading crash, linear, and non-linear solvers (LS-DYNA, Nastran, Abaqus) allows an easy and

thorough information and data sharing between the different disciplines, strongly increases the efficiency in creating subsystem and vehicle models and delivers optimal collaboration between design and engineering teams.

This paper focuses on a comprehensive presentation of the methodologies employed, clearly demonstrates the aims and value that a multi-attribute PLM integrated solution brings, documented by real industrial examples and metrics.

KEYWORDS:

Modelling, Assembly, CAD Associativity, Generic, Multi-Solver, Cross Attribute, LS-DYNA, Impact, CAE, Simulation, LMS Virtual.Lab

INTRODUCTION

To meet the challenge to support the development of an ever increasing number of vehicle models and variants with an optimal quality in the constantly decreasing resource and time requirements, companies are forced to increase the integration amongst and impact of the different simulation disciplines in the core vehicle design and engineering process and to basically reduce the vehicle development process time.

A proposed methodology is offered by LMS through the LMS Virtual.Lab software as an integrated platform for body, chassis, engine and full vehicle engineering. LMS Virtual.Lab offers an integrated software suite to simulate the performance of mechanical systems in terms of structural integrity, crash and impact simulation, noise and vibration, acoustics, durability, system dynamics and ride and handling. It focuses to cover all the critical process steps and required technologies to perform an end-to-end assessment of a design in each of these key disciplines, long before committing to expensive tooling and physical prototype testing. Therefore, engineering teams can quickly and effectively analyze a multitude of design options, and drive major design choices from the perspective of key performance attributes.

Adapting the vehicle development strategy to reduce the overall vehicle development time is of key importance nowadays in vehicle companies. LMS Virtual.Lab, which is based on CAA V5, the open middleware for PLM from Dassault Systèmes, supports this strategy by addressing at the same time the following key areas:

1. Fast full vehicle assembly. In current processes, too much time is lost in the generation of attribute specific full vehicle simulation models from the moment the detailed geometry becomes available. In case of updates, often too much time is spent re-assembling attribute specific full vehicle simulation models since little or no automation exists.

2. Fast design iterations. Partly due to the fact that a lot of time is spent in the modeling of the full vehicle, but also due to the fact that simulation of minor and major design changes has not obtained an optimal efficiency yet, only a few iterations can be performed in a given time window leading to an over design instead of an optimal design. Also special technology for fast body/full vehicle iterations has been developed in this context. (see ref 3)

3. Concept engineering. Frontloading the vehicle development process is an important enabler in compressing the total development time, since proper analysis done in the concept phase when still a lot of design freedom is available, enables to obtain a better initial quality of the first virtual vehicle. Concept engineering can include any simple analysis done by the designer up to full vehicle simulation on models that are obtained by morphing (see ref 2) or other specialized concept tools.

4. Better communication. Especially between design and engineering departments leading to a faster data exchange and use of experience of each.

By addressing these areas, it is possible to decrease substantially – with one prototype phase (see ref 4) – the vehicle development process time.

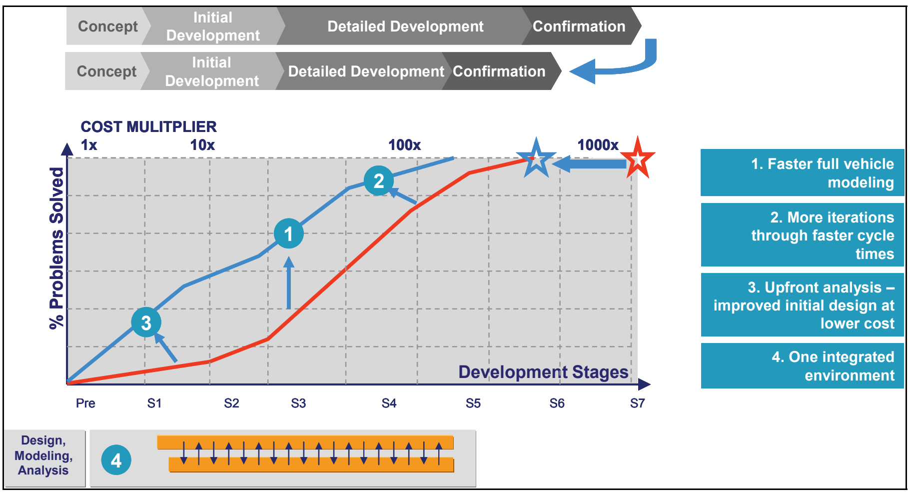


Figure 1: Compressing the vehicle development process (from red to blue)

