Assembly of full-vehicle digital crash models using ANSA techniques

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1 Introduction

The level of complexity of the full-vehicle digital crash models varies between car manufacturers. Undoubtedly, however, it is very high and the trend is to become higher and higher, due to the fact that the development teams want their models to include even more details. During all these years a standard technique, that has become of common use, is the fragmentation of the full-vehicle model into ***INCLUDE** files. Each one contains a distinct physical subassembly of the vehicle, which we shall subsequently name module. This technique offers various advantages, but definitely sets a challenging task. That of connecting the modules to each other and assembling them into a full-vehicle model. Using the embedded capabilities of ANSA we have created processes and tools that enable : i) fast and robust intermodular connections represented by various element types, ii) efficient and reliable integrity check of these connections, iii) the assembly of multi-variant modules, iv) inspection of the connection areas in a lightweight view, v) an error-free update of modules' versions, vi) the overview of the modules participating in the full-vehicle models with aid of graphs, vii) the reusability of already existing models, as the basis for the creation of new ones.

2 Workflow

The data of which a full-vehicle crash model consists are usually stored and maintained by the engineers in LS-DYNA keyword format as ***INCLUDE** files. In many cases the corresponding ANSA files from which these ***INCLUDE**s derive are also available. As a first step of our workflow an automatic procedure undertakes the conversion of both types of data into ANSA Subsystems, ANSA Library items and ANSA Load Cases. These are stored in the ANSA DM (in filesystem) and from that point on are available to the engineer to assembly them, in any combination he wishes, thus creating ANSA Simulation Model/s and Run/s, which can be output in LS-DYNA keyword format files (***INCLUDE**s), referenced by an LS-DYNA simulation main file.

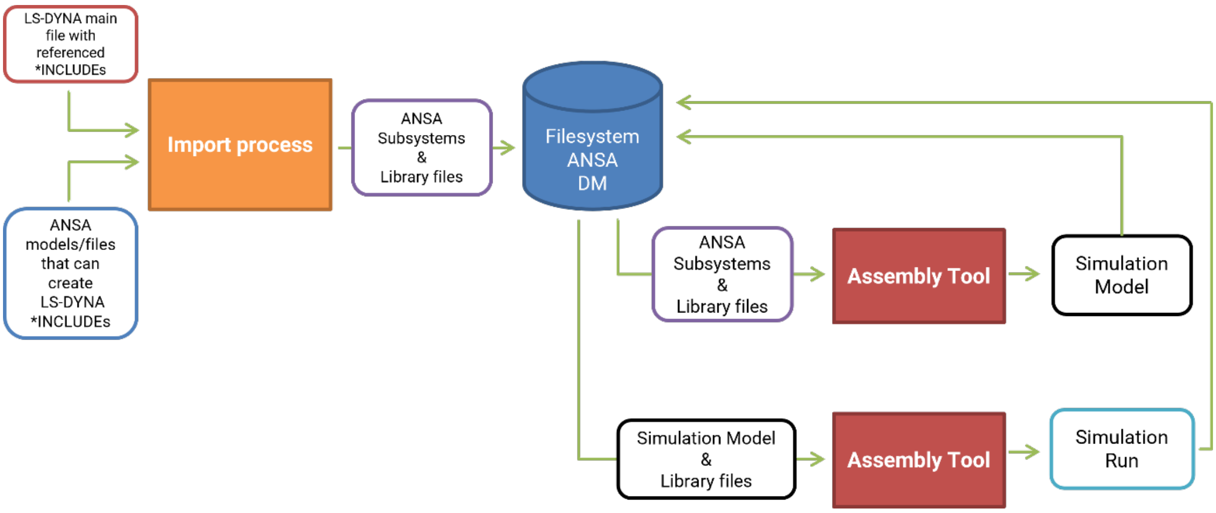

Fig.1: Workflow diagram.

