

Volvo learns to use Modular Function Deployment

Applications for Modular Function Deployment™ (MFD™) are found in a wide range of manufacturing companies in widely differing industries. It has been applied in modularization projects for cars, trucks, vacuum cleaners, staplers, grinding machines, servo drives, washing machines and many other products.

Volvo's experience, which began a number of years ago, shows how the MFD method can be applied and what results it may bring.

Platform thinking

The platform design concept means that a number of predefined models can be built from a common base. The common base, according to Volvo's definition, is "everything that gives synergy in knowledge and investments." It might be compared to a Lego® bricks system where it is possible to build many different structures with only a few building blocks.

Intensive efforts are required to implement a platform strategy for the first time with considerably more exhaustive analyses than for a normal new car project. The intention is, though, that it will pay off in the development of consecutive models. Only new features, or planned design changes, will be of concern in the coming development projects (maybe 15 instead of 100).

Volvo's strategy aims at commonality between the assembly plants in Gent (Belgium) and Gothenburg (Sweden). Modular vehicle design makes it possible to build several car models from a common platform. Volvo introduced platform thinking as an economical and customer-oriented way of building cars. The purpose was to achieve advantages such as shortened lead times, higher efficiency in production and frequent model changes. This, in turn, enabled increased sales and lower costs.

With the new platform concept, it was necessary for the production systems in Gent and Gothenburg to be structured alike. With this commonality, the building of different car models could be moved quickly between the plants, corresponding to customer demand in different geographic areas.

The new production system was concurrently developed with product development and design. Staff from the plants worked together with industrial engineers and designers to verify products and processes in the early phases of the project.

With a modularized product structure, Volvo can outsource larger parts of the car to a smaller number of primary vendors. The primary vendors actively participate in product development and shorten development lead times by implementing concurrent development of modules once the interfaces have been defined.

Modularization of a complete car

Modularization of a complex product, such as a car, demands division into modules on several levels. Modularization on lower levels goes on as long as it is meaningful. For manual assembly, the lower limit is about 50 assembly operations per module. Other aspects, such as the wish to create common units or variety, might make it useful to go on with modularization all the way down to single parts.

The division of a complete car into modules on the highest level (Level 1) is seen as generic and commonplace in the industry. This originates from the evolution of so-called "functional areas," grown out of the need to manage work within a large organization. Within Volvo, this division into "natural" modules has been supported by work done on an earlier modularized concept car. Starting out from the functional areas and with the requirement of lead-time reduction, Volvo identified 18 modules on the top level.

To do so, Volvo analyzed the module drivers for the functional areas, as shown in Figure 1. It indicated functional areas with strong or very strong reasons to shape separate module areas and those with weak reasons, suited for integration.

