MIT INTERNATIONAL MOTOR VEHICLE PROGRAMME

MODULARIZATION AND OUTSOURCING PROJECT

PRELIMINARY REPORT OF EUROPEAN RESEARCH TEAM

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REPORT SUMMARY

BACKGROUND

- European IMVP team has met with Fiat, Ford Europe and Renault, plus all the major door and cockpit module suppliers in the region
- The research has identified two possible routes to outsourced modules. In some cases, the modularization decision is made as part of internal assembly optimisation efforts (some with Neo-Fordist characteristics), with the outsourcing decision following consequently. Alternatively, modularization and outsourcing can occur simultaneously, with OEMs moving directly to externally procured modules. The latter route is common at greenfield sites
- There are certain links between modularity and platform strategy – both are driven by similar goals
- Modularization and outsourcing are possibly related to European OEMs' adoption of lean production and supply principles in the specific European context – certainly, supply base changes have aided the development of outsourced modules
- OEM attitudes differ, but all are investigating the concept and seeking supplier quotations. Even the Japanese in Europe are contemplating outsourcing modules.

OEMs

- Three different strategies appear to drive modularization in Europe:
  - assembly ergonomics
  - increasing reliance on suppliers for technological competitiveness
  - cost and asset reduction
- In addition, maximising engineering resources in the age of multiplying model numbers makes outsourcing engineering tasks attractive
- Cost and asset reduction calculations complex – OEMs often unable to justify outsourced modules on a purely financial basis, unable to capture true costs of in-house assembly and report inconsistent decisions between plants due to methodology failings
- Correlation between attitude of OEM to investors and emphasis on asset reduction clear
- One OEM now demanding that suppliers pay for tooling. This fundamental change has a multitude of implications
- There is no apparent correlation between vehicle size and/or volume – initial implementation on small cars is apparently driven by the model replacement cycle rather than any other factor. However, we believe that there is a correlation between vehicle line profitability and the willingness to try new assembly and sourcing approaches
- Labour cost advantage of outsourced modules of relatively low significance in Europe – any advantage is regarded as temporary.

SUPPLIERS

- Modularity is leading to rapid revenue growth at many suppliers - although profitability growth lags due to margin dilution from bought-in parts
- M&A is a significant factor in development of interior module suppliers – 12 significant acquisitions in 3 years identified
- Quality gains appear material – ppm numbers up compared to individual components but overall vehicle quality enhanced. Control of 2nd tier selection an ongoing debate
- Cockpit module suppliers hail mainly from a background in IP manufacture - door modules from window regulator supply. Current suppliers may be a constraint on full integration
- Standardization of components within the module a possibility and offers many potential gains – but may be incompatible with integration
- Cockpit modules more prevalent in Europe than doors, but both growing rapidly.

1.0 INTRODUCTION

1.1 OBJECTIVES OF MOP

The Modularization and Outsourcing study is a three continent research project funded by the MIT International Motor Vehicle Programme. The study originated from the observation that a major shift was underway in the mode of operation of the industry, above and beyond the well documented trends of tiering and reduction of the supplier base.

Study borne out of IMVP Assembly Plant Survey

IMVP was particularly keen to investigate the development of modularization, and the apparently related trend of outsourcing, given the objectives of the Assembly Plant Survey, the Programme's comparative benchmarking of OEM assembly plants. The task of the Survey has become increasingly complex due to the fact that a rising proportion of the tasks that have traditionally been the domain of the OEM assembly plant are now being carried out by suppliers. The disparity in approaches between OEMs and regions also appear to be considerable, making the job of comparing assembly plants problematic. IMVP felt that as key aspects of automobile manufacturing have changed, benchmarking of vehicle production needed to change to take into consideration not only the operational features of the OEM assembly plant, but also those of the key suppliers working with the OEM to produce the vehicle.

Round 3 of Survey currently underway

With Round 3 of the Survey underway in 1999 (Round 1 having been carried out in 1989 and Round 2 in 1994), and researchers and sponsors keen to understand more about these significant trends, the decision was made to first, devote a significant proportion of the Assembly Plant Survey to the issues of modularization and outsourcing and second, to launch a separate, detailed study of the trend using in-depth case studies of OEMs and suppliers involved in such activities.

Modularity most advanced in interior

Following consultation between sponsors and IMVP researchers, in which a variety of approaches and subjects of study were discussed, it was decided that the advanced state of modularization and outsourcing of the interior of the automobile made it the most suitable area of study. Whilst modularization in other functional areas is underway (such as suspension, exhaust, electronics and braking) and growing, it was decided that the emphasis of the research should be on modules that were already in production on a significant scale for a variety of OEMs.

Doors and cockpit modules selected for study

US sponsors proposed that the project examine the development of modularity in the door and study the various approaches (both in production and at the design concept stage) of participants in the industry. Consultation with European sponsors widened the study to include the cockpit of the car, also variously known as the dashboard and Instrument Panel (IP). The study, undertaken by researchers in the US, Japan and Europe has therefore examined both these modules over the last year, but the nature of the research means that both other interior components (i.e. seats) and other modules (such as suspension) have been discussed. As the study progresses, and our investigation of the OEMs' various approaches to modularity and outsourcing gathers pace, we expect to provide greater analysis of other modules and the whole vehicle.

European research team

In Europe, research for the Modularization and Outsourcing Project ("MOP") has been undertaken principally by Professor Mari Sako of Said Business School at the University of Oxford and Max Warburton, at the School of Management at the University of Bath. In addition, Dr. Fiona Murray of Said Business School has contributed to the Project, focusing particularly on the relevance of R&D and advanced technology for modular design. Our US colleagues, Professor John Paul MacDuffie of the Wharton School and Professor Frits Pil of the University of Pittsburgh have also joined us on certain research visits.

1.2 OBJECTIVES OF THIS INTERIM EUROPEAN REPORT

Initial findings in Europe

The purpose of this report is to provide sponsors, participating suppliers and other IMVP researchers with an overview of our findings to date in Europe. The report will attempt to draw together our initial findings from research visits to OEM sponsors and first-tier suppliers and highlight some of the areas that we think are most significant and most worthy of further investigation.

More detailed report and academic papers to follow in 2000

The report is by no means comprehensive and many of our thoughts and ideas cannot be validated until we complete the detailed empirical analysis that we are planning for early in 2000. We encourage readers to bear in mind that this summary will be replaced by a considerably more detailed and comprehensive report next year, plus some articles on specific areas of research.

The report starts with a discussion of the perspectives of the OEMs we have met with, looking particularly at the origins of modularity and outsourcing, the links between the two, and the variety of factors that have supported modularity at the OEM level. It will then discuss the suppliers' perspective, looking at strategy, the development of capabilities and M&A in the sector. The report will then focus in detail on technical solutions and operating issues for first, door cockpit and second, door modules. The report will then conclude with a summary of what we deem to be the most significant issues at this interim stage and outlines our plans to research these issues in greater detail over the coming year.

1.3 PARTICIPATING COMPANIES

IMVP sponsors - plus other OEMs to follow

We have met with all IMVP's European sponsors over the last year, with particular emphasis on Fiat Auto, Ford of Europe and Renault. In addition, we have approached other European OEMs and hope to meet with them in forthcoming months.

Most suppliers in region have now participated

In parallel, we have identified, sought meetings with and visited the majority of suppliers that are engaged in the production of cockpit and door modules in Europe. The input of the suppliers has been very valuable and most wish to be involved in the forthcoming empirical data collection exercise and are supportive of the idea of specialised workshop (discussed at the end of the report). Participating suppliers are listed below.

Table 1: Participating suppliers in Europe

Company	Business	Location
Brose	Door modules and window regulators	Coburg (HQ) & Hallstadt, D (main module production)
Delphi	Cockpit and door modules, wiring; other.	Wuppertal, D (European technical centre)
Faurecia	Cockpit and door modules, seats;other	Boulogne, Paris, F (HQ)
Kuester	Door modules, window regulators, cables	Ehringhausen, Frankfurt, D (HQ and module production)
Lames	Door modules, window regulators	Fiat Mirafiori, IT (located in Chiavari, IT)
Magnetti Marelli	Cockpit modules	Fiat Mirafiori, IT
Sommer Allibert Siemens	Cockpit and door modules	Meru, F (R&D centre)
Textron	Cockpit modules	Basildon, Essex, UK (European module HQ)
TRW-Lucas Varity	Wiring harnesses, cockpit components	Solihull, UK (Electrical Systems)
UTA (Lear)	Wiring harnesses, electronics	Paris, F (European HQ)
Visteon	Cockpit and door modules, wiring; other	Basildon, Essex, UK (European module HQ)

Remaining module suppliers to follow

As far as we are aware, the only suppliers engaged in (or close to winning business in) the supply of either cockpit or door modules in Europe that remain outstanding are Magna, Mannesman VDO, Meritor and Valeo. We are currently arranging meetings with these companies.

Suppliers of components to non-modular designs also sought

In addition, we are seeking meetings with suppliers of components that go into cockpit and door modules but that appear to be assuming a second tier or non-modular role. HVAC suppliers such as Behr, Hella and Denso, lock/latch makers such as Kiekert and Huelsbeck Fuerst, and wiring harness makers Bosch and Draexlmaier are likely candidates. If the reach of the study is expanded to include other modules, then we may seek meetings with suppliers of other components.[i]

Contract engineers may be relevant too

Finally, following our review of the research visits now completed, we intend to seek meetings with contract engineering companies, particularly those with knowledge of steel panel fabrication and body architecture, such as Mayflower PLC and Wagon PLC.

1.4 RESEARCH METHODOLGY TO DATE

Initial case studies – with quantitative survey in early 2000

The research to date has taken the form of detailed case studies and discussion, aimed at building up a picture of the state of play in cockpits and doors in Europe and identifying the most significant issues worthy of further investigation. We have met with key personnel at both OEMs and suppliers. On the OEM side, we have met with senior strategy, purchasing, manufacturing and engineering personnel (including those at board level), plus operating level purchasing executives and managers.

At the suppliers, we have typically met with personnel in strategy, finance, engineering and sales. We have also visited manufacturing sites and inspected modules in production.

Contribution to global study

This case-study based approach has, we believe, successfully prepared the way for more detailed empirical, comparative analysis, to be undertaken over the forthcoming year. In addition, it will allow us to draw some thorough comparisons with modular trends in the US and Japan, and consider how the approaches to modularization and outsourcing *within* OEMs with multi-national market and production locations differ.[ii]

2.0 THE OEM PERSPECTIVE

2.1 THE BACKGROUND TO MODULARIZATION AND OUTSOURCING IN THE EUROPEAN AUTO INDUSTRY

Is Modularization a European led phenomenon?

When the Modularity and Outsourcing Project was first initiated, a number of sponsors and other interested parties suggested that we would find that modularization was most advanced in Europe. To some, modularization is a phenomenon partially driven by the particular circumstances and *modus operandi* of the European industry. While we have found some support for this perspective, the increasingly global nature of the industry means that developments as significant as modularization and outsourcing cannot be implemented on a purely regional basis. In fact, although there are numerous examples of module use in European OEMs, the implementation of modularity and outsourcing is typically part of a global strategy, with the trends at OEM greenfield plants in less developed regions often at a more advanced stage.

Greenfield sites in emerging markets encourage OEMs to seek benefits at home

Although new plants in emerging markets appear to be allowing (or, possibly, compelling) OEMs to experiment with modularity and outsourcing, our initial understanding is that the use of modules was originally pioneered in Europe by European OEMs. We would be interested to know readers' views on the first use of the term 'module' in the auto industry, and perspectives on which OEMs originally led the way. It appears that modules were first employed by European OEMs in the mid to late 1980s to address their concerns about differentials in labour productivity and rising labour rates. They revised their production systems to employ a high level of mechanised and robotised processes and, while much of the acceleration of automation during this period occurred in the bodyshop, modules - with the advantages of off-line pre-assembly and quick, expedient fitment - were also a part of such initiatives.

First internal cockpit module appeared on 1985 Omega

We understand that the first example of an internally manufactured off-line cockpit featured on the first Opel Omega – launched in 1985 and built at Ruesselsheim. The Omega cockpit integrated the Instrument Panel (IP), steering column, and pedal box to form a subassembly. The offline assembly tasks allowed good accessibility, and the workers were relieved of the error –prone work area of the foot pedals inside the car body, a task that historically involved strenuous physical work.[iii]

..…by contrast, first door module was outsourced

By contrast, we understand that the first door module was externally procured – supplied by Brose for the 1987 Audi 80 coupe.

Fiat's Tipo a pioneer

There appears to be some consensus that Fiat's Cassino plant and its Tipo platform broke new ground in the use of modules. In 1980, Fiat management reportedly concluded that 'the major cost of bringing a new car to market is the capital equipment and facilities required and *not* the car's design and development' (other OEMs we have met actually emphasised that the engineering cost is almost as significant). Fiat therefore embarked on a programme for the Tipo model that simplified the car's design and assembly and maximised the opportunities for component sharing across the Fiat marques (variants included the Lancia Dedra/Delta, Alfa 155, Fiat Tempra). The link between modules and a platform strategy (pioneered, in its modern sense[iv], by the Tipo) is notable and will be returned to (see below).

Tipo employed a number of pre-assembled modules

Fiat's approach to the Tipo's design and assembly can be described as a modular approach, with consultants Group Berkt reporting that 'in 1989, Cassino and the Tipo were the benchmarks for modularization projects', and that 'variability in design is linked to the individual modules, moving it away from the main assembly process, which simplifies automation and permits its justification over more products and provides a longer economic life'.[v]

The Tipo employed a number of pre-assembled modules, such as the cockpit (which Fiat informed us already contained dashboard, steering wheel and pedals grouped together), and a limited door module (an inner door panel with some components attached). The majority of these modules were internally designed, manufactured and assembled.

Modularity and platform strategy may be related

We understand that the success of the Tipo platform was one of the factors that encouraged other European OEMs to pursue platform strategies. While modularity and platform strategy do not necessarily have to be linked, certain OEMs perceive them as related trends. Conceptually, a platform strategy shares some common goals with modularization (certainly an outsourced module strategy - the links to an internally procured module strategy are less compelling), including:

- lowering development, tooling and asset costs for a new model
- maximising the engineering resource of the OEM to deliver variants and shorter model cycles
- allowing easy model facelifts
- increasing flexibility of assembly plant utilisation
- gaining some scale economies (debatable in the case of modules at this stage of development).

Certain OEMs that we have met with regard the pursuit of modularity as a trend related to platform strategies, although we were told that 'platforms bring more significant gains than modules'.[vi] Supporting this, VW report that 'modularization takes place so to speak on the secondary level, its objective being a stronger differentiation from the customer standpoint.'[vii] VW believe that modularization allows greater flexibility to produce variants and/or niche cars – as standard fixing points/interfaces allow new customer facing modules, such as Instrument Panels, to be replaced without altering the architectural hard-points of the car. In addition they report that modules, in combination with platforms, considerably shorten product development times - due to the use of existing product architecture

and developed modules.

Other European OEMs followed Fiat lead

The efforts of European OEMs post-Tipo support this assertion, with platform strategies, most notably that of VW, given great recognition. However, most European OEMs have also sought to accelerate modularity, including VW, Renault, and the US OEMs operating in Europe.

Chrysler also influential

Undoubtedly, the experiences and objectives of Chrysler in the US influenced the attitudes of European OEMs to modularization and outsourcing. The company's use of co-operative development programmes with its suppliers, as one of a number of policies used to tackle financial difficulties in the late 1980s and early 1990s, have been well documented. From discussions with European OEMs, it is apparent that the success of Chrysler's approach with suppliers, initially on the L/H model - which saw the company devolve a considerable amount of design, engineering and assembly responsibility – has been influential on European OEM strategy – encouraging them to consider outsourcing as part of the modularization decision.

Is modularity static or accelerating?

Research interviews to date have not provided sufficient information on the historic, current and probable future pace of the development of outsourced modules. We intend to explore this in some detail over the next year, to follow up on various disparate suppliers' views (some enthusiastically regard it as an inexorable onward march, others believe that certain OEMs are cooling on the idea and limiting the potential of modularity through dual sourcing or taking work back in house[viii]), and our perspective on the impact of the recent decision by certain key European manufacturers to accelerate the use of modularity.

2.2 LINKS BETWEEN OUTSOURCING AND MODULARITY

One of the objectives of the MOP Project has been to seek an understanding of the connections between outsourcing and modularization. Whilst documented examples of outsourced modules provide the clearest and most well known cases of 'modularity', the two trends are not necessarily interdependent. As discussed, the Tipo provided examples of internally manufactured modules and in most modern assembly plants a number of offline assemblies can be seen being built up in-house. Indeed, the split of an automobile into assembly-optimising areas is standard in the industry.

Some OEM functions believe there is no convincing data to support outsourced modules

A number of individuals that we interviewed in the OEMs insisted that most, if not all, of the benefits of modularity can, theoretically, be accomplished just as easily in-house as by suppliers. We have heard it argued that if the OEM organisation were set up into 'module based teams', then the part and weight reduction, functional integration and pre-installation quality testing benefits could all be achieved. These gains may be significant and tangible, but an internal approach still fails to provide *the opportunity* for making further gains potentially available from outsourced modules (whether they are actually achievable is a further issue, see below).