3 Data import process

As mentioned above, the input of this process can be either an already existing LS-DYNA simulation main file which references ***INCLUDE**s and the corresponding referenced files, or/and the ANSA files from which the later are derived. The main actions which take place during the execution of this automatic procedure are :

1. From input files creation of the corresponding ANSA Subsystem entities, stored in the filesystem ANSA DM. An ANSA Subsystem is a container with his own part hierarchy and entities, which stands and can be handled as an individual subassembly within a larger scale model.
2. Identification and marking of the interface points/areas between these Subsystems, by creating automatically ANSA A-Points, which will be used downstream for the assembly procedure. These A-Points can be reused in case an updated version of the Subsystem arrives.
3. Creation of the intermodular (inter-subsystem) ANSA Connectors using the A-Points created in the previous step.
4. In case a module of the model has multiple variants (e.g. the BiW with normal roof and sunroof variant) a MultiVariant Subsystem is created and can be handled appropriately.
5. Multi-instantiated Subsystems are created in case an **`*INCLUDE`** is referenced more than once in the model.
6. Any **`*PARAMETER`** used in the model are also handled.
7. The entities from which the definition of the load case comprises are translated and stored as an ANSA Load Case.
8. The set of Subsystems that compose the model is stored as an ANSA Simulation Model.
9. The combination of the ANSA Simulation Model and Load Case is stored as ANSA Simulation Run.

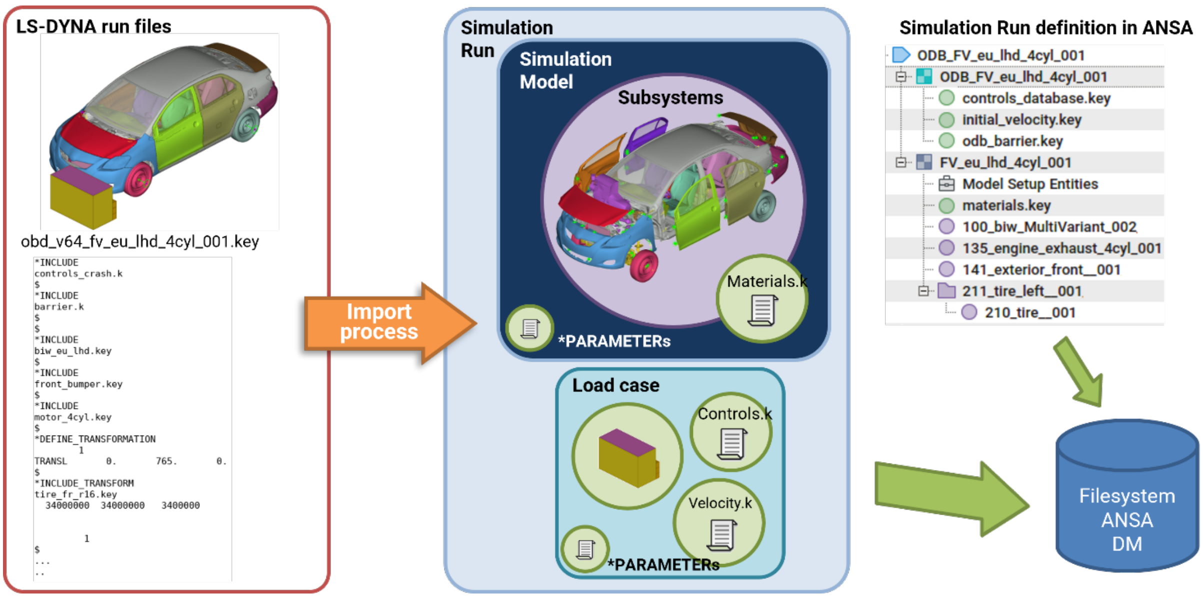

Fig.2: Import of an LS-DYNA run file into ANSA environment and ANSA DM.

4 Intermodular connection

Various techniques and combinations of LS-DYNA entity types are used to model the connection between **`*INCLUDE`**s, which we call intermodular. The ANSA entities, used to represent such connection are ANSA A-Points and Connectors.

ANSA A-Points are generic entities that mark the interface point (node or property, etc.) where the Subsystem is going to be connected with a neighbor one. They can generate interface elements/entities or combination of them, e.g. **`*CONSTRAINED_NODAL_RIGID_BODY`** from the nodes of a hole. The ANSA A-Point offers both a variety of embedded such standard representations and also custom ones. They are an integral part of each Subsystem, meaning they are stored in it.

Intermodular ANSA Connectors create the intermodular connecting entity itself. Particularly in this case, this entity is created between the A-Points of the Subsystems. These Connectors are saved in ANSA DM and are handled automatically during the assembly, with no need of additional maintenance effort.