This paper focuses on a comprehensive presentation of the key methodologies employed in the context of crash/impact simulation, clearly demonstrating the aims and value that a multi-attribute PLM integrated solution brings, documented by real industrial examples.

1. MULTI SOLVER GENERAL FEA PRE & POST PROCESSOR

The basis of the LMS Virtual.Lab solution is a scalable pre/post processor for general finite element analysis, supporting different solvers like LS-DYNA, Nastran or Abaqus. This solution can be offered either as a stand-alone environment or fully integrated into the CATIA V5 platform. The integrated solution offers the flexibility to run a full geometry based analysis process or a mesh based approach. The various process steps and simulation that would otherwise run separately and produce isolated results are integrated. This integration eliminates the need to rework models, duplicate meshes, transfer files, translate data and visualize results in applications specific formats.

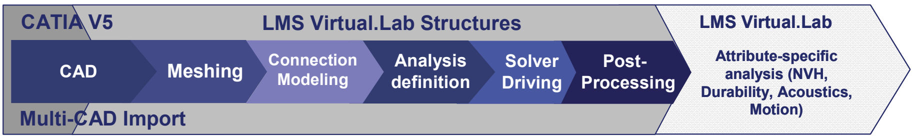
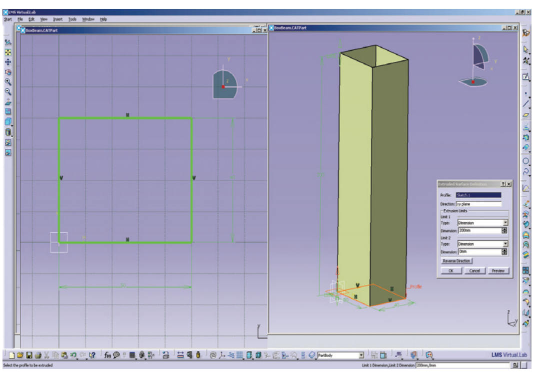
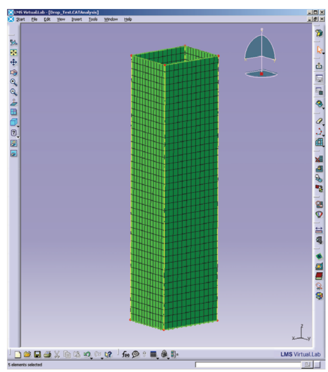
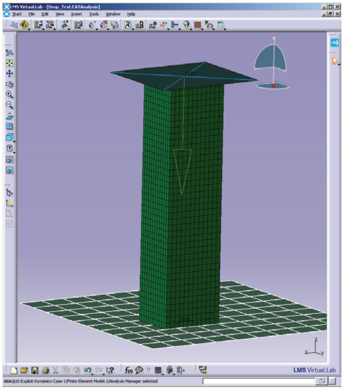


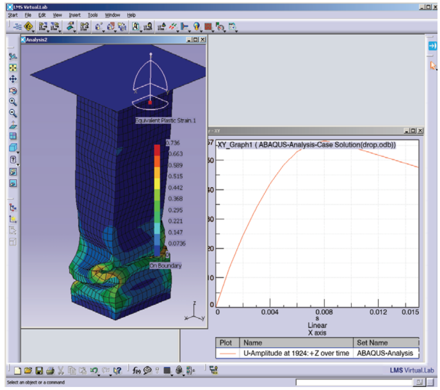
Figure 2: Fully integrated multi-solver pre/post processor.