Typically, modularization precedes the outsourcing decision

Originally in the OEMs, modularity may have been an internal decision, driven principally by production demands for simplified assembly line processes and additionally motivated by engineering and purchasing departments' drives for reduced weight and parts. Such an approach has then typically led to the development of outsourced modules - as the OEM recognises the further potential benefits and the presence of suppliers who have, or profess to have, relevant capabilities. It appears to be the case that by moving to internally assembled modules, OEMs find it easier to compare 'like with like' when considering outsourcing. Certainly, despite the argument from certain factions of the OEMs that the benefits of modularity may be as easily achieved internally as externally, we have found that most companies now involve the purchasing function in any modularization decision - few now regarding modularization as a purely internal procedure.

E.European greenfield sites may support a simultaneous decision

Alternatively, some OEMs have moved *directly* to outsourced modules due to either first, a strategic level decision to embark on such a course or second, the need to develop a new production facility and car model (typically for a subsidiary) with a limited amount of capital and existing plant (the Skoda plant at Mlada Boleslav is probably the best example).

Do interior module suppliers have the technical expertise of systems suppliers (e.g. Bosch)?

The two step process that we have portrayed has logic, but overlooks one important constituent – the importance of suppliers' technological expertise. Looking to other areas of the car, one sees instances where suppliers' control of technology and engineering in certain vehicle systems and components have long been substantial in Europe (i.e braking, electronics). We do not yet have sufficient information to assess the importance of this factor in the modules of study (doors and cockpits), but our initial opinion would be that suppliers' technological contributions to the two modules of study have been slower to develop and are still in gestation. While module suppliers are constantly bringing technical solutions to the OEMs we observe that, at this stage, the expertise possessed by current integrators, and the continuing involvement of OEM engineers in the design process, means the structure and technologies of both modules have yet to differ radically from traditional OEM in-house designs (although more radical ideas are at the concept stage). Our analysis of those companies acting as module suppliers discusses this issue further (see Sections 4.1 and 5.1).

Modularization and outsourcing now increasingly inseparable

In conclusion, we would observe that while modularization and outsourcing can be distinct, separate trends, most members of the European industry (greenfield sites may be the exception) have historically taken the decision to modularise first, and then used it to facilitate outsourcing. We would argue that while internally procured modules are a response to manufacturing imperatives, they are a development that further increases the likelihood of an OEM accelerating the use of externally sourced modules. Furthermore, we believe that the particular local conditions and operating environment of Europe have accelerated the convergence of the two trends. These factors are many, but include:

- on the product side: capacity-driven price competition, increasing feature demands; etc.
- on the industrial side: labour union issues, brownfield sites, need to reduce capital investment; etc.

Although the relative importance of such factors may influence whether an OEM moves to outsourced modules, we would observe that much of the European industry now regards modular supply as a key part of the outsourcing decision, and *vice versa*.

2.3 HOW DOES MODULARITY RELATE TO LEAN PRODUCTION?

How does modularity relate to production systems?

The evolution of production systems in the automotive industry is well documented. Every practitioner and observer is familiar with the origins and rise of mass production and Fordism, the subsequent development of lean production (or Toyota Production System), and the spread and implementation of lean production by US and European automakers. One of the pertinent issues relating to modularity and outsourcing is the question of how the trends relate to these modes of production and, specifically, the widely observed shift from mass towards lean production. In particular, the fact that anecdotally (and supported by the findings of the IMVP Japanese research team) the Japanese OEMs appear to be reluctant to embrace outsourced modules might suggest that modularity is a development that may be a separate, tangential or even opposite to lean production.

Modularity more easily arrived at after European attempts to embrace lean production and supply

Our initial findings lead us to regard modularity as a development that has been partially permitted by, and probably even stimulated by, the spread of lean production – but in regions with their own particular local circumstances that are distinct from those where lean production is found at its zenith. While outsourcing and devolved responsibility for design and manufacture have been a feature of auto production for a number of years, and the boundary between the vehicle manufacturer and assembler has been constantly shifting since the earliest days of the industry, we would suggest that it is possible that the European interpretation and implementation of lean production – which arguably still differs from the production systems in place in Japan – may be a contributory factor behind the development of outsourced modules. Most significantly, supply base reduction and tiering are factors that have helped to make outsourced modules a possibility.

But Europeans and US, not Japanese, have developed it

We intend to revisit the issue of global differences in the adoption of modularity in subsequent work when we draw together the research of all the regional IMVP teams. However, perhaps we can start the debate by suggesting that it is somewhat surprising, or even ironic, that modularization appears to be a phenomenon that the Japanese OEMs have been slowest to embrace, if at all - given that the industry structure that has permitted modularization to arise may well be founded on the Japanese approach to vehicle design, engineering and assembly. The original IMVP work and its description of lean production in *The Machine that Changed the World* documented the fact that under the Japanese system, suppliers held more responsibility, had longer term relations and, through the use of 'black-box' design, possessed certain areas of greater technical expertise.

Modularization a logical extrapolation

In some ways, it could be argued that modularization is a relatively obvious extrapolation of the trend towards a lean auto industry. Once OEMs have revised their approaches to design, engineering, manufacture and procurement, it is a potentially logical step to devolve even greater

responsibility for these activities to the supply base and to encourage integrators of functional assemblies and systems. Why then does it appear that it is the European and the US industry that has pioneered modularity, rather than the Japanese? Some commentators argue that production systems at Japanese OEMs are so lean that they 'leave little flexibility for insertion of modules without disrupting line balance'.[ix] In addition they argue that labour cost differentials between suppliers and OEMs are less significant in Japan than in Europe and the US, but we would argue that this is of only minor significance, as our fieldwork suggests that it is not a particularly relevant factor in Europe anyway (see Section 2.9).

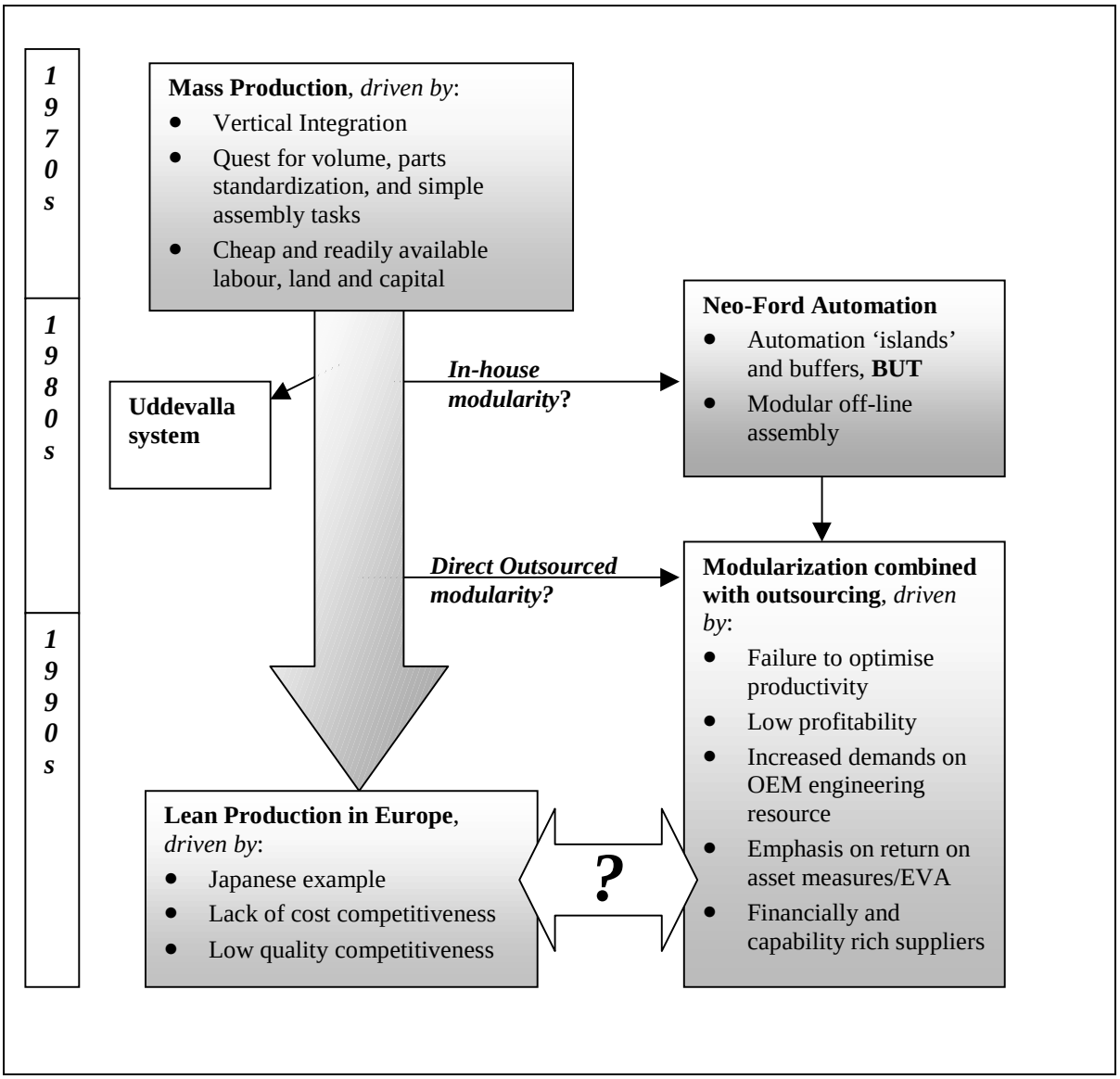
Why have modularization and outsourcing developed in Europe and the US?

While we will explore these issues more fully in the coming year, we would argue, at this stage of the research, that modularization and outsourcing have developed in Europe and the US due to first, OEM production systems being at a particular, probably lower level of efficiency than the Japanese[x] and second, the following additional factors:

- Despite strong labour unions, relatively more easily realised gains from reducing plant headcount
- More easily available land for supplier parks, which may be essential for large scale modularity
- Greater pressure on European and US OEMs to perform against investor imposed return on capital employed measures, which encourages asset reduction (vs. Japanese OEMs' easy access to low cost debt capital)
- More dynamic and independent suppliers, better able to pitch for business to a number of customers and raise finance for capability enhancing acquisitions
- Powerful marketing functions in European and US OEMs demanding high levels of product complexity (complicating assembly task and making removal of complexity from plant attractive) vs. lower level of permutations on Japanese models

We have drawn up a basic schematic of how we believe modularization may fit in to the general evolution of production systems from mass to lean, and we hope that it will be possible to test and validate these very preliminary ideas over the coming year.

Figure 1: A schematic for the possible relation between modularity and production systems in Europe



2.4 DEFINITIONS OF MODULARITY, MODULES AND SYSTEMS

Industry has given thought to definitions

Most of the OEMs and suppliers we met with seemed to have given considerable thought to arriving at definitions of 'modularity', 'modules' and the distinction between them and 'systems'. In some companies, such definitions were enshrined in policy statements and directories – and a number of personnel we interviewed turned to company documentation to provide us with such definitions.

Term 'module' is a misnomer

Before discussing these definitions, we believe it is important to point out that the term 'module', as used in the auto industry, is really a misnomer – now institutionalised in industry parlance but arguably an incorrect term. The Oxford English Dictionary defines a 'module' as a 'standardized part or independent unit in construction'[xi] and while modules as deployed in the auto industry fit the latter criteria – as independent units assembled

separately – they rarely have any element of standardization about them. We would argue that the term 'module' should imply an element of standardization and commonality – with different modules being interchangeable between different 'host' locations (i.e. standard modules should be able to fix into standard interfaces on different OEM's products). In the case of modules in the auto industry, this is patently not the case (although simple assemblies, such as a wheel and tyre, do share common industry standard interfaces – i.e. a standard sized wheel hub). In some cases, the interface between the module and the architecture of the car may be simplified – reduced from a multitude of different fixing points for previously separate components to a limited number that allow quick and easy fitment – but there is almost no element of standardization or commonality across different OEMs. In essence, modules in the auto industry are just sub-assemblies specific to one production model – groupings of adjacent components that reduce the complexity and time taken in the plant for assembly. However, as we discuss in Section 3.6, we believe that there may be scope for increased commonality in the future.

Typical definitions emphasise outsourcing and pre-fitment testing

The definitions used by the OEMs we have met with reflect the realisation that modules are just sub-assemblies. Typical definitions of a module include " a group of components which are physically close to each other, that are assembled and tested outside our facilities and which can be assembled very simply onto the car". Note the fact that a module is explicitly defined as an outsourced item and note also the emphasis on pre-testing of the module – a common theme in such definitions. Definitions of systems show similar consistency, with a typical example being "a group of components that have functional links and combine together to influence an operational characteristic of the vehicle".

From discussions with suppliers, we have learnt that most of their customer OEMs employ very similar definitions for modules and systems, and the differences between the two. However, VW apparently uses the two terms interchangeably – both used to denote what others would define only as a module. Similarly, Mazda report that 'modules are generally classified as a group of parts, classified according to their functions'.[xii]

Suppliers' definitions of modules and systems match those of their customers closely. However, with many suppliers zealous to emphasise their abilities to supply whole modules, the term is often used rather optimistically – a simple IP with a few additional plastic parts often described as a 'complete cockpit module' in sales literature.

2.5 ERGONOMICS

Three different strategies drive the development of modularity

Our initial fieldwork has provided us with three distinct strategies that have driven OEMs towards modularization (plus a fourth, less emphasised, complimentary factor). None of these three strategies is exclusive to a specific European OEM – all factors affecting all OEMs to some extent - but the relative importance of each differed amongst the OEMs we interviewed.

Modules a response to ergonomic problems

Of the three stategies, the least complex is the one that explains the use of modules as a response to the desire to improve assembly process ergonomics. Essentially, this perspective revisits the discussion above of internally manufactured modules coming first, which prepared the way for

outsourced modules. This was certainly the experience of one OEM, that reported that modules were first utilised to reduce assembly complexity (which was increasing as product specification increased) and worker injuries (at the time the OEM was preparing for an increasingly high average age for assembly line workers). Developing modules (essentially just subassemblies) for offline assembly had tangible efficiency, quality and worker welfare benefits.

Japanese OEMs will consider internally made modules, as part of line flexibility efforts

Certain Japanese OEMs that have publicised their investigations into modularity also focus on the ergonomic benefits of modularity, in combination with its role in improving line flexibility and balance. Mazda, writing in 1997, report that modularization of a car's hood/bonnet and lift gate/rear hatch reduced work time by 2.52min/unit (from 23.46 min/unit),[xiii] removed 'blind' assembly tasks, lessened fatigue and improved quality.

Interestingly, Mazda regard modularization as a key part of efforts to maximise the efficiency and line balance of a mixed model production system (in combination with common parts, sequential supply and automation). Mazda, which in some plants produces four or five different models on the same line, sought to reduce line length, increase flexibility and use sub-assembly lines to absorb the extra work load required for some models through effective line balancing. Mazda report that 'in reducing walking distances by using a modular structure, we can shift main line assembly jobs to sub-assembly lines. In the case of the door module, as the station pitch length of the sub-lines is shorter than those of the main line, workers at the sub-lines walk fewer steps. As a result, total work time is reduced'[xiv]. Notably, reporting details of their efforts to adopt modularity, Mazda also record that there was resistance amongst product engineering to production engineering's initiatives, due to concerns about the need to revise the car's architecture and reorganise product development.

Internal modules allowed European OEM to compare like with like

The European OEM concerned with ergonomic gains reported similar objectives and achievements. With a number of assembly tasks taken off the main assembly line, assembly tasks were made more ergonomic, reducing the need for workers to move with the line, stretch into uncomfortable positions and undertake tasks that they could not see directly.

The OEM explained that this assembly driven approach accelerated the use of outsourced modules as comparison of costing and other benefits was eased by internal modules – since the assembly task, whether by the OEM or a supplier, were now essentially identical. The subsequent approach of the OEM, which has outsourced cockpit, door and front-end modules, supports this assertion.

2.6 TECHNOLOGICAL COMPETITIVENESS

An alternative perspective was provided by an OEM that argued that one of the principal, if not *the* principal objective of modularization and outsourcing (in combination) was the benefit to technological competitiveness that it can bring. This view has profound implications for the well versed discussion of the relative power between OEMs and suppliers.

Modularization a key part of purchasing strategy

At the OEM concerned, modularization is part of a very well defined set of imperatives that determine purchasing strategy, that include cost reduction, a shift to systems co-design and the globalisation of purchasing. The OEM has taken a group wide strategic decision to modularize and, from our interviews, it was evident that outsourcing is now regarded as a central part of modularization. The OEM has identified 10 modules that the engineering and product development functions are encouraged to adhere to. These 10 modules include the cockpit and the 'inner door'.