As described in the previous chapter, the identification of both interface and connection entities for existing models and the creation of A-Points and Connector take place automatically during our import process. In this automatic recognition and creation we support a variety of combinations, such as : **`*CONSTRAINED_NODAL_RIGID_BODY`** - **`*ELEMENT_BEAM`** - **`*CONSTRAINED_NODAL_RIGID_BODY`**, or **`*CONSTRAINED_RIGID_BODY`** (s. Fig.3), and many others.

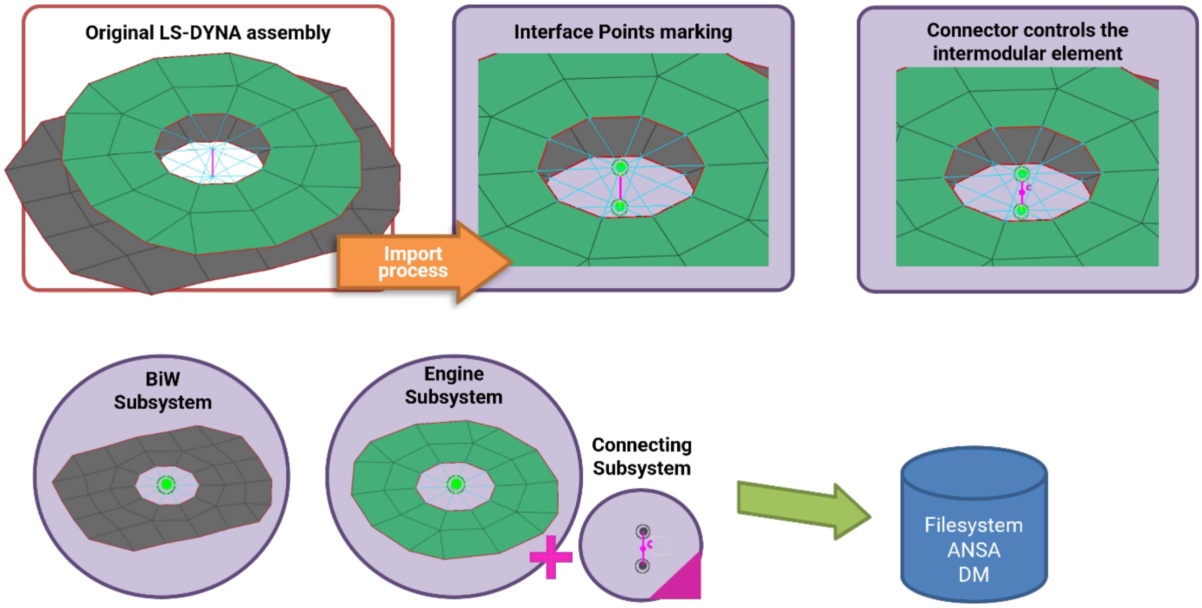

Fig.3: ANSA "A-Point – Connector – A-Point" concept for intermodular connection.

The advantages of the "A-Point – Connector – A-Point" intermodular connection concept are :

- ANSA Subsystems can be prepared in-parallel, independent of each other, ready to be assembled.
- The interface points of each Subsystem are easily identified and selected, so that they can be inspected and used during assembly.
- A-Points can be reused in the newer versions of a Subsystem and regenerate effortlessly the interface elements/entities.
- ANSA Connectors are saved independent of the Subsystems.
- ANSA Connectors can be reused to connect different versions/representations of Subsystems.
- Subsystems are connected solely via the A-Points (robust interface points identification).
- ANSA Connectors can be easily created and maintained (between neighboring A-Points).
- Assembly is validated easier via ANSA Connectors' status in the corresponding list.

5 Multivariant Subsystem

For several modules of a full-vehicle model, there are variants available. Typical examples of such modules are : the BiW, the engine, the wheels, and many other components. ANSA offers the capability to host all these variants in a single file, in the form of Configurations, creating in this way the so called 150% model. This file is converted to a Multivariant Subsystem, which is actually a Subsystem with multiple Configurations. Alternatively, a Multivariant Subsystem can be created from several LS-DYNA keyword files, each one of them representing a distinct variant of the same module.
A Multivariant Subsystem gives us the option to select and use in the assembly process of a Simulation Model the desired module variant, and guides us to select and connect with it only the Subsystems that share the same variant attribute, e.g. a RHD variant of the BiW Multivariant Subsystem is allowed to connect with the RHD variant of the Cockpit Multivariant Subsystem.
In a Multivariant Subsystem each variant has its own A-Points giving to the assembly process the capability to filter and use only the A-Points that belong to the Configuration, chosen to participate to a particular assembly (s. Fig.4).