As an example the drop test analysis shown in the below pictures (geometry, mesh, Analysis setup, result) can be set-up and run in a completely geometry associative way. Any change in the geometry can be automatically accommodated and lead to a new result with a simple push of a button.









The solution is scalable in the sense that the same platform can be used be either:

- **Designer** performing simple, standard analysis starting from the design. These standard analysis templates can be defined by the specialists. As the solution can be embedded into CATIA V5, the step-in and learning curve for the designer is extremely low.

- **Analyst** performing general finite elements analysis, typically starting from the geometry and using meshing engines, integrated in the framework.

- **Performance simulation engineer** performing advanced attribute simulation and post-processing, often starting from meshes and needing general analysis as a starting point for the attribute simulation.

The solution is also scalable in the sense that it can be used for **component**, **subsystem** and **full vehicle** level analysis, by offering a comprehensive suite of connection modeling, assembly and trim functionality.

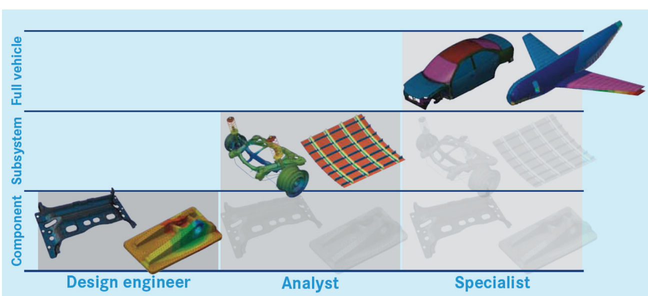


Figure 3: A scalable solution for general finite element analysis

The key values of this multi-solver pre/post processing environment are:

1A. Integration. One the one hand, the solution is embedded into CATIA V5, eliminating the geometry translation step thus speeding up analysis time. On the other hand, the solvers can be driven from within the solution and run jobs are monitored which means that the solver becomes a "black-box" and it becomes available for more user to access the advanced solution power of these solvers.

1B. Scalability. Since the designer, analyst and performance simulation engineer use the same environment, automatically the communication between them is improved and costly design cycles are reduced.

1C. Fast iterations by associativity. The whole analysis process is specification driven, and any change in a parameter will trigger all the downstream processes to be updated. Solver jobs will be automatically restarted and new results readily available. This allows performing more analysis in the same time window

In the drop test analysis example mentioned above starting from geometry the first iteration requires the definition of all phases: meshing, analysis case and post-processing. Sub sequent iterations only involve CAD modifications. Through an "update" mechanism the mesh is updated to match CAD modifications, then the analysis case and finally the post-processed results are automatically updated. Thus, section or thickness influence on buckling mode can easily be investigated. This unique capability enables even more performance for optimization, reliability and uncertainties studies.

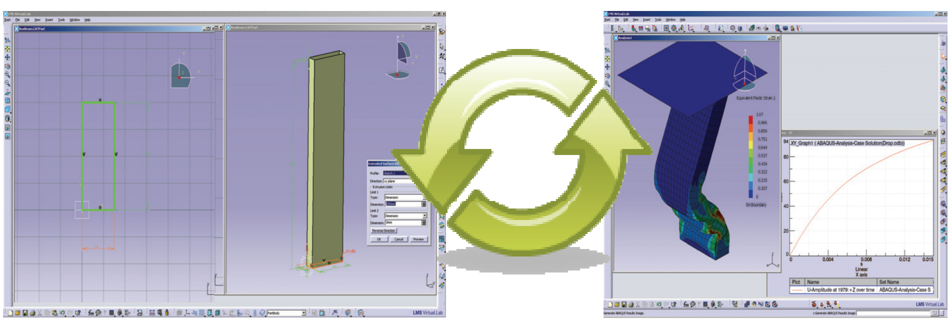


Figure 4: Drop test analysis - Associativity with CAD

1D. Template based. Since all steps of a process are kept in a so-called "specification feature tree", it is easy to understand a process and to capture standard processes in templates. These templates can then be performed by the designers enabling up-front proven analysis.