Systems suppliers have priority

Interestingly, returning to the issue of the differences between modules and systems, the OEM reported that, while it is currently studying how to improve the interaction between system suppliers and module suppliers, at present a system decision has priority over a module decision (i.e. a system will be specified first (such as the car's wiring system), and if components of that system cross the boundary of a module, then the module supplier must integrate the system supplier's component (such as a wiring harness), rather than his own choice.

Increasingly, suppliers are proving to be the source of competitive technology – through integration and scale

The OEM concerned feels that, if it is to remain technologically competitive, then one of the most efficient ways to do so is to task suppliers with developing, engineering and supplying modules. It believes that there are two advantages to this. First, a supplier acting as an integrator may be better positioned to develop new technologies and to make other gains. Second, it spares the OEM from the direct investment cost and from having to research a number of different technologies that may not come to market. In addition, it was clear that the OEM believes that constant dialogue with suppliers allows it to keep abreast of what competitors are working on, through the intermediary of the supplier. The OEM concerned was not alone in its pursuit of this objective, which we believe is of crucial significance. It has often been argued that US and European suppliers are able to ensure confidentiality between projects for different customers, with effective 'Chinese Walls' in place – yet two OEMs that we have spoken to have stated that outsourcing modules and systems to suppliers allows them to monitor and gain knowledge of what competitors are doing, to avoid being outflanked – an extraordinary development.

OEMs feel that information leakage about competitors plans advantageous – reduces risk of being caught out

If suppliers are acting as intermediaries - transferring ideas and helping to ensure equality of technology between OEMs – then we believe this has not yet been well documented, and merits further investigation. We note however, one recent case that shows that suppliers are still able to preserve confidentiality between projects for different OEMs. An OEM, due to be supplied with seats for a forthcoming medium sized MPV by a US supplier has, we understand, had to postpone production for up to a year to re-engineer the vehicle after a competitor – supplied by exactly the same seat maker – revealed its new medium MPV with seating for 7, rather than the category standard 5.

Is reliance on suppliers for technology a sustainable policy?

We regard a decision by an OEM to turn to suppliers for technological competitiveness as highly significant. An OEM which has an annual production output that can be measured in the millions that increasingly regards itself as unable to first, fund technological breakthroughs itself or second, offer suppliers sufficient volumes to command control of new developments, places itself in an interesting *long term* strategic position.

Indeed, one of the significant findings of our research has been confirmation that certain European suppliers have now become so large and powerful that they are challenging OEM decisions – notably by refusing to develop and supply dedicated technology solutions to OEMs with anything other than the highest volumes.

2.7 COST AND ASSET REDUCTION

The cost and asset advantages of outsourced modules were only cited as the overriding gain by one OEM. However, we would argue that this may possibly be *the* most significant factor driving modularization, despite the other advantages often stated.

Cost

Accurate calculations extremely difficult

Although it is complex to separate out cost and asset reduction gains, cost is perhaps the more easily defined component of this argument, since asset reduction is so hard to calculate. One would expect to find that a move to outsourced modules would only be undertaken by an OEM if there were compelling proof that such modules offer cost advantages. However, such judgements are beset with difficulties. We intend to explore this more fully in the coming year, but at present we have yet to identify any consistent approach between OEMs in their calculations. Such calculations, it is clear, need to include analysis of costs including:

- direct labour
- indirect labour
- material and component costs
- purchasing department costs (incl. warranty)
- plant (i.e. building) costs
- land and space costs
- scrap and quality control costs
- overhead cost and split
- design and R&D costs
- capital costs

Inconsistent decisions between plants/models suggest methodology problematic

The OEM that emphasised the central importance of cost insisted that the decision to outsource was only made when there was compelling financial support for doing so – yet personnel within the company report that decisions between plants are inconsistent (i.e. in the manner in which modules are used and/or delivered) due to the lack of a standard methodology, explaining that ‘you can prove whatever you want’.

We have interviewed senior financing personnel from one OEM in order to investigate the company’s approach to the make/buy decision, and intend to revisit the other OEMs to complete this part of the research. However, it is already clear from our interviews that OEMs are not always convinced that they have developed methodologies that allow them to fully calculate, with any accuracy, the total costs of external and internal supply. It is apparent that OEMs will consider outsourced modules, even if the immediate cost calculations do not show tangible gains – believing instead that, even if the cost gains cannot be measured, a total ‘gain’ is

realisable – possibly at a future date due to a variety of factors including technology gains, (supplier) volume gains and reduced future (OEM) investment. One OEM supplied us with their standard make/buy analysis template, which contains a number of lines for estimates of 'other costs', - a best guess estimate, due to the difficulty of actually defining costs such as sunk costs, allocation of overhead and central, non-product specific, R&D expense.

We will discuss our plans to investigate in more detail the financial arguments for modularization and outsourcing in Section 6.

Asset reduction

Some correlation between shareholder emphasis of OEM and outsourcing

The asset reduction part of any calculation is more complicated. The significance attached to this factor by the OEM appears closely correlated to its relative reliance upon, or attitude to, publicly held equity and its consideration of the performance measurement tools employed by the investment community. Those OEMs that are in closest communication with the investment community, and pay most attention to acting in a way that supports their share price (often encouraged by employee stock option schemes), are probably most concerned with maximising their performance against measures such as return on assets. By contrast, those OEMs with large minority shareholders (typically families or, in the case of VW, the local government) or those perceived as national institutions with employment responsibilities, may be less concerned - although such a distinction is fast diminishing.

Capital raising difficult for industry – encouraging focus on minimising capex

Certainly, our initial research has revealed such a relationship, with the principle of asset reduction given greatest emphasis at the OEM we would classify as most concerned with its stock market perception. However, we also note that certain decisions made by VW may be similarly concerned with minimising capital expenditure. Despite the large shareholding of the local government (Lower Saxony with 19.6%) and some perception amongst the investment community that VW is unconcerned about certain performance measures (especially EVA), VW appears to have been cautious in its use of capital when investing in new models, plants and brands – possibly due to the capital market's lukewarm reception of its capital raising efforts in 1997 (where an attempted rights issue only succeeded in raising half the amount sought – due to investor reluctance to provide capital when investment plans were unspecific). Such an analysis, if it is correct, suggests that even those OEMs that appear to be less concerned with the investment community are affected by its decisions, and the moves by other European OEMs to publicly embrace the concept of maximising shareholder returns (such as Fiat), implies that the importance of asset reduction as a driver of modularity can only accelerate.

Dual strategy to reduce capex

From our research, we have become aware that OEMs are increasingly concerned with the capital expenditure demands of new models. In the intensely competitive European market, making an adequate return on a new model is exceptionally demanding. OEMs are aware that the investment community analyses both operating profit margin (even at a model level – hence the emphasis on small car profitability) and return on capital employed. Irrespective of the exact method of calculating this latter measure, it is clear that the more an OEM is able to minimise capital

expenditure, be it on plant, tooling, R&D, or engineering, the better the company's performance will be – the operating profit margin being improved by a reduced depreciation charge, and the return on capital employed measure being boosted by a reduced asset base.

With this in mind, OEMs are increasingly eager to avoid investment in fixed assets, leading to a dual strategy:

- reduce the need for new body and component development with each model cycle (through a platform strategy and the use of common parts and 'on the shelf' technologies respectively)
- minimise expenditure on tooling and manufacturing plant.

Only one European OEM currently demanding that suppliers pay for tooling

While the former appears well advanced amongst European OEMs, the latter strategy appears less developed. OEMs appear to recognise that modularity is a convenient way to get suppliers to fund the design, development and assembly of significant parts of the manufacturing process. Furthermore, the most financially driven OEM that we have met with has sought to persuade suppliers to actually pay for the tooling for the modules that they will manufacture and assemble. This, we believe, represents a fundamental change in the industry structure, driven by two main imperatives:

- pushing the risk of investment in dedicated assets onto suppliers
- reducing the cost of model facelifts and redesigns – the OEM believing that if suppliers are responsible for tooling costs, they will invest in far more flexible equipment that can be altered easily to produce new modules (i.e. suppliers will reduce the asset specificity of their tooling investment).

Does supplier owned tooling represent a new industry paradigm?

In addition, we believe that such a shift in the funding of the industry's capital investments may represent a further, possibly unintended goal with externalities:

- the development of a supply base that can minimise the investment mistakes made by the industry by allowing rapid, easily facilitated changes in the dedication of component manufacturing assets, which may allow suppliers to sustain profitability despite involvement in failed models (the latter increasingly likely as the industry seeks product diversity and ever more distant niches).

While certain suppliers that we have talked to believe that such a new structure for the industry is inevitable, and are not concerned about their (the suppliers) ability to fund such tooling investments, other suppliers, including some very sizeable companies, are extremely concerned about it, stating categorically (both to us and to OEMs) that they will not pay for product specific tooling.

Detailed analysis of this development in the coming year

We believe that this issue deserves detailed investigation in the coming year and we intend to undertake a detailed analysis of the demands being made by OEMs and the experiences and attitudes of suppliers to this development. In particular, we would like to investigate the efficiency of such a form of industry financing where, initial investigation suggests that suppliers, if smaller than the OEM, will incur higher financing costs (both

debt and equity) than the vehicle assemblers which ultimately, the latter will pay for. [xv]

For further analysis of financial issues, please refer to Section 3 and Section 6.

2.8 MAXIMISING CURRENT ENGINEERING RESOURCES

A supplementary factor, mentioned by all the OEMs we have met with, was the fact that outsourced modules can theoretically ease the engineering burden placed on the OEMs. The industry believes that there are four key factors that are forcing up the level of engineering needed to deliver a competitive model range on to the market – which, if OEMs are to avoid raising their fixed costs, requires them to seek the support of external engineering resource:

- Rapidly falling average vehicle life expectancy in the market
- Increasing demand for niche models – with many OEMs having to react rapidly when a competitor opens a successful new niche
- Increasing complexity and specification of product
- Increasing customer intolerance of any quality problems or slow production 'ramp-up' during the vehicle's first year.

The table below shows that the average volume per platform is rising – by 33% between 1990 and 1999. While this would suggest that engineering effort might be falling (per new vehicle developed), the consensus is to the contrary, with the proliferation of niche models (total number of models up 84% between 1990 and 1999) requiring ever increasing amounts of engineering resource. Therefore using module suppliers, who can provide a flexible, readily available body of engineering resource (that can instantly transfer from one OEM to another as their model cycles show some segregation – rather like the aerospace industry) is attractive.

Table 2: Analysis of European Industry model proliferation and platform use

	1990	'92	'94	'96	'97	'98	'99E	'00E	'01E
No. platforms in use (all Europe)	60	64	63	57	56	53	51	45	45
No. body types offered (all Europe)	88	109	125	139	148	157	162	170	178
Av. No. bodytypes/platform	1.5	1.7	2.0	2.4	2.6	3.0	3.2	3.8	4.0
Av. Volume by platform ('000)	212	199	193	224	241	273	283	316	326
Av. Volume by body type ('000)	144	117	97	92	91	92	89	84	82

Source: Salomon Smith Barney, 11 June 1999

2.9 MODULARITY, VEHICLE SIZE AND VOLUME

Modularity may be driven by profitability pressures - especially on small cars

A number of OEMs noted that modularization as a strategy has been given greater emphasis due to the intense profitability problems facing the industry. We have heard the expression 'necessity is often the mother of invention' during our research visits, and believe that European OEMs, facing intense price competition, high capacity and rising standard specification levels, are increasingly prepared to try new approaches in their quest to increase, or even just to achieve profitability. It is therefore perhaps logical that there appears to be some correlation between the use of modularity and vehicle size. In the main, modularity appears most advanced on smaller vehicles – the low level or loss making nature of B or sub-B class cars forcing OEMs to adopt new engineering and manufacturing strategies.

We have also questioned the OEMs and suppliers that we have met with about any potential correlation between vehicle volumes and modularity. The general consensus is that, at this stage of development, the strategic and financial imperatives of modularity are independent of vehicle volumes. Instead, the OEMs that we have met with have typically explained that the deployment of modularity is largely a function of the model replacement cycle (i.e. it is a coincidence that small car models are the first to be replaced following the adoption of modularity), we believe that there is a correlation between car line profitability and an OEM's readiness to try modularization (and labour unions willingness to accept it). We sought to establish whether there was any significant explanation for why modularity remains less developed on large vehicles, particularly sport utility vehicles (SUVs). Those with knowledge of the US industry typically reported that the main explanation resided with the fact that many SUVs are old designs (some with their origins in the 1970s), but we believe that there may be some correlation between the profitability of these vehicles and their non-modular production – the high profits reducing the likelihood of OEMs investigating new production and procurement methods.

OEMs often use niche models to experiment with modules

A complimentary perspective, gained from our research, is the use of niche models to experiment with modularization and outsourcing. A number of pioneering modules, and the use of outsourcing, have first appeared on OEMs niche models, where the risk of failure is less acute (i.e Audi TT, Mercedes M-Class)[xvi]. We believe that there is evidence that the success of these experiments may often pave the way for more widespread deployment of modularization across and OEM's product range.

2.10 LABOUR ISSUES

Labour cost on a module relatively insignificant

In the existing literature and commentary on modularization and outsourcing in the auto industry, reference is often made to the importance of lower labour costs in the decision to outsource. From our initial research with OEMs and suppliers we would conclude that it is of lower relevance than is widely perceived. The proportion of cost in a module allocated to labour surprised us. Typically, a cockpit module takes 20-35 minutes to assemble, which means that, even at a unionised OEM plant, it is unlikely to cost much more than $25 per module (including other on-costs such as social security). Splitting out other, overhead, labour (such as

plant managers, security, maintenance etc.) is complex, but typical estimates suggest this has a piece price cost of less than $10 a module.

Suppliers typically have lower labour costs, but the $25 direct labour cost in the plant for a complex module is unlikely to drop to much less than $15 in a supplier's plant. This $10 maximum gain is not of huge significance for an item with a piece price of between $600 and $1200 (depending on complexity and car type) – a saving of only 0.75% to 1.5%. Notably, one supplier emphasised to us that while labour cost is only a small part of total module cost, it is a more significant part of variable cost, so remains a notable factor in certain outsourcing decisions.

Suppliers insist they must offer far more than lower labour costs

However, suppliers emphasise that if the only attraction to OEMs of using a module supplier is lower labour cost, then their long term position is probably untenable. All the suppliers we have met with emphasised the fact that their long term position is only sustainable if OEMs recognise their integration, design expertise and project management abilities- rather than their marginally cheaper labour.

Even if suppliers can offer cheaper labour, there are other factors that can minimise this advantage, principally:

- Pressure on suppliers from OEMs to take the latter's redundant labour (which continues on OEM rates)
- Possible creeping unionisation of supplier plants (Delphi and Visteon labour in the US remains UAW dominated)
- Falling labour cost differentials over time due to the close location of supplier and OEM plants (often right next to the assembly plant on a supplier plant).

The issues surrounding unionised labour in the OEM plant and the movement of assembly tasks to suppliers are complex. Some of the suppliers we met with have had to set up specially structured arrangements to ensure that they can benefit from lower labour cost. At one supplier, assembly work is subcontracted to a logistics company that is not bound by the need to employ unionised labour at the OEM customer's rates. The supplier must be careful, for legal reasons, not to be seen to be supervising the assembly labour – instead, it utilises a manager who liases with a supervisor employed by the logistics company. Similarly, at another supplier, they have established a joint venture with a logistics company – in which the logistics company has a majority stake (51%) – allowing the J.V. to employ workers at non-unionised rates. While such arrangements are carefully crafted, we would argue that the need for them is relatively temporary – for modularization and outsourcing must be justified in the longer term by factors other than lower labour costs.

We intend to explore the implications of modularization and outsourcing from a labour relations and social perspective over the coming year - and to seek more substantial data over the coming year to validate our interim conclusions (see Section 6).

3.0 THE SUPPLIER PERSPECTIVE

3.1 DEVELOPING MODULAR CAPABILITY

Suppliers pre-occupied with advertising modular abilities

The terms 'module', 'modularization' and 'modularity' are perhaps some of the most widely used in the automotive industry at present. Suppliers with origins in a wide variety of components fill the pages of specialist publications with claims about their expertise and capabilities in modules. Headline merger and acquisition activity is explained by the need for suppliers' to deliver systems and modules. Undoubtedly, there is a widespread perception amongst the supplier community that their roles and the demands of their customers are changing. But what exactly do suppliers need to offer to participate in modularity? Our initial research has sought to investigate a number of issues relating to the supplier community including an assessment of which firms in Europe are now able to supply cockpit and door modules, how they have arrived at their respective positions, the capabilities they currently offer and the capabilities that they believe they need to develop.

OEMs expected to accelerate deployment of modular sourcing

The fact that firms from all backgrounds are claiming modular capability is indicative of the consensus in the industry that OEMs will continue to rationalise and reduce their supply bases. The efforts made to be recognised as a modular supplier appear to be an extension of the rush to maintain first tier status in recent years - with a perception amongst suppliers that a direct relationship with the OEM is essential to ensure long term prosperity, or even survival. Whilst modular supply is probably at too early a stage to provide conclusive evidence, suppliers appear to be acting on the basis that higher profitability and growth are most likely for direct suppliers. It seems that suppliers entering the module market are being driven by either one or both of the following factors:

- a positive desire to pursue growth
- a more defensive posture seeking to avoid marginalisation.