6 Assembly process

All the Subsystems saved in ANSA DM either following the aforementioned import process or during a model update loop can be listed as shown in Fig. 5. After selecting in this list any combination of them we can proceed to their assembly either in batch mode or by viewing them in ANSA. All the necessary connecting entities needed for the assembly of this particular selection of subsystems are fetched automatically and the integrity of all their intermodular connections is checked and reported (Fig.6).

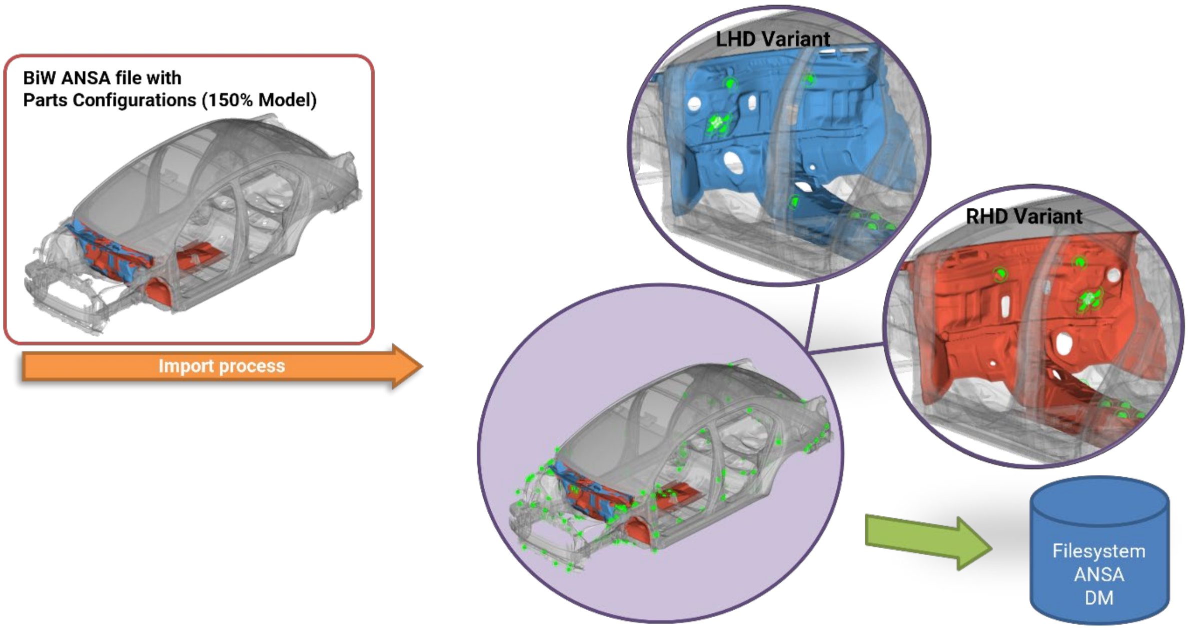

Fig.4: Multivariant Subsystem (BiW) with two Configurations (LHD and RHD).