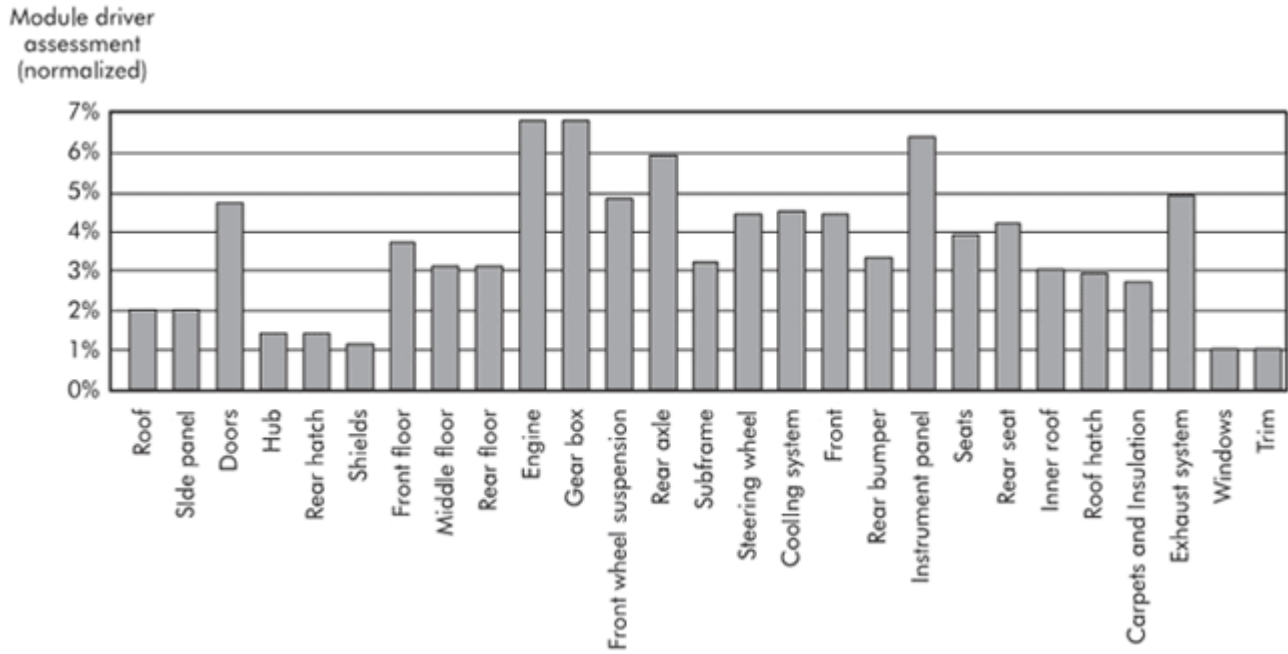


Fig 1. Module drive assessment for Volvo's functional areas.

A horizontal summation of the module drivers in the Module Indication Matrix™ (MIM™) showed how each was weighted (see Figure 2). The module driver profile served as a basis for discussions about strategies, competencies and vital technologies.

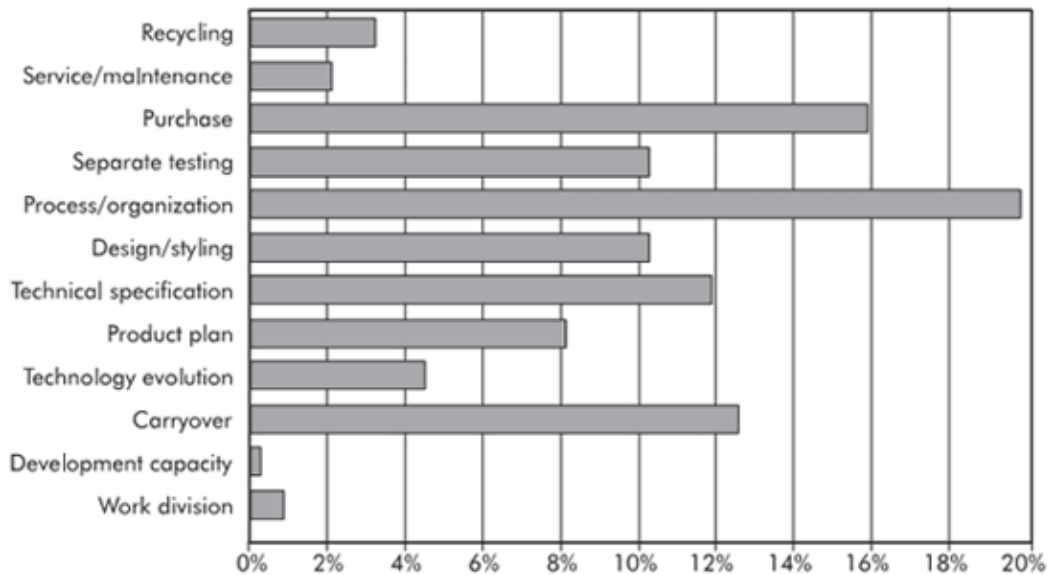


Fig 2. Normalized module driver profile for the functional areas at Volvo.