Modularity has benefited some suppliers greatly – with CAGR of over 15%

Certainly, a number of the suppliers we have met with have experienced very rapid growth – both organic (i.e. internal) and through acquisition. The rates of organic growth that we have noted in certain module suppliers are pretty remarkable for the mature automotive industry (Brose, the door module supplier, tripled sales between 1990 and 1998 – representing compound annual growth of 15.2%) - and suggest that for certain participants, modularization has been highly beneficial. For others, the position is less clear. Modularity, whilst it has boosted top line revenue, has not always brought incremental gains in profitability – a point we discuss later (see Section 3.3. However, it appears that few suppliers have made the strategic decision NOT to attempt to offer modules and that, at present, most are working on the assumption that they must try to compete in the race to achieve integrator status.

3.2 M&A IN THE EUROPEAN SUPPLIER INDUSTRY

Modularity may be influential but is only one of many drivers

In their efforts to compete in the module market, a number of suppliers are engaging in mergers and acquisitions activity. However, such activity must be assessed in a more general industry context with influential

factors such as:

- A mature industry operating in a business environment where M&A, irrelevant of sector, is accelerating – with senior management, capital markets and other 'stakeholders' increasingly willing to support it
- Continuing supply base reduction and constant pressure from the OEMs for annual price reductions
- OEMs increasingly demanding that suppliers follow them globally
- Smaller, low growth firms becoming increasingly less attractive to investors, with large, index-classified firms gaining greater support due to the growth of index-tracking funds.

Modularity easily digested concept for financial advisors and consultants

In addition to these industry wide factors, we believe that the desire to compete in the modular market is driving some M&A activity. Not only is it a relevant issue for suppliers, but it also an easy and digestible concept for consultants and investment banking firms to pick up on and use as a focus for their advisory activities – which may have a significant influence on firm strategies.

M&A amongst European suppliers relatively slow to develop – with many private companies still significant.

In the modules that we have focused on, M&A activity has been significant, although perhaps not as extensive as one might expect given the general industry concern about modularity. Amongst Europe suppliers, the importance of privately held companies, a different 'equity culture' and an apparent willingness to establish joint ventures may have limited M&A to date. However, the situation amongst US companies offers an interesting contrast, and the greater willingness (and financial ability) of these companies to engage in M&A has also been a feature of the market in Europe – with some of the most substantial acquisitions made by US firms. We discuss the most significant recent deals below and attempt to assess the extent to which they have been motivated by the desire to increase a firm's ability to offer modules. While the evidence is not overwhelmingly supportive of the assertion that modularity is driving M&A, we believe that such factors are significant and we are inclined to believe that, as some of the realities of modular supply become apparent, further M&A activity is likely.

Dominance of US interior companies in European M&A significant

Need to act a modular suppliers may affect exit route when businesses sold

With a number of industrial conglomerates deciding to sell their automotive businesses in recent years, it is interesting to consider whether the choice of exit route (i.e trade sale or flotation) is related to the prospects of that industry in a modular supply environment. Although other factors such as maximising sale proceeds and minimising taxation are probably more significant, it may be the case that those companies able to engage in 1st tier modular supply are more likely to be floated (i.e Meritor – an Initial Public Offering (IPO) from Rockwell), with those suppliers less likely to be able to act as integrators sold to trade buyers (i.e UTA, sold to Lear).

Table 3: Recent European interior supplier M&A activity potentially driven by modularity

Date	Target	Acquiror	Comments	Modular?
1999	Plastic Omnium (France)	Visteon (US)	IP and door trim/module maker – accelerated Visteon's European abilities and market share	✔
1999	UTA (US)	Lear (US)	US deal, but with implications in Europe – allows Lear to capture high value wiring content of interior to compliment seats and plastics	✔
1999	Commerfin (IT)	JCI (US)	Door panels for Fiat – whole interior driven	✔
1998	Paulish (Germany)	Magna Corp. (Can)	Seat maker – gave Magna greater scale and market share rather than total module/interior ability	✗
1998	Roltra Morse (Italy)	Magna Corp. (Can)	Window regulator maker – added to Magna's trim & component units	✔
1998	Bertrand Faure (Fr.)	ECIA (Fr.)	Brought BF's seat business together with ECIA's cockpit and door plastics business	✔
1998	ITT Electronics (US)	Valeo (Fr.)	Many aspects to deal, but allows Valeo to add high value wiring in cockpit to compliment plastics	✔
1998	Becker (D)	JCI (US)	IPs and door trim – significant German OEM contracts – whole interior driven	✔
1998	Ymos (D)	Magna Corp.(Can.)	Exterior and interior plastics (no details given, but suggests complete interior driven)	✔
1997	Keiper (D)	Lear (US)	Seating systems - scale and market share driven, rather than whole int.	✗
1997	Empetek (Czech)	Lear (US)	Headliners etc. – whole interior driven	✔
1997	Tricom (UK)	Magna Corp.(Can.)	Seating maker – market share/facilities driven	✗
1996	Marley Auto (UK)	Magna Corp. (Can)	Marley manufactured IPs and similar plastic injection mouldings – added IP ability to Magna's seat and door capabilities	✔
1996	Borealis (Sweden)	Lear (US)	IPs and interior plastics – complimentary to seats, plus Swedish/European market share	✔
1996	Prince Hold. (US)	JCI (US)	European facilities for door trim, sunvisors, headliners – whole interior driven	✔

Sources: Amdata, Securities Data Co, press articles

3.3 SEEKING PROFITABLE GROWTH

Modular supply provides attractive revenue growth

The undoubted acceleration of modular design, manufacturing and procurement in Europe is reported as one of the key factors driving both organic and acquisitive growth. The list above shows how the desire by large suppliers to be able to offer OEM customers whole modules – or indeed, complete interiors – has contributed to supply base consolidation. In the case of the large suppliers – notably the North American giants Lear, JCI and Magna - financial ability has allowed them to expand to produce a number of components that can make up an interior. However, even these suppliers do not have the ability to produce all the components that comprise whole cockpit or door modules - and their smaller competitors, who typically specialise in one type of component, certainly do not. This leads us to one of the most significant findings of the research to date.

But acting as an integrator requires a supplier to buy in other parts – which dilutes margins

Most suppliers are participating in the rush towards modular capability. However, few of those currently engaged in contracts to supply modules actually produce more than a few items found in such modules – the majority being bought in from other suppliers that are either 2nd tier or, for the purposes of a particular piece of business, demoted to Tier 2. OEMs demand information of the cost structure of a module supplier and invariably know the purchase costs of the bought in parts. The OEM customers are therefore only allowing a very small margin, or carrying charge (typically 0.2% to 1.0% - if any at all) on such bought in parts – far lower than the margin permitted (or rather, due to less specific information, achieved by the supplier). OEMs argue that they are already paying one profit margin to the manufacturer of such components – paying an additional margin to an integrator is just an additional overall cost. The consequence is that typically, modular business achieves a far lower operating profit margin than normal component supply.

Operating profit on a cockpit module could, to use a nominal example, fall from 5% to 1%

By way of example, a typical cockpit module in a C-class car (i.e. Astra, Golf, Focus), with heating, ventilation and air conditioning (HVAC) but without any extra optional electronics (i.e. navigation, audio), costs approximately $600-$700. The majority of cockpit module suppliers originate from a plastic injection moulding background and continue to only manufacture the plastic moulded parts of the cockpit – the Instrument Panel – which typically costs $80-$100. While the operating profit margin on an IP may be in the region of 5%, the margin permitted on bought in parts may be only 0.5%. Therefore, a module supplier, going from IP supply to whole module supply, will see its total margin fall dramatically. Ignoring the extra costs of engineering, land, facilities and management, the margin will fall from 5% on a $100 IP to 1.2% on a $700 module – since all the bought in parts must pass through the supplier's profit and loss. Such a fall is truly dramatic and has significant implications for a publicly quoted company's market valuation.

Fear of margin dilution blocking some contracts

Many of the suppliers we have met consider margin dilution to be very significant issue, with one US based supplier reporting that US management had blocked a new business opportunity because, although it offered incremental income, they feared that it would harm overall margins. Our perspective is that, under current arrangements, dramatically lower margins are inevitable. Many currently acting as integrators are

accepting financial 'pain', in the hope and expectation that they will be able to improve margins in subsequent years - once competition has eased and relationships with OEMs have become entrenched. However, if modular supply as currently practised is to continue, we believe that there are only three likely solutions to this issue:

- Senior management impress on the investment community the fact that margin dilution is not necessarily an indication of poor performance- either emphasising return on assets of publishing pre-module and post-module business margins
- Establishing some form of payment system whereby the purchased components do not pass through the module integrators profit and loss – this form of pay on consignment is already in place for one module supply arrangement we have examined. However, suppliers believe that unless they have control of purchasing and price negotiation, then they cannot optimise their role as integrators
- Module integrators ensure that they actually manufacture a greater proportion of the module themselves – either through organic expansion or by acquisition (see below).

Industry argues that modularity can boost return on assets

Theoretically, investors should look beyond simple operating profit margins, to return on invested capital but, unfortunately, due to the complexity of calculating such measures on a comparable basis, operating profit margin is often used as a proxy for the quality of the business. Industry analysts are looking to return on capital, as the quote below demonstrates, but it remains a fact that margin dilution is of fundament concern to suppliers. In addition, we have no evidence to date that modularization actually improves return on capital –in fact, we would be inclined to believe otherwise. Although investment for assembly may be less costly than full manufacturing, it is still substantial and, with suppliers increasingly being required to pay for tooling (see Section 2.7 below), some of this burden will fall on the module assembler. We would be inclined, at this stage, to assume that the profit margin permitted on bought in parts is insufficient to compensate significantly for increased investment and to raise return on capital.

'As the automotive industry moves towards modularization – with suppliers acting as integrators rather than pure manufacturers – we would expect the RoIC at Faurecia to improve from current levels. This is because module assembly, although a lower margin business, ties up less capital than more traditional component manufacturing'.

Goldman Sachs Autos Equity Research, Faurecia, 9th June 1999.

We intend to explore these issues in detail over the coming year, with particular emphasis placed on financial issues in our forthcoming quantitative survey.

3.4 CAPABILITIES

Acting as a modular supplier requires new skills

One of the objectives of the research has been to understand both OEM and supplier perceptions of what capabilities module suppliers need to possess and/or develop. Our interviews to date have generated quite a consistent picture of what management skills are required of suppliers, but

often quite divergent views on what physical manufacturing capabilities such companies require. It is apparent that suppliers are having to develop a range of new abilities, including:

- genuine project management skills – the ability to manage Tier 2 suppliers
- technical knowledge and engineering capability, including safety and crash testing expertise
- systems integration abilities
- quality and warranty management expertise

Project management skills probably most significant – and greatest cause of concern

A number of functions in the OEMs remain concerned about supplier abilities in these areas –informing us that certain suppliers, including those that have won modular contracts, are failing to deliver projects on time, to the quality required and with the technology and other gains originally envisaged. We intend to explore the factors behind such failure over the coming year.

Shift of expertise from OEMs to suppliers not leading to movement of OEM personnel into the supply base

The new capabilities that module suppliers must develop are requiring the companies to place an increased emphasis on recruitment. We were interested to find out whether, as responsibility for various activities traditionally carried out by the OEM has been shifted to suppliers, there has been any movement of suitably qualified professional employees from OEMs to suppliers. Surprisingly, in our view, companies reported that there has been virtually no such movement. While they have had to increase the size of their engineering departments, they have recruited almost entirely from other suppliers, new graduates, or from related industries. Both OEMs and suppliers pointed out that a wage differential between suppliers and OEMs is an issue – typically, an OEM engineer would have to take a significant pay cut to move to a supplier. Certain OEMs also argued that the wage differential may affect the engineering capability of suppliers – believing that the best engineers go to OEMs, with less well qualified engineers finding employment at suppliers.

Wage differential an issue

Few suppliers reported targeted recruitment of personnel with project management skills – developing existing employees' abilities instead. However, one individual at a supplier we visited had been recruited from a military systems manufacturer, where he reported that 'systems integration has been a feature of the defence industry for a number of years, so I had great experience of project management and technology integration, which made my skills attractive in the auto industry'.

3.5 QUALITY CONTROL AND TIER 2 MANAGEMENT

Outsourced modules supposedly benefit quality

One of the stated advantages of outsourced modules is the quality improvement that they bring - due to factors including:

- integrated design
- reduced part counts
- more ergonomic assembly
- pre-testing of modules before installation; and
- division of quality control into smaller units – and quicker response to quality problems of vehicles in use

A fuller assessment of the quality implications of modules will be attempted when we undertake the quantitative data collection exercise planned for early 2000 – but our research interviews to date have built up a very mixed picture of quality impacts. The OEMs report that overall, they believe quality has improved although, due to the fact that the deployment of outsourced modules is at a relatively early stage, the long term durability implications (i.e. 5 years/100,000 km) are not yet fully apparent. Notably, the OEMs stress that the ability to contact an integrator in the event of a quality problem, rather than a multitude of suppliers, is one of the most attractive features of modular supply

Ppm levels for modules higher than for individual parts due to complexity, but overall vehicle quality up

The first tier integrators report that that the quality levels (on a parts per million basis – p.p.m.) of the modules they supply are lower than for individual components – but that is perhaps inevitable given the greater number of parts (e.g. 80 rather than one).Typically, they report ppms up from figures in single digits or tens (e.g. 5 –50 ppm) to figures in the hundreds (e.g. up to 500) – but claim that OEMs are happy with such levels as the overall ppm of total deliveries to the assembly plant are lower due to the reduction in number of suppliers. Similarly, due to increased responsibility for warranty claims, suppliers report a rise in such expenses – which have typically risen from c.0.5% of sales to c.2.0% of sales. Again, suppliers appear unconcerned about this rise as they factor it into their piece price – with an element that reflects expectations of continuous improvement.

Some suppliers claim 0-1 ppm!

There were some anomalies amongst the suppliers we met with – one supplier claiming that its module operation could boast ppm of 1. We are not clear whether this is a quality figure for just the assembly process or if it includes all the parts supplied, assembled and delivered – if it's the latter (we intend to return to clarify it), it's a sensational result.

2nd tier selection an important issue – with OEMs and suppliers reporting different views

As discussed, one of the claimed benefits of modular supply is the manner in which it permits the OEM to devolve responsibility for quality and to be able to contact just one direct supplier in the event of a problem. In order for this arrangement to function efficiently, module suppliers stress the importance of having control of sourcing and price negotiation of 2nd tier suppliers. However, at present this is rare in instances of module supply. Typically, the OEM chooses specific suppliers – particularly those that are providing systems (e.g. electrical architecture) to the vehicle – and also controls pricing. Suppliers are generally unhappy with such arrangements. Although they acknowledge that certain contracts are the legacy of programmes that moved to modular sourcing half way through their development (i.e. the OEM had already given business to a 2nd tier – and then asked a supplier to act as a module integrator) – there is concern that many OEMs expect to continue to retain control of lower tier selection and pricing. Without control, suppliers are exposed to a situation where:

- margin enhancement is very difficult (due to totally transparent input costs)
- integration is complex (as the OEM defines the sub-components according to existing vehicle architecture)
- purchasing scale is hard to achieve (as integrators must source from different 2nd tiers according to customer)

- quality responsibility is unclear (as OEM chosen suppliers cannot always be resourced despite a problem).

The only real attraction for a supplier of a situation where the OEM controls 2nd tier purchasing is that, if the OEM pays the 2nd tier directly, then the integrator's profit margins may be more flattering.

OEMs appeared unspecific in their policies and future intentions. While most currently exercise some control of 2nd tier selection, in our interviews they seemed to consider the matter to be of low importance and appeared to be open to the concept of module integrators taking control - in contrast to suppliers perceptions. Even with regard to safety systems (i.e. airbags), OEMs reported that, subject to certain guarantees, they can envisage passing responsibility to module suppliers. The difference in opinion on this subject between OEMs and suppliers certainly merits further investigation.

3.6 COMMONALITY AND STANDARDIZATION

Standardization of module components a real possibility

We have already argued that the term 'module' is possibly a misnomer – describing as it does a dedicated sub-assembly rather than a standardized, common interface item. However, whilst modules in the auto industry appear at present to be dedicated to one model, we believe that a number of factors may increase the possibility of increasing standardization of parts across vehicle makers:

- the devolution of responsibility for design and assembly to suppliers
- suppliers' growing financial strength and ability to fund investment
- suppliers' accelerating technical expertise
- reducing asset specificity of suppliers' investment – including certain OEMs persuading suppliers to pay for tooling – which may encourage suppliers to seek scale economies through commonality.