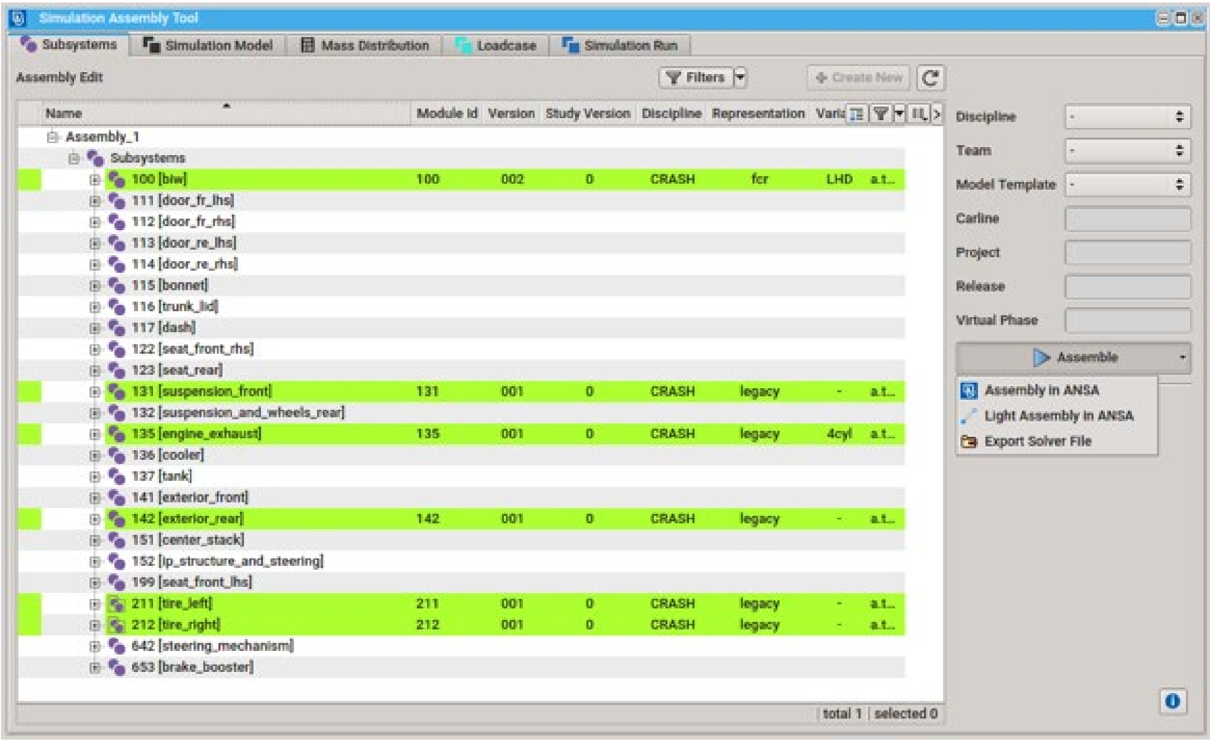

Fig.5: List of Subsystems available in ANSA DM.

When the assembly takes place by loading the Subsystems in ANSA we have the option to perform it in a lightweight view, where just the interface entities created by A-Points of the intermodular connections of the Subsystems and the corresponding Connectors are loaded, facilitating in this way the establishment, edit and check of this connectivity (Fig. 7). When working in this mode, any changes performed to this reduced representation areas are stored to the corresponding Subsystem itself and can be reflected to all its potentially existing variants.

The result of such an assembly is an ANSA Simulation Model which can be handled in a similar way (Fig. 8) and when combined with an ANSA Load Case entity, result in an ANSA Simulation Run.

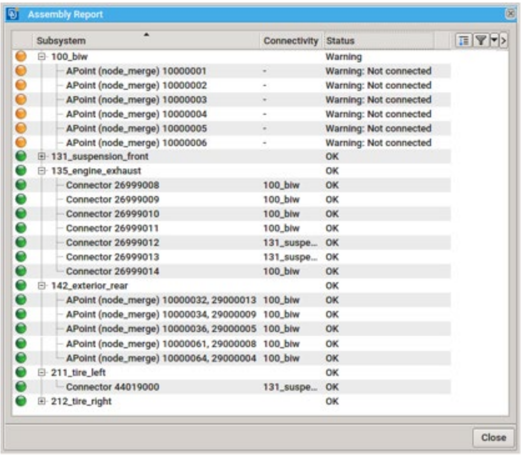

Fig.6: Report for failed and successfully realized intermodular Connectors during the assembly.