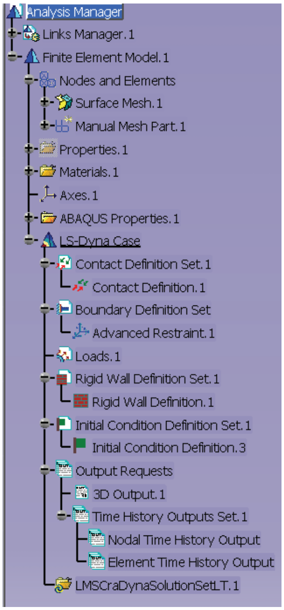
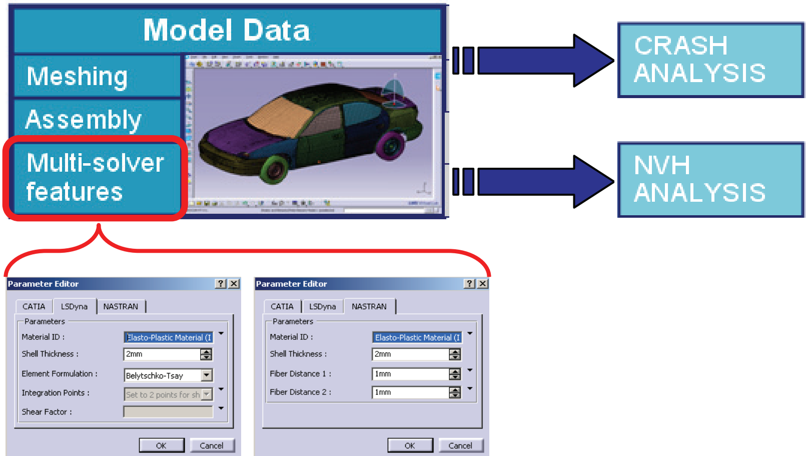


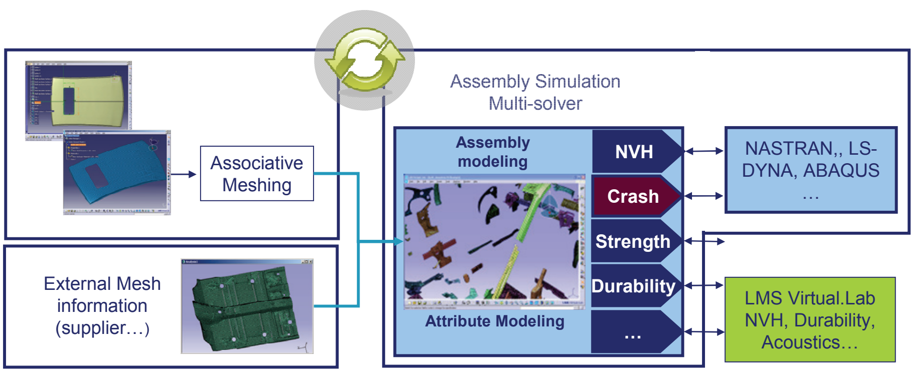
Figure 5: Feature tree of drop test analysis, showing all steps of the process

1E. Multi-solver. Specific multi-solver features enable in one feature (e.g. a material property, connections) to model the general characteristics and the solver specific characteristics. Also since model data (mesh) are translated into a "common data model" it becomes straightforward to reuse an LS-Dyna model for instance in a Nastran context or vice versa.



2. GENERIC AND EFFICIENT MULTI ATTRIBUTE ASSEMBLY

LMS Virtual.Lab offers an integrated solution for building quickly attribute specific subsystem or system level simulation models and analyzing their performance by driving industry standard solvers like LS-DYNA, Nastran or Abaqus. These models also serve as starting point for more detailed attribute simulations. Vehicle simulation models can be made either starting from meshes or starting from attribute independent geometry models and associating one or more attribute specific meshes or component analysis documents to them, as such enabling concurrent engineering and leveraging of common parts. Once the layout is defined, the engineer disposes of a wide range of general and attribute specific connections and connection properties that can be generic and/or attribute specific.