Some suppliers looking at it already

During our research visits, we have attempted to test these ideas through discussion and by asking the suppliers of the modules we've focused on to identify which components have the potential to be standardized. The variation in attitude and opinion was considerable – some suppliers shot down the idea - arguing that OEMs will always first, demand specific, dedicated parts and second, will always pay for tooling (and that, for example, producing parts for VW on tooling paid for by BMW was unworkable). Others however, have actually given the idea considerable thought already. There was some consensus amongst this group that the potential for standardization is high.

Specific (steel) door module parts suitable

In the case of a door module, the glasshouse, the beltline and parts location (i.e. latches, handles etc.) are very similar across models (i.e. Laguna, Passat, Vectra etc.) and some module suppliers believe that a semi-standard module could be realistic if they could win contracts with a number of OEMs in a vehicle class. Of the components in a door module (see Section 5), some suppliers have studied the possibility of using semi-standard carriers, window guides and mounting fixtures. The manufacturing method for window guides (extrusion) lends itself to producing standard parts, although the curve of the car's glasshouse is more problematic than glass weight and thickness - which tend to be

similar, and window height – which can be adjusted for. Similarly, some door module suppliers have been examining the possibility of 'block casting' carriers to allow standardized elements. Locks and internal parts such as cables are already often standard.

Cockpit parts also feasible

In the case of the cockpit, such studies seemed less advanced, although the potential gains could be even greater. While OEMs will always insist on differentiated IPs, and probably switchgear 'feel', the location of the IC, the HVAC, electronics, glovebox and many airvents is very similar across products in the same vehicle class. Suppliers believe that standardization, which is already a feature within OEMs, has the potential to develop across vehicle makers. The main hurdle to such standardization may be the need to make late, pre-production changes to ensure crash test compliance.

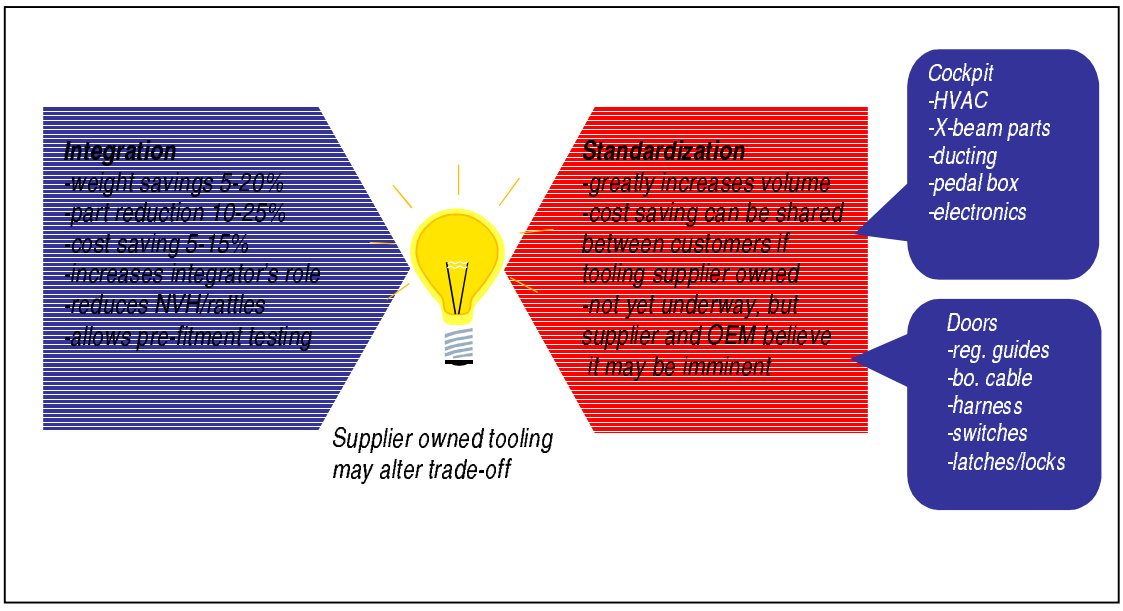
OEMs supportive in principal – although not yet pushing suppliers

The OEMs we met with are open to the idea of the standardization of unseen parts. Although many argue that certain characteristics of parts found in the cockpit module are features of their brand (i.e. "Fords have always been known to have powerful airconditioning units"), the increasingly high and uniform standard of such systems will negate such concerns if real cost reductions through scale are possible.

..but standardization may be incompatible with integration

The main issue that arises when analysing the potential for *standardization* is the fact that the current preoccupation of both modular suppliers and procuring OEMs is *integration*. Integration is trumpeted as one of the main attractions of modular supply – potentially offering great weight, part number and cost reductions. However integration, by definition, implies that modules must become more model specific – with non-functional parts removed and systems reengineered to locate them more closely with surrounding components. In many respects, integration is an entirely antithetical development to commonality.

Figure 2: The possible trade-off between module integration and parts standardization



Obviously, if the OEMs and supplier community were to be able to develop standardized parts, such cost reductions offer no long term net gain for an individual OEM's cost competitiveness – as gains will be

shared between the OEMs using such standard parts. However, there may be short term gains, differences in the OEM's abilities to harness such economies and, finally, a more general benefit for the industry.

Standardization may enable suppliers to cope with a build-to-order environment

The industry is becoming increasingly aware of the possible gains from moving away from its current system of production – where the majority of vehicles are built to a forecast that is prepared many months in advance. This production-centric approach - designed to smooth output at the assembly plant, ensure high volumes, and keep a steady stream of finished vehicles flowing to dealers and other outlets - is almost universal, irrespective of OEM. However, the resulting stock of finished vehicles at the OEM plant, in distribution centres and at dealers, plus the frequent need to incentivise customers to take a car with an alternative specification to that which they desire, potentially implies huge costs for the OEMs. If OEMs move towards build–to-order systems, whereby customers place orders for specific vehicles and they are scheduled, built and delivered as quickly as possible, then current supplier scheduling will also have to alter considerably. It is likely that current supplier scheduling will not be able to cope with fluctuations in demand between customers – as demand profiles for different models (due to season, life cycle etc.) will no longer be smoothed. Rather than having tooling and component production dedicated to specific customers, the possibilities of switching supply between OEM customers according to demand– potentially possible through component standardization – may be attractive and efficient. It is a concept that we certainly wish to explore in more detail over the coming year.[xvii]

4.0 COCKPIT MODULES IN EUROPE

4.1 CURRENT INTEGRATORS

Most current integrators of cockpit and door modules hail from similar respective origins

The nature of a module means that, typically, it is comprised of a number of components traditionally produced by a variety of suppliers. In the case of both cockpit and door modules, a large number of sources still contribute to a module – from a wide variety of technical disciplines. It is apparent from our initial research that only particular types of suppliers, with their origins in similar types of component production, have assumed the role of module integrators and suppliers – in preference to other possible groups of integrators from other backgrounds. The uniformity of this trend is striking in both cockpits and door modules.

Cockpits

Cockpits are typically comprised of a number of different components – produced by suppliers with expertise in very different areas. We will expand on the exact content of various cockpits in our discussion of technical solutions in Section 4.2, but the key components and their typical suppliers are:

Table 4: Significant components in a cockpit

Component	Material	Typical manufacturer
Instrument Panel	Plastic injection moulding	Sommer Allibert
Cross car beam	Steel	Benteler
HVAC	Plastic, steel, other	Behr
Wiring loom	Cables, electrics etc.	Delphi
Instrument Cluster	Plastics, electronics	Magnetti Marelli
Steering gear	Steel, plastics	TRW
Airbags, SRS	Metal, plastic, other	Autoliv

IPs amongst the lowest tech parts of the cockpit

As the table above demonstrates, components for cockpit modules derive from a variety of backgrounds, with many supplied by the largest, most technologically competent suppliers. One of the most low technology and low value components in the cockpit (although tooling costs are high) is the Instrument Panel (typically c.$80- $100 in a cockpit that can have a typical value of $600-$700, or a total value of over $1000).

Table 5: Cost breakdown of a typical C-class cockpit

Cockpit module component	Proportion of value
Instrument Panel	11%
Instrument Cluster	10%
HVAC	15%
AC electronic controls	5%
X car beam	5%
Wiring harnesss	17%

Other fascia plastics	4%
Ducting	3%
Steering column	6%
Radio cassette	7%
Fascia airbag	8%
Driver airbag and wheel	10%

Source: various suppliers

But most cockpit module suppliers come from IP background

However, the majority of cockpit suppliers in Europe (and elsewhere we understand) have their origins in IP manufacturer – and most continue to produce only that component. The summary of the leading cockpit integrators below provides a brief analysis of the businesses from which they originate, and shows that the majority come from a plastic injection moulding background.

Table 6: Leading cockpit integrators in Europe

Cockpit supplier	Original business
Becker (JCI) (D)	Interior plastic injection moulding
Delphi (US)	Plastics/HVAC/electrics
Faurecia (F)	Interior plastic injection moulding
Lear (US)	Interior plastic injection moulding
Magneti Marelli Integra (IT)	Plastics/HVAC
Mannesman VDO (D)	Electronics/ metal forming
Plastic Omnium (Visteon) (F)	Interior plastic injection moulding
Sommer Allibert (+Siemens) (F)	Interior plastic injection moulding
Textron (US)	Interior plastic injection moulding
Valeo (F)	HVAC, electronics, some plastics
Visteon (US)	Plastics/HVAC/electrics

Some logic in IP producers as integrators

The suppliers argue that only the manufacturer of the plastic moulding that holds many of the other components together and provides structural rigidity has the expertise to design, engineer and integrate the cockpit. There are some arguments that support the role of IP manufacturers as integrators, including:

- suppliers may have built up certain expertise in recent years as they have worked more closely with OEMs – and through such joint engineering may have gained a strong understanding of the functionality and performance requirements of other components in, and systems that cross, the cockpit.
- Integration and part reduction opportunities are probably initially greatest in the plastic parts of the cockpit – such as structural elements, vents, ducts etc.
- Some OEMs still not specifying cockpits with integral heating, ventilation and air conditioning (HVAC) units – so knowledge of and integration of these components is not always necessary
- Assembly is currently a significant part of module supply and the task requires certain components to act as structural members during assembly. Therefore, the IP manufacturer is well positioned to engineer plastics that can be used in this role

But role of integrator driven by historical precedent –– current integrators will not necessarily remain in position

However, we would like to suggest that the last of these factors has been granted too much significance in the module sourcing decisions of OEMs. It can be argued that current cockpit module suppliers, with their origins in IP production, have been appointed as integrators due to:

- a perhaps excessive emphasis on *modularity in production* (rather than design etc.)[xviii]
- the willingness and readiness of a number of IP makers to engage in modular design – many publicising and marketing such a role earlier than competitors from other component groups.

The historic nature of cockpit assembly – where the plastic IP is used to attach many of the other components, is preserved in new outsourced arrangements. While the assembly and early integration tasks are both important, integrators based on modularity in production may not be the ideal, or most effective holders of this responsibility in the longer term.

We would suggest that the rapid growth of certain suppliers – acting as module integrators–provides some possible evidence of sudden, expedient and perhaps even overly hasty decisions by OEMs to outsource modules.

Role of higher technology suppliers may accelerate

We believe that there are strong factors that may lead to suppliers from other component groups assuming an increasingly prominent role in module supply and consider that it is possible that they may usurp current integrators. There are strong arguments that other suppliers, currently in second tier roles, may be better placed to act as integrators in the future, including:

- Higher technology contributions to the cockpit (notably electrical harness and HVAC) – as performance demands from OEM customers rise, managing technology becomes difficult for IP manufacturer if 2nd tier supplier must communicate through integrator
- Search for further integration and part reduction gains will see emphasis shift from easy gains in plastic components to more complex gains in higher technology areas
- Higher value contributions to cockpit – margin dilution may become increasingly problematic for current integrators (unless investors accept rationale for it) - suppliers that manufacture a greater proportion of the cockpit value in-house will better preserve margins
- Increased need to manage overlap of modules and systems – engineering of cockpit module easier for supplier who is also responsible for key systems (i.e. electrics, HVAC)
- Increasing financial demands placed on suppliers by OEMs, as they request that suppliers pay for tooling. Higher technology companies are often larger concerns – allowing them access to cheaper capital.

Why have higher technology suppliers not entered the arena?

So why is it that suppliers from other component areas have not entered the cockpit market *en masse*? The analysis in Table 6 (see above) reveals two significant facts in this respect. First, some cockpit suppliers actually have most of the technologies included in a cockpit in-house. Those that have all of HVAC, electronics and plastics are limited in number and the multiple abilities of these companies are largely a function of their

historical origins as in-house suppliers of the largest OEMs. Delphi and Visteon are unusually placed to supply whole cockpits, largely because GM and Ford previously built entire cockpits in-house. This capability, now in the ownership of completely or partially separate entities, allows such suppliers to build the majority of components that comprise a cockpit.

JVs and collaborations significant

Second, some suppliers with historic backgrounds in IP moulding are seeking joint ventures and/or collaboration with suppliers of other componentry. Most notably:

- Sommer Allibert's joint venture with Siemens allows the combined company, SAS, to provide a greater proportion of the content of a cockpit in-house.
- Valeo, which has only limited plastics capabilities but a strong presence in HVAC has been seeking new business in collaboration with Plastic Omnium (although the relationship may be terminated after Visteon's acquisition of Plastic Omnium).
- Magnetti Marelli Integra – a three party venture between Marelli, Textron and Breed, the airbag maker.

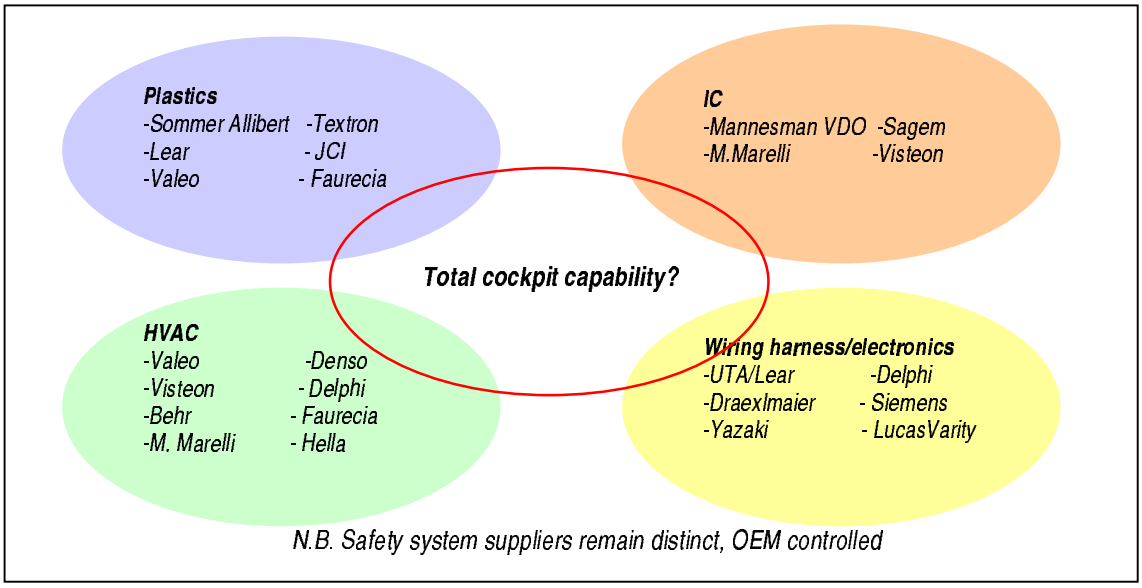
But full cockpit capability driven M&A limited to date

As discussed above, certain companies are engaging in mergers and acquisitions ('M&A') that are partially driven by the desire to build modular capabilities. However, while many appear to be aimed at a long-term goal of being positioned to supply a 'complete interior' (particularly in the case of the N.American seating giants), the extent of M&A explicitly aimed at building a complete cockpit capability remains limited.

But growing HVAC and electrics supplier involvement likely

Both OEMs and suppliers that we have met with emphasised the fact that, at present, OEMs will often select 2nd tier suppliers on a model by model basis and current integrators have some reservations about allying themselves to particular HVAC and electrics suppliers – as OEMs, having selected a systems supplier for the model or platform, will demand that the cockpit maker works with that chosen supplier. However, we are inclined to think that further agreements and/or consolidation between suppliers with different technical expertise is likely.

Figure 3:Analysis of companies supplying components to cockpit modules in Europe



Why have HVAC and electrical systems suppliers not entered the cockpit market?

We intend to investigate the attitudes and strategic objectives of both electrics (i.e wire harness) makers and HVAC suppliers over the coming year, to get a fuller understanding of their likely future role in the cockpit module. At this stage, we have only limited knowledge of the objectives of such suppliers but our preliminary understanding is that electrical systems suppliers such as Bosch, Siemens and Draexlmaier are not yet attempting to win modular business, because:

- They do not believe that they need to enter the module market for defensive reasons as they are likely to remain as systems suppliers whoever integrates the module – and expect to preserve close relations with OEMs – even if they are not Tier 1 on every project
- They are reluctant to enter an essentially low margin business in which they have little expertise at present
- OEM customers have not approached them with a view to offering an alternative to current module suppliers.