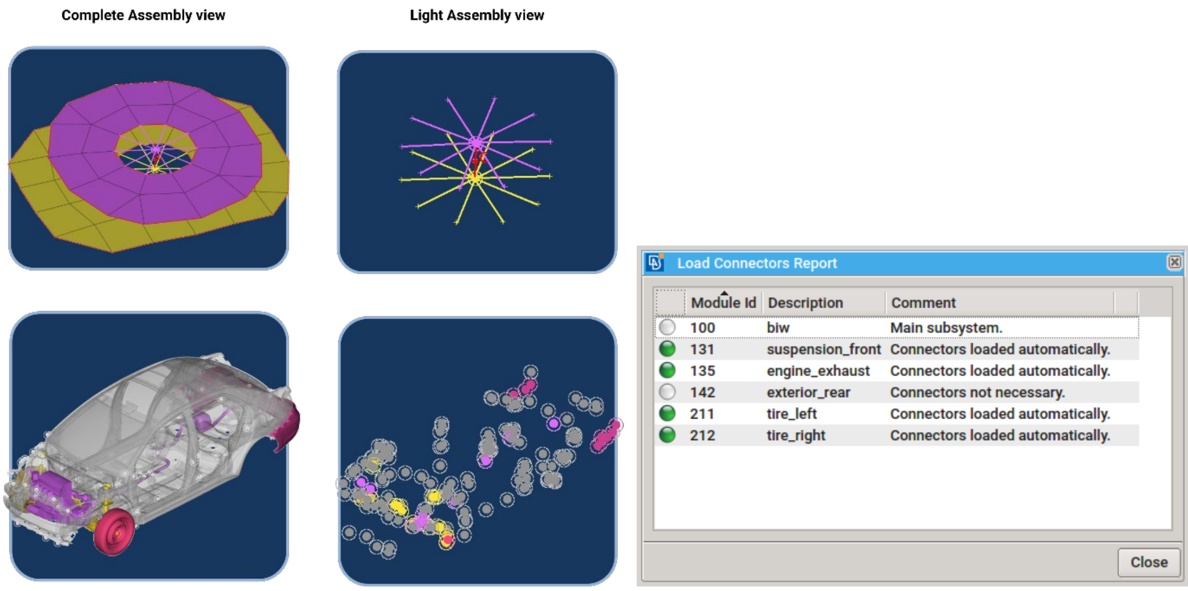

Fig.7: Assembly of Subsystems in full and lightweight view.

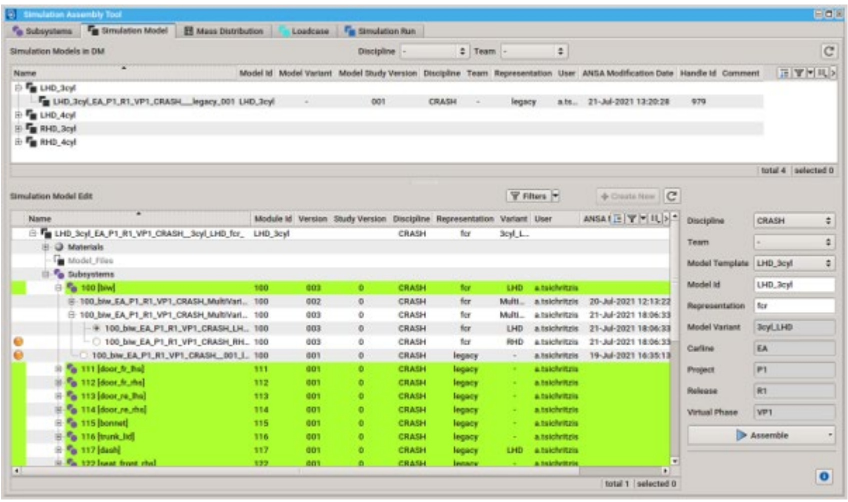

Fig.8: Creation and handling of ANSA Simulation Model from Subsystems.

7 Traceability graphs

Two types of graphs are available in order to have an overview of all simulation data and navigate between their different types. The Lifecycle Graph (Fig. 9) which captures the evolution of a Subsystem during the development cycle, meaning which version of a Subsystem was created from which.