The key values of this assembly solution are:

2A. Decreasing initial full vehicle built & analysis time. Dedicated solutions are available to speed up typical time consuming steps in the assembly process. Special tools are available to model thousands of spot welds in a matter of minutes and quickly identify, find root causes and correct spot welds which could not been meshed. Also a unique and dedicated solution is available to model & keep track of all the lumped and non structural masses in a vehicle.

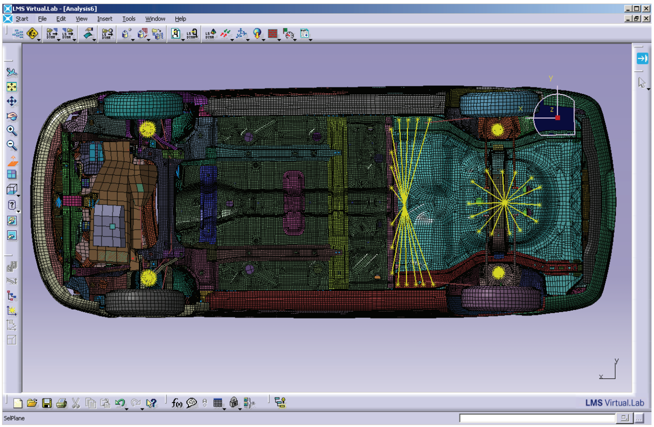


Figure 6: Lumped mass trimming of vehicle.

2B. Attribute independent connections and assembly. The assembly can be defined on an attribute independent geometry or wireframe model containing the hard points on which also the connections and the connection properties are defined. Attribute specific component meshes can then be associated as "representations" to this attribute independent assembly and it becomes straightforward and quick to switch from one attribute to another, e.g. to reuse an LS-DYNA model in a Nastran NVH context.

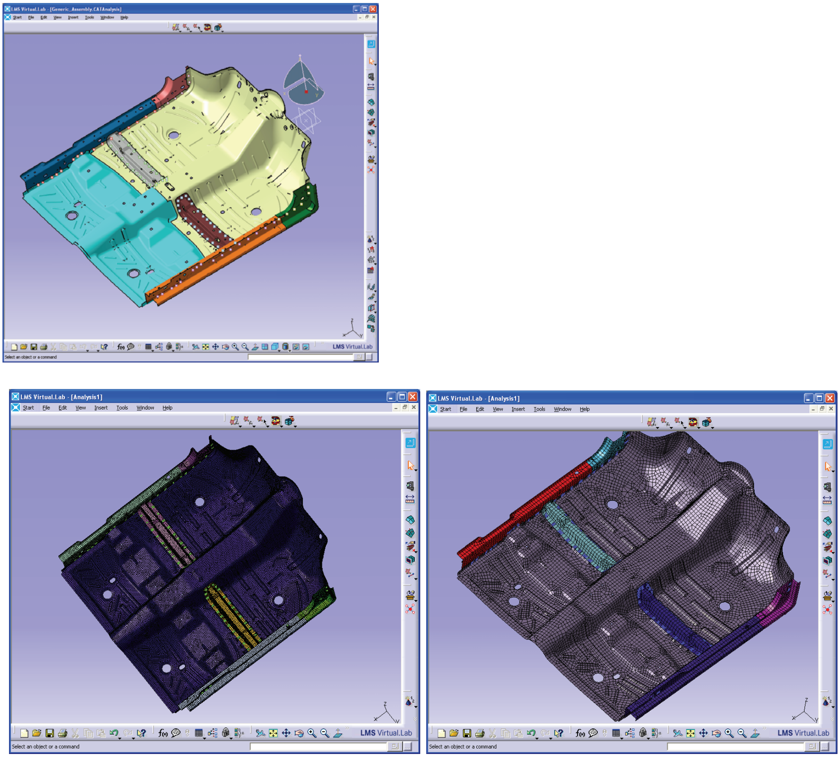


Figure 7: From assembly defined on CAD towards crash and NVH representations

2C. Improve confidence in simulation model. Since all the additions to the model are kept as part of the specification tree (the template representation), it becomes straightforward to know the model history and to find out the model composition at any time. For instance, unlike in other tools, the mass trimming step is really a separate and traceable step in the process. Each trim item can be given a meaningful name for the application engineer or can be part of a trim set.