Our understanding of HVAC suppliers suggests similar motivations – with a role as a systems supplier secured, there is little need to enter the module market. Furthermore, as discussed above, not all OEMs are specifying modules with HVAC as an integral part – further preserving the HVAC makers independence. However, like certain wiring harness makers (i.e Siemens), some HVAC makers have engaged in joint ventures and/or other collaborations (i.e. Magnetti Marelli, Valeo).

4.2 TECHNICAL SOLUTIONS

Variety in technical solutions relatively limited

We expected to encounter a great variety of technical solutions during our research visits. However, although we have reservations about making the following statement (we are not engineers and are aware that there may have been deficiencies in our methodology and research approach) – in general we think it is acceptable to argue that in Europe, the variety and complexity of technical solutions for cockpit modules remains relatively

limited.

In general, the majority of solutions both in production and at the concept stage follow a relatively generic physical structure. The typical key components are:

- a centrally located HVAC unit
- a plastic IP with some structural role
- plastic ducting to channel the HVAC's output and fresh air to the passenger compartment
- other plastic items such as the glovebox and console
- a cross car beam (some do not, but for full cockpit modules it appears to be increasingly common)
- a wiring harness and other electrical cabling
- the instrument cluster in front of the driver
- controls and other electronics located centrally in the unit
- a steering column support and, in some cases, the steering column and wheel pre-fitted
- in some cases, a pedal box.
- in some cases – the firewall/front bulkhead of the car, occasionally complete with some engine bay components such as the brake master cylinder and tubing.

From our research visits, it became clear that externally procured cockpit modules have not yet deviated greatly from this arrangement of components. The opportunity to design a more radical solution is tempered by:

- the need to meet fairly generic industry expectations for the interior (i.e. customers expect controls to be in similar locations across different OEM's products)
- Logical locations for certain components - governed by weight, engineering and production volume constraints (i.e. HVAC located near floorpan)
- Standard safety critical items (i.e airbag locations)

Two factors may be limiting innovation

While it may be the case that the physical demands made on the cockpit mean deviation from the industry standard is not actually possible or realistic, we would argue that there are two significant factors that have limited module suppliers opportunities to explore genuine innovations:

- *Continuing close control of the cockpit by the OEM*– the cockpit module is far from a 'black box' solution. The design of the cockpit is totally reliant on the vehicles monocoque architecture (i.e firewall location, need for cross car beam etc.) and the OEM still sets detailed performance and dimension specifications and still leads much of the engineering task. It also often seeks a cross vehicle standard brand look and feel for the cockpit which may limit innovation. In addition, the fact that the module crosses many of the vehicle's systems means that it cannot be designed as a distinct entity – the module integrator must work around the systems' dimensions and characteristics which take precedence. Furthermore, the OEM still controls the selection of many of the 2nd tier components.

- *Continuing segregation of supplier expertise* – the majority of current integrators of cockpit modules have their origins in IP and interior plastics manufacture. A number of the technical solutions we have seen shown integrate the plastic parts of the cockpit, but leave the HVAC and electronics in a standard form. We believe that opportunities for innovation would be enhanced if the suppliers of the higher value components of the cockpit – the HVAC and wiring, were able to contribute more to the integration task. A cockpit supplier with true knowledge of all the systems and components in the module may be able to develop more innovative solutions than those whose scope is limited to the packaging of the cockpit.

We would argue that the factors above partially explain why the majority of concepts that we were shown during our research visits were relatively similar in their design, integration methods and reported cost and weight gains. Certainly, the variety of door module concepts that we were shown appears to be much greater.

Some concepts using HVAC integration and advanced electronics

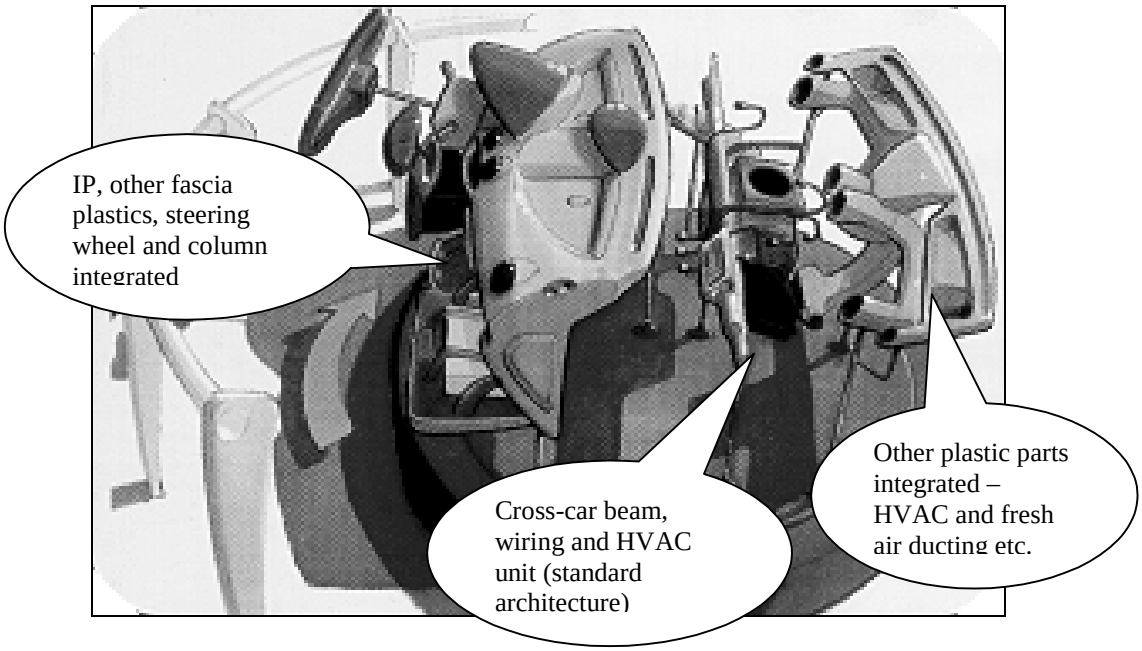
Although some cockpit module suppliers discussed integrating HVAC components into the IP and/or the cross car beam and others talked about the benefits possibilities of flat wiring and multiplexing – in general, this remains at the conceptual stage and is technology in the hands of other, non-integrator suppliers (we intend to investigate this technology more fully with specialist suppliers over the coming year).

Module suppliers with 'total' capability (i.e. Delphi) not proposing dramatically different concepts

However, we would draw attention to the fact that during our research visits, those suppliers that are able to manufacture most or all of the components in a complete cockpit did not put forward radically different concepts to those of the IP suppliers – supporting the argument that it is the physical and performance requirements of the cockpit (or other, unidentified factors) that limit innovation rather than the current separation of suppliers of components for the cockpit.

The figure below shows a typical cockpit module concept developed by an integrator with a background in interior plastics. It shows the typical approach of such suppliers whereby they are able to maximise the integration and parts reduction opportunities of the IP and other plastic components, but the HVAC unit and electrical components (although reduced in weight and complexity in this instance to an extent) remain relatively standard in architecture and approach.

Figure 4: Typical plastics manufacturer-led cockpit integration concept



4.3 COST, WEIGHT AND PERFORMANCE GAINS

Cockpit design such as the one displayed here are reported to offer a number of gains, including (typical figures, complied from a number of suppliers who discussed similar concepts):

- a 5-10% reduction in the number of parts
- a 5-15% reduction in weight
- a 10-20% reduction in cost

While the data used for existing, internally-procured cockpits are not necessarily reliable for the purposes of comparison, there is consensus amongst both suppliers and OEMs that gains of this sort are achievable even with plastics-led integration. However, our preliminary research leads us to question whether greater gains could be made if the suppliers of higher technology and higher cost parts were to lead integration efforts. However, we must refer again to the fact that those suppliers able to manufacture most or all of the components in a complete cockpit did not put forward radically different proposals to those of IP suppliers. We are therefore keen to explore this issue in more depth over the coming year.

4.4 WHO'S SUPPLYING WHOM?

Modularity extensive and outsourced modules growing rapidly

The extent of the adoption of modularity in the cockpit varies greatly between OEMs, models and plants in Europe. The analysis below shows which current and future models in Europe have modular cockpits, whether they are internally assembled and who the current Instrument Panel (IP) supplier is. The analysis, compiled from our meetings with the supply base, is currently in draft form, but allows us to draw a number of broad conclusions, including:

- The adoption of modular cockpits is now extensive, but with the majority designed and assembled in-house
- Of the 92 products that we have identified as being either on the European market or due to come to market in the next two years, at least 45 (49%) feature cockpit modules. Of this total, at least 18 (40%) are externally supplied (note that our survey is not yet complete and some sourcing decisions have yet to be decided).
- Amongst the OEMs there are distinct proponents of modular cockpits and some notably resistant, with the majority of OEMs appearing to make case-by-case judgements
- There is a strong correlation between vehicle age and the use of cockpit modules – a significant proportion of forthcoming models use modules, many externally supplied
- All but a few of the companies that appear to be winning business are IP producers – the exception being VDO which appears to just have an assembly role at present (unconfirmed as we have yet to meet with them)
- Acting as an IP supplier on existing models appears to position a supplier to move into full module supply
- There is no clear correlation between vehicle size and the deployment of cockpit modules
- There is some correlation between vehicle production volumes and the deployment of cockpit modules – niche products/new market sector entrants often see OEMs try modules for the first time
- There is a correlation related to the point above, with cockpit modules often used at greenfield sites
- We also note with interest the use of non-core brands/subsidiary companies for an OEM's first experiments with cockpit modules (i.e Rover, Skoda, Seat etc.)

Table 7 The extent of modular cockpits in the European auto industry

OEM and model	Introduced (E=estimate)	Cockpit module?	Assembled by:	IP manufacturer (split equlas dual sourced)
Audi				
A2	2000E	Yes	In-house	Peguform
A3	1996	Yes	In-house (D), SAS (BZL)	Magna
A4	1993	Yes	In-house	Peguform
New A4	2000E	Yes	In-house	Peguform
A6	1997	Yes	In-house	JCI (Becker)
New A6	2004E	Yes	In-house	JCI (Becker)
TT	1999	Yes	In-house	Peguform
A8	1995	Yes	In-house	JCI (Becker)
BMW				
3-series	1998	Yes	In-house	BMW plastics
5-series	1996	Yes	In-house	BMW plastics
7-series	1997	Yes	In-house	Magna
New 7-series	2001E	No	N/A	BMW plastics
Z3	1995	No	N/A	S.A.
New Z3	2002E	Possible	S.A (?)	S.A.

Citroen				
Saxo	1995	No (?)	N/A	S.A.
New Saxo	2001E	No (?)	N/A	P.O. (Vist)/Faurecia
Xsara	1997	No (?)	N/A	P.O. (Vist)/Faurecia
Xantia	1992	No (?)	N/A	S.A.
New Xantia	2000E	No (?)	N/A	S.A.
XM	1991	No (?)	N/A	S.A.
New XM	2001E	No (?)	N/A	S.A.
Fiat				
Punto	1999	?	?	?
New Bravo/a	1994	Yes	Magnetti Marelli Integra	M.M.I./Textron
Bravo/a	2001E	?	?	?
600	1996	?	?	?
Coupe	1995	?	?	?
Alfa 145/6	1994	?	?	?
Alfa 156	1997	?	?	?
Alfa 166	1999	?	?	?
Lancia Y	1995	?	?	?
Lancia Lybra	1999	?	?	?
Lancia Gamma	1996	?	?	?
Ford				
Ka	1996	Yes	Visteon	Visteon/Erousa
Fiesta	1989	Yes	In-house	Visteon
New Fiesta	2001E	Yes	Visteon	Visteon
Focus	1998	Yes	Visteon	Visteon
Mondeo	1993	Yes	In-house	Textron
New Mondeo	2001E	N/A	Confidential	Textron
Mercedes-Benz				
C-class	1993	No	N/A	S.A (old MB pl'nt).
New C-class	2000E	No	N/A	S.A.(")
E-class	1996	No	N/A	S.A.(")
S-class	1999	Yes	In-house	S.A.(")
M-class	1996	Yes	Delphi	Delphi
SLK	1996	No	N/A	JCI (Becker)
CLK	1998	No	N/A	Eldra
Vito	1994	No	N/A	S.A.
New Vito	2002E	No	N/A	S.A.
Opel				
Corsa	1993	No	N/A	JCI
New Corsa	2001E	Yes	In-house	S.A./Delphi
Astra	1998	Yes	In-house	JCI/Delphi
Vectra	1994	Yes	In-house	Opel plastics
New Vectra	2001E	Yes	In-house	Delphi
Omega	1992	Yes	In-house	Opel plastics
New Omega	2001E	Yes	In-house	Delphi
Peugeot				
106	1991	No	N/A	P.O. (Visteon)
206	1997	No	N/A	P.O. (Visteon)
306	1992	No	N/A	S.A
406	1995	Yes	In-house	Faurecia
706	2000E	Yes	In-house	Faurecia

Renault				
Twingo	1991	No	N/A	P.O. (Visteon)
Clio	1997	No	N/A	P.O. (Visteon)
Kangoo	1996	Yes	In-house	S.A.
New Clio	2002E	Yes (?)	Undecided	Undecided
Megane	1995	No	N/A	P.O. (Vist)/S.A.
New Megane	2001E	Yes	S.A.S.	S.A.
Laguna	1994	No	N/A	S.A.
New Laguna	2000E	No	N/A	S.A.
Safrane	1993	No	N/A	S.A.
New Safrane	2001E	No	N/A	S.A.
Espace	1994	N/A (?)	N/A (?)	N/A (?)
New Espace	2001E	Yes	S.A.S.	S.A.
Rover				
200/400	1994/2	No	N/A	Magna
R75	1999	No	N/A	Faurecia
R50 (new Mini)	2001E	Yes	Magna	Magna
Freelander	1997	No	Seeking quotes for next car	Magna
Discovery	1998	No	Seeking quotes for next car	Magna
Range Rover	1995	No	Seeking quotes for next car	Magna
Seat				
Arosa	1998	Yes	VDO assembled	S.A
Ibiza	1995		VDO assembled	S.A./Peguform
Toledo	1999		VDO assembled	S.A.
Skoda				
Felicia	1994	No	N/A	Peguform
Octavia	1997	Yes	S.A.S.	S.A.
VW				
Lupo	1998	Yes	S.A.S	S.A.
Polo	1996	Yes	S.A.S.	S.A.
New Polo	2001E	Yes	S.A.S./in-house	S.A./in-house
Golf	1997	Yes	In-house/VDO/S.A.S.	S.A./VW plastics
Passat	1996	Yes	In-house/VW	Faurecia
New W8	2001E	N/A	N/A	N/A
Volvo				
S40	1995	No	N/A	JCI
S70	1993	Yes	In-house	S.A.
New S70	2001E	Yes	S.A.S	S.A.
S80	1998	Yes	In-house	Lear

5.0 DOOR MODULES IN EUROPE

5.1 CURRENT INTEGRATORS

Dominated by window regulator and interior trim suppliers

Most of the companies in Europe competing for door module have their origins in one of two types of component – either window regulators or plastic interior trim. Furthermore, the majority of companies that have actually won business, and are actually engaged in door module supply, have their origins in window regulators.

Table 8: Leading door module suppliers in Europe

Door module supplier	Original business
Brose (D)	Window regulators
Delphi (US)	Window regulators, plastics and electronics
Faurecia (F)	Interior plastics
Kiekert (D)	Door latches
Kuester (D)	Window regulators
Lames (IT)	Window regulators
Lear (US)	Interior plastics
Magna (Can.)	Many – but have bought both regulator and trim businesses in EU
Meritor (US)	Window regulators
Sommer Allibert (F)	Interior plastics
Valeo (F)	Interior plastics, electronics

All suppliers trying to win business, but regulator makers doing best

A large number of companies with their origins in a variety of components are all attempting to win door module business – due largely to the aforementioned dual strategies of defensive expansion or top line revenue growth. Suppliers of most of components that go into doors are attempting to win business – including the regulator makers, the locking mechanism and latch mechanisms, the plastics makers and even wiring harness makers. In addition, companies with origins in seat supply (JCI, Lear, Magna) are attempting to win business in their efforts to supply 'complete interiors' – partly through the acquisitions of window regulator and door trim manufacturers, as discussed in Section 3.