Based on the Level 1 analysis, modularization work continued on the next module level (Level 2). Three examples of such work are the inner roof, vehicle front and car door.

Part 2 - Cost-driven modularization: The inner roof

In identifying the submodules of the inner roof (Level 2), the project members learned how systematic modularization could be performed.

The project was driven by the production engineering department. The first assignment for the team was a functional decomposition -- addressing the question: "What is the function of each technical solution that is contained, or should be contained, within the inner roof?"

The ideal number of modules for the inner roof was calculated at about six because about 40 parts (or assemblies) were contained there (six is the nearest square root of 40). This ideal number would be valid, provided that the interfaces were so well designed that an interface assembly (modules to each other) could be accomplished in about 10 seconds per interface. If this were not possible, the ideal number would be set lower.

The discussions were intensive, absorbing and very rewarding. Many creative contributions and ideas came from the purchasing people as they expressed quite different views on the matter. The result of the work on the MIM is shown in Figure 3.

Subfunction (technical solution) Module driver	Base frame	Cables	Inner light	Braking light	Padding	Rear clip	In-step handle	Sun shield	Bearings	Mirror	Reading light	Roof hatch connection	Score
	Carryover			●	●		●	●	●	●	●	●	
Technology push		●			●								12
Planned design changes													0
Technical specification	●		○	○				●		○			9
Styling	●												9
Common unit		●	●	●	○	●	●	○	●	●	●	●	65
Process/organization							●	●		●			27
Separate testing													0
Black box		●	●	●				●			●		45
Service/maintenance	●												3
Upgrading													0
Recycling	●	●	●	●				●			●		54
Score	24	36	31	30	5	18	27	40	18	22	36	18	

● = strong relation (9) ● = medium relation (3) ○ = weak relation (1)

Fig 3. Module Indication Matrix for the inner roof.

The six technical solutions that had the highest scores are as follows:

- Sun shield,
- Cables,
- Reading light,
- Inner light,
- Brake light and
- In-step handle.

With the MIM assessment as the basis, the rest of the technical solutions were tested for integration or grouping with one of these module candidates. The final proposal is shown in Table 1.

Table 1 -- Final modules of inner roof

Module	Strongest drivers	Number of variants	Technical solutions
M1 Brake light module	Carryover Common unit	1	Braking light Rear clip
M2 Sun shield module	Carryover	2	Sun shield
M3 Harness module	Technical evolution	2	Cable base and option
M4 Inner light module	Carryover Common unit	1	Inner light
M5 Reading light module	Carryover Common unit	1	Reading light
M6 Base module	Styling Recycling	2 (hatch or no hatch)	Base frame Bearing Padding In-step handle (Roof hatch connection)

Work on the inner roof project was conducted by a large team of 15 persons, which is in conflict with the usual recommendation of eight participants. Too large a group easily becomes inefficient and difficult to manage. Someone often was missing, delaying the process.

However, such difficulties tend to decrease as the project picks up pace. The module driver profile for the inner roof is shown in Figure 4. The weighting of the different module drivers (summed horizontally in the MIM) is given as a percent of the total sum of all module drivers. Thus, the result is normalized and could be used for comparison with results from other teams.