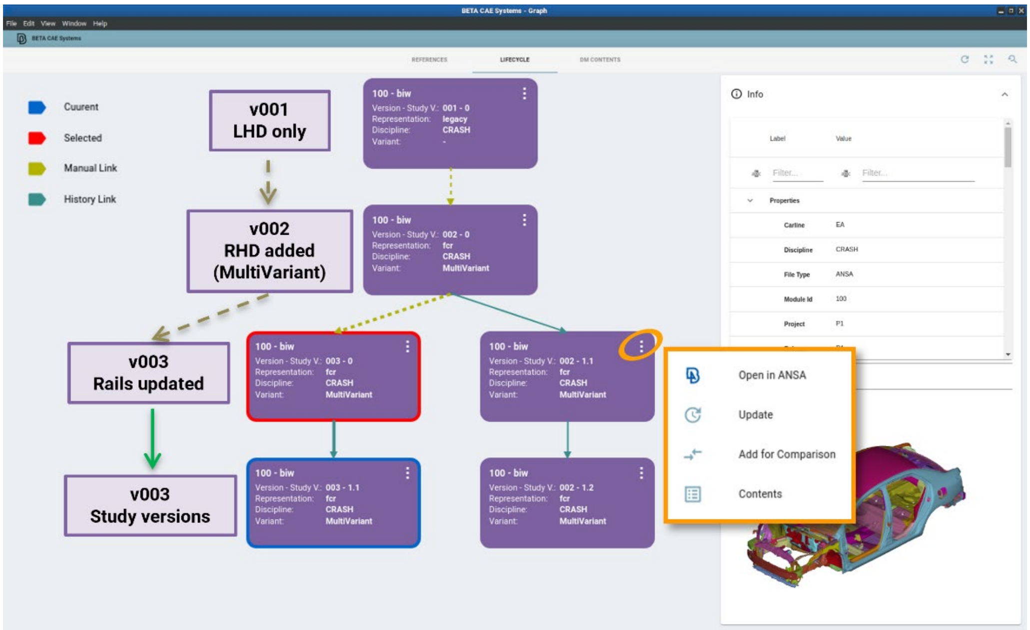

Fig.9: Lifecycle graph of an ANSA Subsystem.

And second, the References Graph (Fig. 10) – a more complicated one - which exhibits the references of a Subsystem in the whole ANSA DM data set, i.e. Simulation Models and Runs, helping in this way, for example, to identify which Simulation Models and Runs should be updated in case a version of a particular Subsystem changes. This graph gives us also the capability to conduct comparison tasks between its entities.

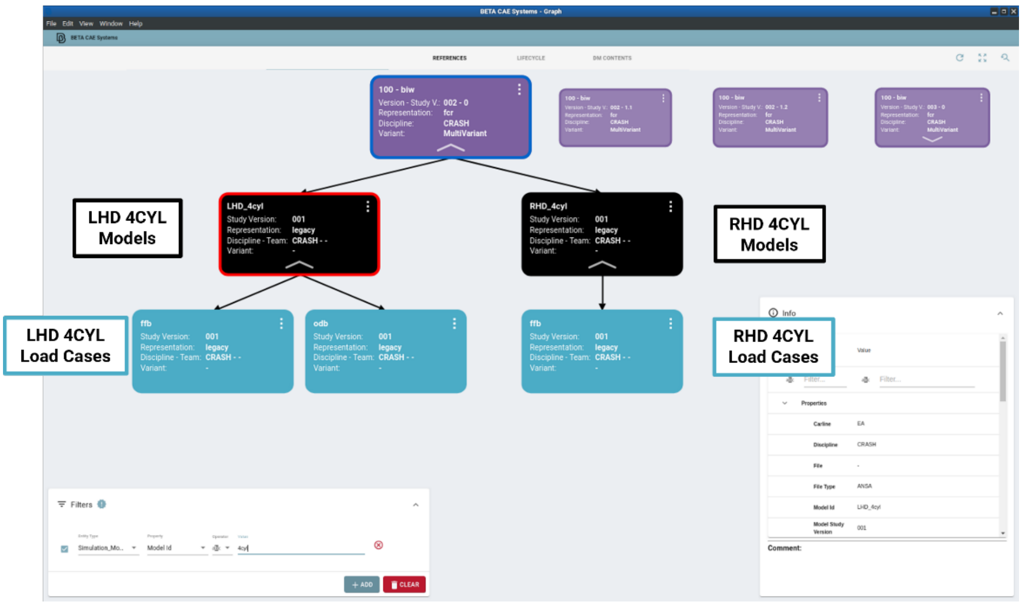

Fig.10: References graph of ANSA Subsystems, Simulation Models and Simulation Runs in ANSA DM.

8 Summary

The assembly process of a full-vehicle digital crash model which was demonstrated here is based on the entities of ANSA data model (Subsystems, Simulation Model and Simulation Run). The key enabler of this process is the “A-Point – Connector – A-Point” intermodular connection concept. All the representations of the intermodular connections, used by crash development teams, can be covered by this concept and its implementation in ANSA. The main target of our effort is the simplification of the assembly procedure of the multiple modules. A target that is achieved within the proposed process, by i) fragmenting the modelling work into smaller, easier, and with better overview tasks, something that has as an additional effect the parallelization of the modelling work, and ii) by automating in the background many tedious tasks that otherwise could lead to errors and waste of time.