Once the preliminary assembly planning (AP) has been performed, a detailed design for assembly (DFA), combined with a detailed AP, can be undertaken. The design of the generic components (GCS) is further specified, the joining processes are determined, the operating methods are chosen, and potential equipment is selected for each operation. Several these topics are still areas of research in our team at the present time. The authors will thus only outline the essential features of the several topics to tackle and mention former results at the basis of future improvements.

This chapter is organised as follows. A short discussion on standardisation of the design amongst the product variants (PVs) is presented in section 8.1. The selection of joining processes and assembly methods is addressed in section 8.2. Section 8.3 describes the detailed AP procedure. The equipment preselection is discussed in section 8.4. An illustrative case study is presented in section 8.5 and conclusions are reported in section 8.6.

1. A detailed DFA principle for PFS: standardisation

It is very difficult to dissociate DFA issues from the remainder of the design process at detailed design stage. As a matter of fact, DFA intervenes in all previously mentioned topics: joining process selection, operating method determination, detailed AP and equipment preselection. Moreover, it is nearly impossible to present detailed DFA rules because they are context dependent. Such issues have been extensively exposed in the literature (refer for instance to [17, 19, 123, 148]). The main ideas to keep in mind are: simplify, standardise, release precedence constraints (PCS). Most of this advice has already been described in chapter 5.

The authors will linger on an issue that was only mentioned previously, and which is of first importance in the design of product families (PFS): standard-
isation. An essential requirement in refining the design of a PF is to stress on varying GCs (VGCS) and optional GCs (OGCS). Ideally, these GCs should have a common reference (see section 4.1.6). This can be achieved through the standardisation of:

- feeding features (used for orientation in small parts feeders);
- prehension surfaces;
- orienting features (for insertion);
- interfaces between GCs.

The need for several resources according to the considered GC variant — especially for handling and insertion — should be an exception, as it increases the cost of the production system and could lead to delicate station designs. This standardisation is very important, because it is one way to ensure the adaptability of the assembly line. Indeed, if all PVs present the same feeding, orienting and grasping features as well as the same interfaces between their GCs, the introduction of a new PV in the PF will be facilitated. The materials of the new GCs should also be chosen so as to avoid questioning the chosen joining techniques. Respecting this advice will often make possible to use the same orienting, prehension and insertion devices. It is also essential to standardise interfaces between functional entity (FEn) variants amongst the PVs.

2. Joining process and assembly method selection

The first stage considered in the detailed AP and DFA procedure is the choice of the joining processes. Ideally, no liaison should add unnecessary degrees of freedom in the PV under construction. This means that all liaisons should be attachments unless they prevent a function of the assembled PF. A DFA principle strives to the reduction of the number of GCs in the PF. However, if a liaison must be dismountable, screws and bolts stay a common practice. In that case, it seems unrealistic to secure all liaisons because it would provoke an unnecessary increase of the number of GCs to assemble. On the other side, attachments are more specific operations than a placement or an insertion, take more time and may require specific resources. Ultrasonic welding for instance, does not increase the number of GCs but asks for expensive equipment. Thus, it seems more realistic to claim for attachments when the number of instabilities generated during the assembly of a PV becomes too high (most often, this means that there are instabilities in more than one spacial direction). Hence, the design of the PF has an important influence on the number of attachment liaisons that will be required to ensure a simple assembly process.

Several references describe joining processes [22, 98, 176, 195, 197] or assist the designer on joining technique selection [32, 51, 145]. Yet, to the authors’ knowledge, there exists no tool considering this selection as part of both