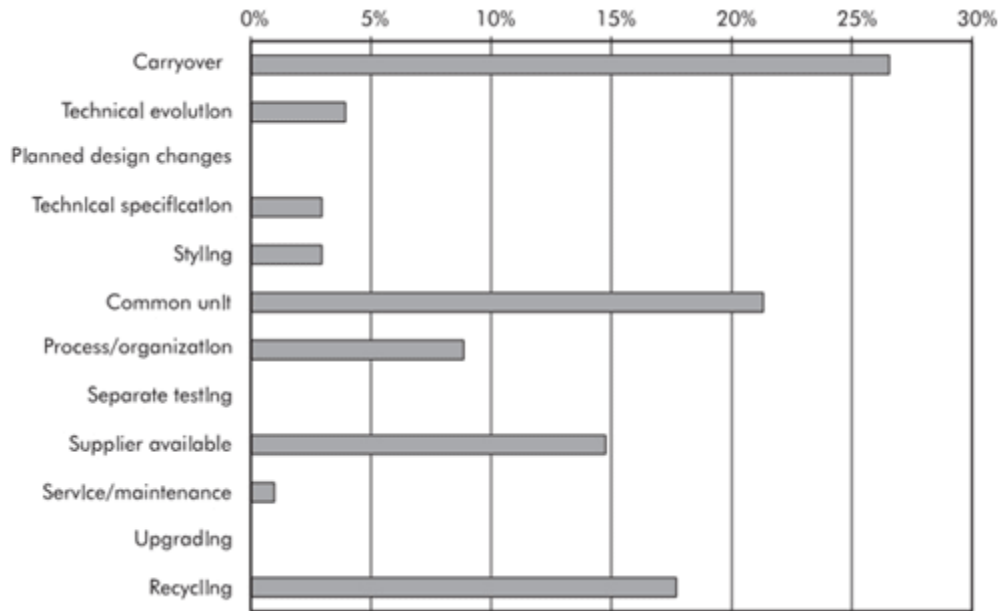


Fig 4. Normalized module driver profile for inner roof.

It should be noted from this profile that the highest-weighted module drivers concern internal company issues (carryover, common unit, supplier available), while more customer-oriented drivers received very little attention.

Clearly, the team values are directed toward building cars as cost effectively as possible and with respect for the environment. However, a modular product affords the opportunity to be more aggressive, using planned design changes and styling to attract customers.

Part 3 - Seeking integrated and holistic design

Vehicle front

Two modularization projects for the car front were conducted. One was initiated by the production engineering department at the assembly plant for Volvo 940/60, the other by the module team for the vehicle front in the ongoing development project for new cars.

The purpose of the assembly plant project was to define how the front of existing cars could be redesigned to make assembly easier. The front assembly created assembly line balance problems, and the assembly work contained many ergonomically uncomfortable conditions. The operator often had to crawl down into the engine compartment to fit all the components. A front module that could be pre-assembled and then fitted complete onto the chassis was desired.

The purpose of the new car project was to evaluate the MFD method and give the vehicle front team the necessary data for a future modularized front (Level 2).

In the project initiated by the assembly plant, the work was conducted in a team mostly made up

of production engineering staff, while the new car project was conducted in a cross-functional team dominated by process planning staff.

Figure 5 shows details of the module driver profiles generated by each team. For further comparison, the profile for the inner roof is also included.