Regulator makers logical at this stage

The role of regulator makers as integrators has perhaps a more thorough logic than the role of IP manufacturers as cockpit integrators. The principal supporting factors behind the regulator makers role as module supplier include:

- A significant proportion of the value of the module
- One of the most significant types of technical expertise required (i.e knowledge of the window lifter, knowledge of door water sealing)
- Similar fabrication skills required for the module carrier (if it remains as a steel pressing) – although some module suppliers buy in most components

The components contained in a typical module are listed below, with an approximate split of value (note that figures are for a relatively simple

steel carrier based module for a C-class car–see below for discussion of types):

Table 9: Cost breakdown of a simple steel carrier door module

Door module component	Proportion of value
Window lifter	30%
Latch	20%
Wiring harness	20%
Carrier (steel)	10%
Loudspeaker	5%
Fastening & taps	5%
Rods and bowden cable	5%
Labour	5%

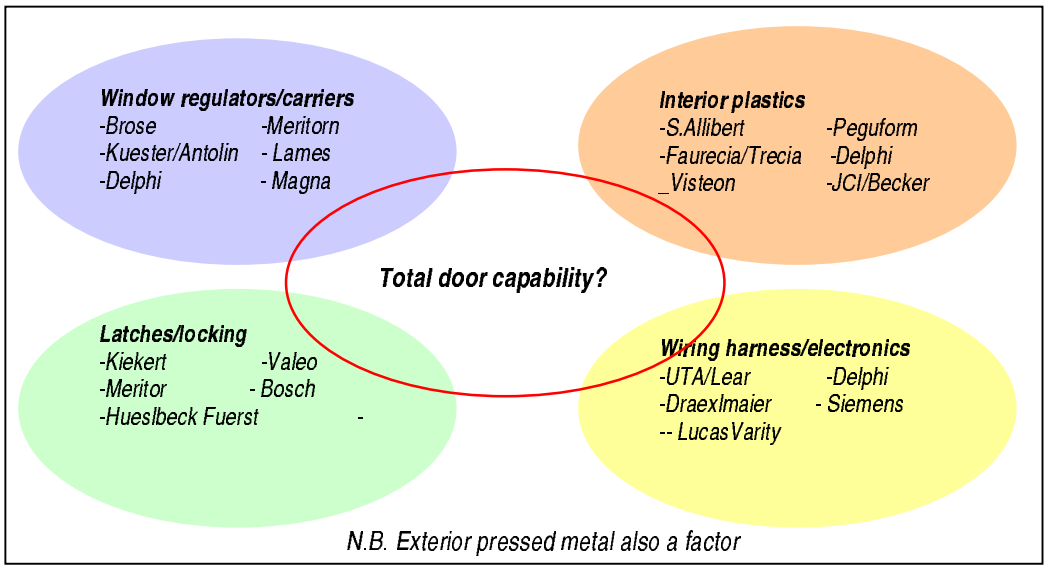
Source: various suppliers

The predominance of window regulator manufacturers as suppliers of door modules is marked. The majority of door modules in production utilise a steel carrier (see below for discussion of technical solutions) - which makes the regulator manufacturer a natural supplier. Typical current modules utilise a steel carrier, with the regulator and a limited number of components attached (the carrier is then inserted in the door of the vehicle) – which remains very similar is design to a normal, non modular door. The figure below shows the various parties involved in the supply of components to the door – including the inner trim and functional components. The following discussion of technical solutions shows how most parties are putting forward technical solutions – each of which sets out to secure a continued role for their respective technologies.

Role of privately held firms notable

One of the interesting characteristics of the door module industry is the role of privately held firms that have experienced rapid, apparently internally funded growth. Brose, Kuester, Group Antolin (Erousa) and Lames hold a significant share of both the window regulator market and module market in Europe. The private nature of these firms (all three are family rather than venture capital owned) and their apparent ability to fund investment in product development, satellite plants and other facilities is surprising. All three stress the importance of maintaining their independence despite regular and direct approaches from publicly quoted companies.

Figure 5:Analysis of companies supplying components to door modules in Europe



5.2 TECHNICAL SOLUTIONS

Technology of the door still very open

The strategic imperatives facing firms wishing to engage in the supply of door modules are, we believe, largely dependent on how the technology of the door evolves. Although the IMVP Modularization and Outsourcing Project did not set out to investigate the technology of modules to any great depth, it has become clear to us that due to the complexity of producing a true door module, the variety of technical solutions both in production and at the concept stage, and the obviously key role of suppliers' technical ideas, it was necessary to develop an understand of such technical solutions in order to analyse the issue of modularization and outsourcing.

While our summary here is limited, due to the preliminary nature of this report, we have listed below some of the technical solutions that we have encountered during our research and attempted to draw some brief conclusions.

Steel carrier v. plastic carrier the current debate

Although there is some polarization between suppliers from a metal forming background who are pushing steel carriers, and those with interior trim expertise emphasising the benefits of plastics, most suppliers report that they are not advocates of one kind of module but will rather consider a variety of solutions depending on what the OEM customer requires or would benefit from. Although we have noted which suppliers are currently producing the different types of modules – and which are developing specific concepts – it appears that most module suppliers wish to be perceived as being capable of producing any of the following types of module.

Currently in Europe, the metal versus plastic carrier debate remains open, but it is useful to consider the following summary points:

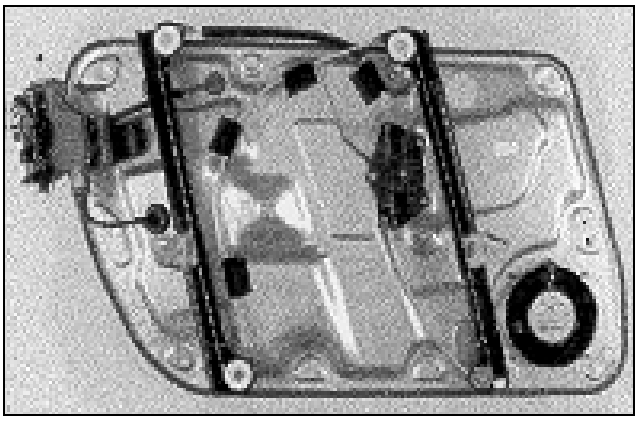
- Only the simple steel based carrier is in volume production in Europe
- Some more advanced solutions are in production for niche models

- A large volume contract for a plastic carrier is about to be placed
- No modules in production include interior trim – modules remain body and component related packaging solutions
- There is some consensus that a plastic module, built up from the interior trim, is highly attractive if it can be achieved
- The concept of a door module incorporating exterior sheet steel is regarded as very unlikely, although a limited number of suppliers believe it may one day be possible.

Type One: Steel carrier with door structure support

Brose type steel carrier

This is the most widely produced door module in Europe – closest in design and function to a non modular door and requiring the least changes to the metal of the car's door.



Characteristics	
Components	Carrier, regulator, motor, latch, wiring harness, speaker, internal locking parts
Supplied to	Golf, Passat, Laguna, R50, next Brava
Supplied by	Brose, Meritor, Kuester
Weight (claimed)	Down 5-10%
Parts (claimed)	Down 10%
Cost (claimed)	Down 10-20%
Economics	Suitable for high volumes

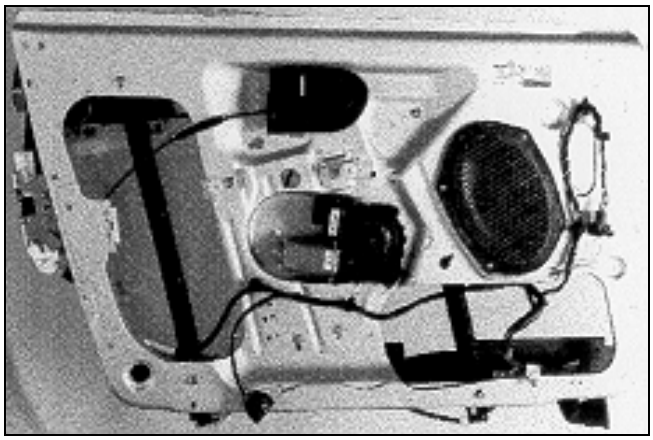
The module consists of a metal carrier plate holding a limited number of components together – typically the window speaker mount and latch. The complexity of such modules varies - typical examples (and the modules in highest volume production) are the Brose modules for the VW Golf and Passat – the latter holding more components than the fomer. The Golf module is also produced under license by Meritor[xix] – as is Brose's module for the Renault Laguna, which is a very simple first generation module with a small, low functionality carrier (holding just lifter and motor).

The module removes the need for a separate waterproof shield to keep the components in the door dry – instead a thin seal is fitted to the carrier which, when inserted in the door, meets the sheet metal and seals the dry area.

Type Two: Steel carrier with door structure support

Steel carrier module suppliers also offering modules with structural role

Similar to Type One, but with some structural support. Removes need for door to have metal on the belt line – allowing the window to be fitted as part of the module. To our understanding, not yet in production in Europe, but under consideration. Requires/allows modification of the steel of the door as the module itself provides some structural integrity and crash protection between the A and B pillar.

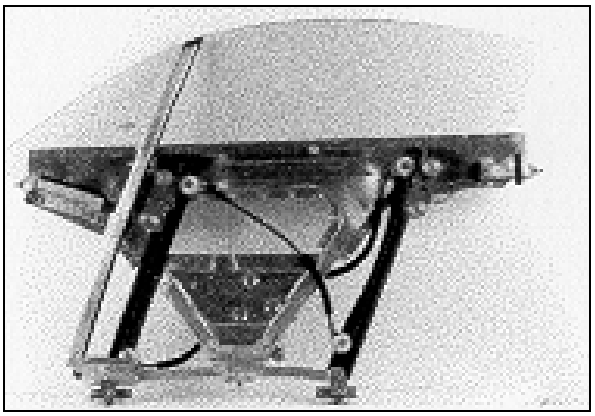


Characteristics	
Components	Carrier, regulator, motor, latch, wiring harness, speaker, internal locking parts, inner door handle, some interior trim
Supplied to	N/A
Supplied by	Kuester, Meritor (?) concepts
Weight (claimed)	Down N/A
Parts (claimed)	Down N/A
Cost (claimed)	Cost neutral/may be more expensive
Economics	Suitable for frameless doors, niche products

Type Three: Steel carrier with glass and integral door structure support

Structural module features on Audi TT

A fully structural module that is an integral part of the door. Demands a different approach to the design of the steel of the door as the module itself provides structural integrity and crash protection. Designed explicitly for frameless doors/ convertibles – the module has built-in adjustment mechanisms that allow the glass and window guide to be aligned with the body quickly (5 minutes v. 30 minutes per door for a non module). Fitted to the Audi TT. Only really suitable for niche models as not financially viable on lower margin cars.



Characteristics	
Components	Frame, regulator, sealing, glass, adjustment mechanisms
Supplied to	Audi TT
Supplied by	Kuester
Weight (claimed)	Down N/A
Parts (claimed)	Down N/A
Cost (claimed)	Up: More expensive
Economics	Only for frameless doors, niche products

Type Four: Plastic/composite carrier (i.e Delphi 'Superplug')

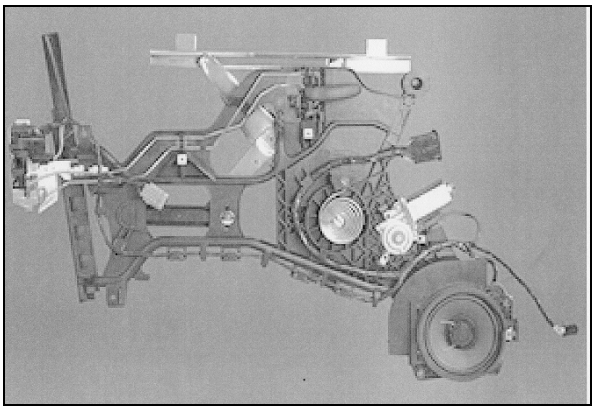
Plastic carriers problematic but many offer greater integration opportunities – and OEMs recognise this

While the majority of door modules in production are steel carrier based, a number of suppliers have sought to develop plastic carrier based modules. The plastic v. steel debate is to central to the debate about door modules, with many suppliers believing that to optimise integration in the door, it will be necessary to find a way to utilise plastics, or even build the module up from the interior trim (see Type Six below). The Delphi 'Superplug' was a well publicised effort to use a plastic carrier (without interior trim). Using an injection moulded engineered resin, the 'Superplug' allowed the carrier to integrate parts such as clips and attachments – which is not possible with a steel carrier.

However, despite the integration opportunities offered, such a design may have a number of problems related to it:

- it requires careful engineering to allow adjustment during fitment –as BIW differences can cause alignment problems.
- the plastic carrier faces problems passing the European NCAP offset crash test.
- possible water sealing problems (requires a separate water shield)
- competitors claim that its cross-arm lifter has reliability problems

While Delphi has altered the 'Superplug' design to incorporate steel components, it believes the plastic carrier ultimately offers the greatest integration opportunities One of the OEMs we interviewed in-depth about the door module supported this assertion – reporting that, although a plastic carrier is typically more expensive than steel, the OEM wished to appoint a supplier of a plastic carrier 'to encourage thoughts about integration with the interior trim on the next generation'.



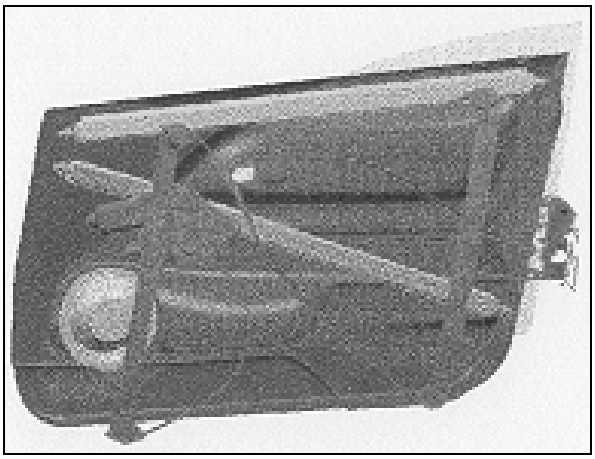
Characteristics	
Components	Plastic carrier, regulator, motor, wiring harness, loudspeaker, latch
Supplied to	Forthcoming models (significant volume)
Supplied by	Delphi, Sommer Allibert Siemens, other
Weight (claimed)	Down N/A
Parts (claimed)	Down N/A
Cost (claimed)	Neutral, but carrier more expensive than steel
Economics	Volume production

Type Five: Plastic interior trim based integrated module

Plastic module built up from interior trim difficult but potentially very attractive

Although some way from production at present, a plastic module built up from the interior trim is the ambition of a number of suppliers (including the 'complete interior' lobby who come from an interior plastics background – such as Sommer Allibert, Faurecia, JCI and Lear). It has some compelling logic if the engineering problems can be overcome, offering maximised integration opportunities for virtually all the components that go into a door. The principal engineering problem reported by both OEMs and suppliers is the difficult of finding a plastic that can satisfy the need of interior aesthetics (i.e. softness, texture etc.) and simultaneously provide the necessary structural rigidity to support the rest of the door components. Those suppliers claiming to have solved this problem point to the use of a composite sandwich of different plastics and/or metal – but this may increase cost considerably.

There are no such examples in production at present, with one supplier who has pitched the idea to OEMs reporting that 'customers are currently not open to this concept since they don't believe that suppliers can handle it'. However, we believe that the deployment of such a module is possible in the medium term.



Characteristics	
Components	Regulator, latch, inner door release, wiring harness, inner door reinforcement panel, crash panel, loudspeaker, glass, inner trim and fabrics latch
Supplied to	None as yet
Supplied by	All suppliers (including current steel carrier suppliers) developing concepts
Weight (claimed)	Down Considerable
Parts (claimed)	Down Considerable
Cost (claimed)	Unknown – potentially much cheaper
Economics	Unknown - tooling costs suggests high volume, handling costs high (weight and interior trim must be kept clean)

Type Six: Complete door including exterior steel

Consensus is that complete door, with steel, will remain unfeasible

The prospect of a full door, including the steel outer, is a subject we discussed with both OEMs and suppliers. Although both groups are aware that such a scenario is a possibility, the general level of interest on both sides was very low. OEMs seemed disinterested – the tasks of pressing, welding and painting the body in white (BIW) are regarded as an OEM task and not something any current door component supplier has any competency to provide. It appears that personnel at the OEMs have only given the idea brief consideration – there is a consensus that the economics, competency transfer and paint match problems are unworkable.

Those that argue it will be possible unable to provide details of paint developments that will allow it

Amongst the supplier community, the concept is seen as so ambitious as to be almost unrealistic. Paint match and economics (of a separate paint facility) are the main factors behind the lack of enthusiasm. With just two exceptions, all suppliers believe the paint match problem is not solveable - and those who were more optimistic were unable to give any details of the technology advances that they believe will allow it to be achieved.

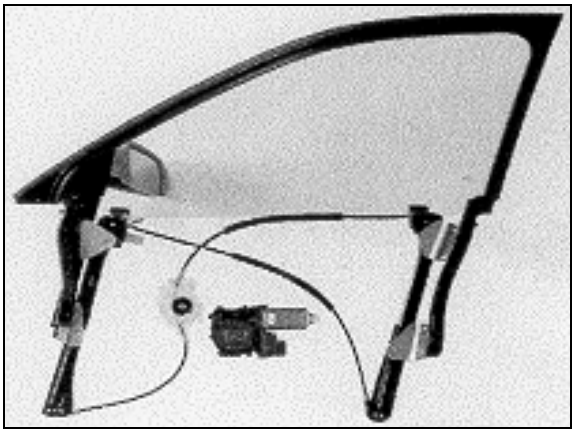
The only realistic way of involving the steel outer would be off-track door assembly by the supplier – after the doors have been painted by the OEM in the assembly plant. Such a scenario is realistic given the likelihood of adjacent location in a supplier park, but represents a process that is little different to the less ambitious module concepts heading for production. It

appears that unless plastic panels and/or methods of physically separating panels with another material become more popular (both features of the Smart), then a complete door module including outer will remain purely conceptual.