2D. Accuracy. Different attributes require different representations of connections. For instance, for strength a simple rigid or beam type spot weld representation is generally selected, but for N&V typically a Hexa based spot weld is more appropriate while for durability fine spot weld patterns are needed to be able to correctly model stresses in the neighborhood of spot welds. (see ref 1)

2E. Quick model updates in case of design changes. Since the whole assembly solution is integrated and associative, it enables quick analysis of engineering variants and modifications. Modifications in component analysis documents automatically ripple through the complete assembly and analysis sequence. Moreover, it is easy to replace one component by another one in an assembly or to replace one mesh by another one. The connections will automatically re-established or in case this is for some reason not possible (e.g. major design change), the engineer will be prompted to intervene.

Integration with CAD & Test & Attribute specific post-processing. The fully integrated solution enables to start from geometry, but it is also possible to integrate for certain application test based descriptions of the behavior of a model. On the other side of the process, the assembly is integrated in a global solution which enables solving and post-processing connecting to attribute simulation as well.

LS-DYNA SUPPORT

This section clarifies the current & future support of LS-DYNA in LMS Virtual.Lab. The first focus of the development is the support of vehicle assembly, trimming, and analysis set-up for structural impact analysis.

This includes modeling of LS-DYNA spot weld and other connections between orphan meshes and/or CAD, a comprehensive import/export for most keywords related to crash analysis and set up a complete structural crash analysis with all crash analysis related features (except occupant safety features).

The 1st customer shipment will further extend support of assembly, and model checking will be implementing, especially tools to check and fix intersections and penetrations.

With revision 8 and 9, safety features such as airbag modeling or dummy positioning will be available. These versions will also show Virtual.Lab post-processing functionalities for crash.

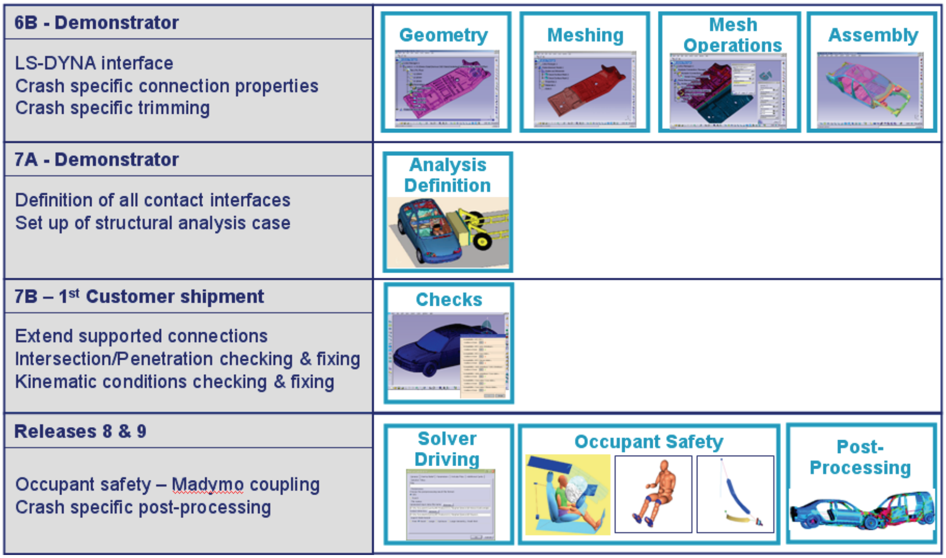


Figure 8: Virtual.Lab LS-DYNA Roadmap

CONCLUSIONS

In this paper, the LMS Virtual.Lab software suite is presented as a proposed methodology to increase the integration and the impact of the different simulation disciplines in the core vehicle design and engineering process. The key benefits of an integrated multi-solver pre/post processor and a multi-attribute vehicle assembly environment are explained and illustrated and the current and future roadmap of crash/impact with LS-DYNA is exposed.

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