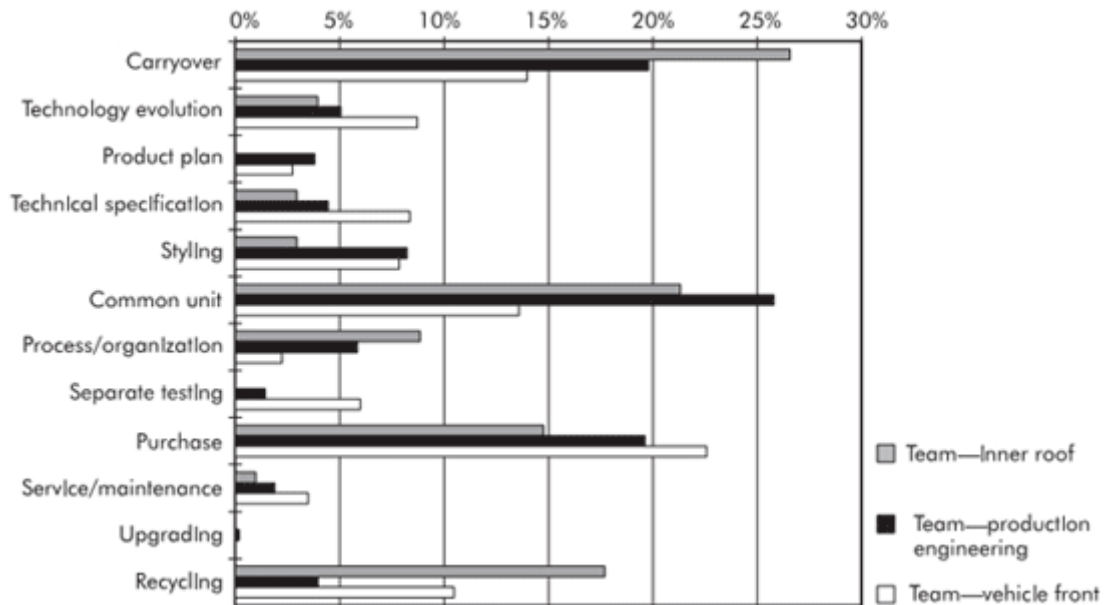


Fig 5. Module driver profile for three different modularization projects at Volvo.

A comparison between the production engineering team and the vehicle front team (the new car project), reveals that the production engineering team focused on a modular design to simplify assembly work. The search for common units and carryover can clearly be seen. A modular design with a high percentage of such features will improve the possibilities for increased automation, as well as create conditions that make manual assembly work easier.

At the same time, it is clear that the production engineering team does not expect greater technical evolution and/or planned development. The vehicle front team, more cross functional, has slightly greater expectations. A far-sighted modularization provides for needs within both process and product development. However, this requires that all interests are represented on the project team, in other words, a cross-functional project team.

Comparison with the inner roof module driver profile shows that different parts in a product have different property demands. The inner roof profile reveals stronger reasons to form a module for easier recycling than the vehicle front, so those involved with the inner roof should have special competence in material and environmental issues.

The driver profile serves as an excellent base for choice and allocation of resources and competencies within different parts of the company. It also helps coordinate work in different module areas to achieve overall company strategic objectives.

In Figure 5, it can be seen that all teams have focused on the purchase driver, which might reflect the overall trend in the car industry today. A high degree of integration is sought, with a limited number of vendors who are responsible for complete systems.

Car door



In earlier research, modularization of a car door (inside) was studied in connection with the introduction of Volvo's model 800. In the 800 model, assembled directly on the final line, all parts in the glass lifting device were grouped into a so-called "door cassette" that could be outsourced to a vendor. In doing so, it was assumed the assembly costs would be reduced by 60%. The door cassette, however, actually increased logistics costs because a special packing material was required. This had not been assessed during the modularization of the door. Also, the door cassette only fit the 800 car model.

Two engineering students from the Chalmers Institute of Technology (Gothenburg), in cooperation with Volvo staff, conducted a new systematic modularization supported by the MFD method for the door. The objective was to improve the cassette design by creating a more holistic base for the modularization. This time, the work encompassed all the subsystems in the door, not just the glass lifting device.

The resulting proposal indicated that the door should be divided into seven modules. The new design did not contain a complete lift cassette. Instead, a divided lifting device was proposed. Because of its common unit driver, the driving motor was proposed to be integrated in a larger "inside plate" module. The lift rail was grouped together with the glass in a type-dependent variant module. Space requirements led to two different solutions for the lift rail, one with a wire lift and the other with a cross-arm lift. If the lifting mechanism was integrated with the inside plate, it would disturb the commonality and prove unsatisfactory.

The car door example shows the necessity to implement a holistic approach to modularization before a particular module concept is adopted. Otherwise, there is an obvious risk for suboptimized modules.

If you want to read more: "Controlling Design Variants: Modular Product Platforms," by Anna Ericsson and Gunnar Erixon, published by the Society of Manufacturing Engineers.