Type Seven: Niche module with integral window frame

Other concepts in development for certain limited niches

This module is unlikely to be of great relevance to mass produced vehicles in Europe but provides an interesting example of the ingenuity of suppliers' concept ideas in their efforts to find solutions that allow a greater proportion of the door to be outsourced. The module reduces the proportion of the door that the OEM needs to build – by supplying the upper half of the door in the form of a frame and glass. In addition, it offers easy assembly – allowing the module to be fitted from above on the final assembly line. The main limitation of such a design is that the design of the car must permit a frame that is always supplied in one, or a limited number of, colours – probably black – to avoid paint match problems.



Characteristics	
Components	Frame, regulator, sealings, mirror, glass and guides.
Supplied to	None as yet
Supplied by	Kuester
Weight (claimed)	Down (Alu. or magnesium possible)
Parts (claimed)	Down N/A
Cost (claimed)	N/A
Economics	Niche market due to colour issues?

5.3 COST, WEIGHT AND PERFORMANCE GAINS

Gains depend on the technology that prevails

The claims made for door modules vary greatly, but all the suppliers we have met with believe that the integration opportunities will ultimately guarantee both weight and part number reductions. The discussion above details the gains claimed for a variety of types of door module – but to summarise, with most of the modules in production (and nearing production) being similar to Type One (i.e. steel carrier based with limited integration), the typical gains are in the region of 5%-10% for weight, 10% for parts and 10%-20% for cost. However, these figures have not yet been verified by the OEMs and we have had no clarification of the basis of comparison – particularly for the cost claims. The gains made by both

plastic carrier modules and by plastic fully integrated door modules are unclear due to the early stage of their development but are, potentially, much greater. However, once again, the cost line is particularly difficult to analyse.

5.4 WHO'S SUPPLYING WHOM?

Door modules still limited in Europe despite use on region's best seller

The extent of the adoption of modularity in the remains relatively limited in Europe, although the use of modules on the region's best selling car (VW Golf) is significant. The two part process of adoption seen in cockpit modules – with internal modules being an initial development that are then superseded by externally procured modules – is notably absent. As far as we understand it, there are no internal modules – assembly is either undertaken in the conventional way (almost all doors-off assembly lines with individual door components and a water shield all added individually) or external suppliers provide modules. The following is a very early and provisional list of the use of door modules in Europe, which will be updated as we collect information. However, we believe the following statements are valid:

- Modularity in the door is rarely an internal OEM decision (but some door trim fitted as one piece)
- Door module use remains limited, with the steel carrier based module most common
- The majority of door module business is still being won by firms with origins in window regulator manufacture – although we understand a significant contract for a plastic based module is about to be placed.

Table 10: The extent of modular cockpits in the European auto industry (draft)

OEM and model	Introduced (E=estimate)	Door module?	Supplied by/type:	Regulator manuf. (split equals dual sourced)
Audi				
A2	2000E	No	N/A	?
A3	1996	No	N/A	?
A4	1993	No	N/A	Brose
New A4	2000E	?	N/A	?
A6	1997	No	N/A	Brose
New A6	2004E	No	N/A	?
TT	1999	Yes	Kuester – integrated door structure and glass	Kuester
A8	1995	No		Kuester
BMW				
3-series	1998	No	N/A	Brose
5-series	1996	No	N/A	Brose/Kuester
7-series	1997	No	N/A	Brose
New 7-series	2001E	?	N/A	?
Z3	1995	No	N/A	?
New Z3	2002E	No	N/A	?

Citroen				
Saxo	1995	No	N/A	?
New Saxo	2001E	No	N/A	?
Xsara	1997	No	N/A	?
Xantia	1992	No	N/A	?
New Xantia	2000E	?	?	?
XM	1991	No	N/A|	?
New XM	2001E	?	?	?
Fiat				
Punto	1999	?	?	?
Bravo/a	1994	Yes	Lames	Lames
New Brava/o	2001E	?	?	?
600	1996	?	?	?
Coupe	1995	?	?	?
Alfa 145/6	1994	?	?	?
Alfa 156	1997	?	?	?
Alfa 166	1999	?	?	?
Lancia Y	1995	?	?	?
Lancia Lybra	1999	?	?	?
Lancia Gamma	1996	?	?	?
Ford				
Ka	1996	No	?	?
Fiesta	1989	No	?	?
New Fiesta	2001E	Yes	Confidential	Confidential
Focus	1998	No	?	?
Mondeo	1993	No	?	?
New Mondeo	2001E	N/A	Confidential	Confidential
Mercedes-Benz				
C-class	1993	No	N/A	?
New C-class	2000E	No	N/A	?
E-class	1996	No	N/A	?
S-class	1999	No	N/A	?
M-class	1996	No	N/A	?
SLK	1996	No	N/A	?
CLK	1998	No	N/A	?
Vito	1994	No	N/A	Kuester/Antolin
New Vito	2002E	N/A	N/A	?
Opel				
Corsa	1993	No	N/A	?
New Corsa	2001E	No	N/A	?
Astra	1998	No	N/A	?
Vectra	1994	No	N/A	?
New Vectra	2001E	No	N/A	?
Omega	1992	No	N/A	?
New Omega	2001E	No	N/A	?
Peugeot				
106	1991	No	N/A	?
206	1997	No	N/A	?
306	1992	No	N/A	?
406	1995	No	N/A	?

706	2000E	No	N/A	?
Renault				
Twingo	1991	No	N/A	MGI Coutier
Clio	1997	No	N/A	Brose/Meritor
Kangoo	1996	No	N/A	Brose/Meritor
New Clio	2002E	Open	Open	Open
Megane	1995	No	N/A	Antolin/Meritor
New Megane	2001E	Open	Open	Open
Laguna	1994	Yes	Brose/Meritor – steel carrier (limited parts)	Brose/Meritor
New Laguna	2000E	No	N/A	Meritor
Safrane	1993	No	N/A	Meritor
New Safrane	2001E	No	N/A	Meritor
Espace	1994	No	?	?
New Espace	2001E		N/A	Meritor
Rover				
200/400	1994/2	No	N/A	?
R75	1999	No	N/A	?
R50 (new Mini)	2001E	Yes	Kuester	Kuester
Freelander	1997	No	N/A	Brose
Discovery	1998	?	?	?
Range Rover	1995	?	?	?
Seat				
Arosa	1998	?	?	?
Ibiza	1995	?	?	?
Toledo	1999	?	?	?
Skoda				
Felicia	1994	?	?	?
Octavia	1997	?	?	?
VW				
Lupo	1998	No	N/A	?
Polo	1996	No	N/A	?
New Polo	2001E	Yes	Confidential	Confidential
Golf	1997	Yes	Brose/Meritor	Brose/Meritor
Passat	1996	Yes	Brose	Brose
New W8	2001E	Yes	Kuester	Kuester
Volvo				
S40	1995	No	N/A	?
S70	1993	No	N/A	?
New S70	2001E	No	N/A	?
S80	1998	No	N/A	?

6.0 SUMMARY OF KEY ISSUES IDENTIFIED FOR FURTHER RESEARCH

The purpose of this section is to draw together this preliminary report by highlighting the specific issues relating to modularity and outsourcing in Europe that we regard as most significant and most worthy of further research over the coming year (1999-2000).

6.1 STRATEGIC ISSUES

The research and analysis undertaken to date in Europe has revealed a number of significant challenges for both suppliers and OEMs. We believe that it will be valuable to explore and attempt to validate some of our initial conclusions reached here, including:

- INTEGRATORS: Are the companies currently acting as module integrators the most effective long term holders of this responsibility? More explicitly, do current integrators have the right expertise and capabilities to fully develop modules and forge ahead with the potential integration opportunities they offer? Why have suppliers of higher value items (particularly in the cockpit) not come forward and competed for modular supply – does the argument that companies such as Bosch have refrained due to the security of their position indicate that module integration and supply is an inherently unattractive business? Are module integrators driven into the market by the need to act defensively or does modular supply offer more than that? Furthermore, we wish to investigate whether the split between system and module suppliers is sustainable – would it be feasible for the two roles to merge, given that module suppliers must always bow to the suppliers of systems? Finally, will margin dilution drive firms to find a way to manufacture more of what they supply?

- LOWER TIER CONTROL, PROJECT MANAGEMENT AND QUALITY: Can the vehicle makers expect module suppliers to continue with current practices and can they harness the real benefits of modularity if they still insist on selecting 2nd tier suppliers, providing specifications based on current architectures and continuing shadow engineering? What are the real quality benefits of modularity and what is best practice in this respect? Do different approaches to 2nd tier control correlate with quality levels? Is there any correlation between approaches to module supplier selection and co-operation and the success of projects? What are the factors that explain the failure of certain module projects?

- PARTS COMMONALITY: Is there potential in the industry for module suppliers to drive ahead with parts commonality – or will modules remain as dedicated sub-assemblies rather than genuine standardised parts with common interfaces? What is the likelihood of standardising non-customer facing parts in the two modules of study – can HVACs, steering columns, window regulators and motors be homogenised across OEMs' products? What are the potential benefits and dangers of such a development and what might it permit in terms of supplier scheduling and a build to order market?

6.2 FINANCIAL ISSUES

Financial imperatives are central to the development of modularization and outsourcing and, despite the probable difficulties of collecting detailed comparable data, we hope to explore more fully a number of financial issues over the coming year:

- THE ACCURACY OF THE MAKE/BUY DECISION: We have already investigated the make/buy decision process at one OEM – including interviewing senior (board level) personnel, purchasing financial controllers and individuals involved in developing and using make/buy analysis tools. We intend to expand this with other OEMs and research the practices and processes used by the various vehicle manufacturers, differences between them, and their approaches to evaluating the most difficult factors such as sunk costs, space saving and overhead allocation. We hope to be able to report next year on the differences between methods, the viability of such approaches and the accuracy of the make/buy decision.

- CAN OUTSOURCED MODULES COMPETE ON COST?: In a related vein, we wish to explore more fully how suppliers build up a piece price for a module, by examining approaches to factor costs, R&D and engineering cost, new plant investment, depreciation, volume predictions and related adjustments, overhead allocation and capital costs. We hope to compare the costing of modules from suppliers with in-house production and understand whether the decision can be justified in purely financial terms. Our interview-based research suggests not – if this is validated, we hope to establish what other factors are driving OEMs to make the decision. In particular, we will consider whether the decision to devolve responsibility to suppliers –which appears a resource or competency based decision (i.e. the view that certain tasks and responsibilities sit more naturally with suppliers)- is supported by the reality of capabilities in the supply base. If, as we suspect, such devolution requires the rapid development of the necessary expertise in the supply base, we hope to establish whether it is possible to quantify the costs of this development. In addition, we wish to explore the issue of margin dilution more fully, examining the implications of this for suppliers and their views on potential strategies to overcome it.

- SUPPLIER OWNED TOOLING: We intend to investigate more fully the possibility that more OEMs will demand that suppliers own tooling – and will research differences in perception and opinion in the supply base. If it is apparent that supplier owned tooling is a likely scenario, then we will investigate what the financial implications of such a shift are for the industry and, in particular, will examine differences in the cost of capital of the various participants in the industry – hoping to understand whether the shifting of investment responsibility from OEMs to suppliers is a real net gain for the industry.

6.3 SOCIAL ISSUES

We wish to investigate a number of social issues related to the shifting boundaries of the firm brought about by modularization and outsourcing, and in particular would like to understand more about the roles and organisation of workers in supplier parks.

Our investigation in Europe so far has shown that the boundary of the firm has become increasingly blurred with the outsourcing of modular assembly and design. Supplier companies are asked to make use of physical capital (e.g. land, buildings) owned by an OEM or a third party (e.g. local governments). Moreover, in part to get around the problem of paying workers different wages, a supplier company might partner with another firm (typically a logistics company) that has direct responsibility for supervising employees engaged in modular assembly. This creates a complex form of employment contract in which operators are supervised, disciplined and paid by a firm, but who are also accountable to another firm for their quality of work. As part of an outsourcing decision, a group of workers at an OEM may be taken on by the supplier company on a permanent or temporary basis to work on essentially identical modular assembly tasks. These developments point to the following set of issues:

- What is the range of current practices in supplier parks, with respect to who owns what and who is responsible for what (quality, delivery, etc.)?
- What are the mechanisms to ensure that workers hired by supplier companies are of as good quality as those hired by the OEM?
- What is the extent of co-ordination and co-operation between the OEM and suppliers, and among suppliers, in training employees that they hire?
- How are the benefits and costs of such joint provision allocated?
- What is the role of the local authorities in facilitating the creation and maintenance of supplier parks?
- Is the maintenance of differences in pay (and other terms of employment) between the OEM and suppliers in supplier parks viable in the long run? What are the implications for OEMs, suppliers and employees if and when the differential falls?
- What is the role of trade unions in this respect in various countries?

NEXT STEPS

We have purposefully avoided including any conclusions at the end of this report, to reflect its preliminary status. We believe that our research to date has revealed a wide range of significant and fundamentally important issues surrounding modularization and outsourcing, but we are aware that much of our analysis and many of our conceptual ideas are at an early stage. We wish to explore some of the issues we've encountered in greater detail over the coming year, and our research will therefore be focused on the areas described above in Section 6. To enable us to tackle these issues, we plan to:

- undertake further research visits with other European OEMs (we are currently seeking a number of meetings), the remaining cockpit and module suppliers in the region and other relevant parties (electrical systems suppliers, HVAC suppliers and contract engineers); and
- develop and despatch a detailed quantitative (and confidential) data collection questionnaire to those companies that have already participated (most have indicated that they are keen to be involved) – focused particularly on quality, technical and financial data. We intend to develop this in combination with the other IMVP research teams covering the US and Japan and plan to despatch it early in 2000.

Finally, in order to share, clarify and refine our findings, we may hold a workshop in Europe for personnel from sponsor OEMs and suppliers of cockpit and door modules, later in 2000.

[i] we have already met with Bundy (UK), which recently acquired Walbro Corp. (US), enabling it so supply 'fuel modules'.
[ii] i.e. the approaches of Japanese transplants in Europe to modularity
[iii] Hsieh, L-H, Schmahls, T. and Seliger, G. (1997), Assembly Automation in Europe – Past Experience and Future Trends, in Transforming Automobile Assembly (1997) (eds. Shimokawa, K., Juergens, U, and Fujimoto, T., p.29
[iv] We use the term 'modern sense' in order to acknowledge the role of independent body manufacturers in Europe between the two world wars, who took standard rolling chassis and built variants upon them.
[v] Berkt Group – The current status and trend of passenger car and light truck assembly modularization in NAFTA and Europe through 2010 (July 1998), p.2-2
[vi] The study in Europe has also highlighted the possible importance of the movement of senior management between OEMs in the spread of modularity, with advocates of the trend implementing modularization approaches at their new company that have already been successfully employed elsewhere.
[vii] Wilhelm, B. (1997), Modular Assembly in Mixed-Model Production at Mazda, in Transforming Automobile Assembly (1997) (eds. Shimokawa, K., Juergens, U, and Fujimoto, T)., p.99
[viii] We are seeking, but have yet to identify, an example of an OEM adopting a module, then reversing the decision for a subsequent model. (we believe the new BMW 7, due in 2001, reverses the use of an external IP supplier)
[ix] Mercer, G (1995), Modular supply in the 1990s: the keys to success, Europe's Automotive Components Business, Q2 1995, p.127
[x] Claims such as these will be easier to quantify after the results of Round 3 of the Assembly Plant Survey are compiled
[xi] Oxford English Dictionary 1997
[xii] Kinutani, H. (1997), Modular Assembly in Mixed-Model Production at Mazda, in Transforming Automobile Assembly (1997) (eds. Shimokawa, K., Juergens, U, and Fujimoto, T)., p.98
[xiii] *op.cit. p.97*
[xiv] Kinutani, H. (1997), Modular Assembly in Mixed-Model Production at Mazda, in Transforming Automobile Assembly (1997) (eds. Shimokawa, K., Juergens, U, and Fujimoto, T)., p.99
[xv] We note, with interest, the involvement of financial institutions in the funding of supplier capital investments dedicated to one OEM.
[xvi] Note also the correlation with greenfield sites
[xvii] Note Max Warburton's funding from the UK based 3 Day Car Programme, which is investigating these concepts.
[xviii] Please refer to Sako and Murray (1999*),'Modules in Design, Production and Use: Implications for the Global Automotive Industry*, for further discussion.
[xix] We understand that the Golf and Laguna modules are Brose designs but we can only verify this after meeting with Meritor.