Decision-making in many business situations is easier if those responsible have a good idea of what a product or component actually costs to make. Armed with this information, procurement teams can be much smarter in their detailed negotiations with suppliers, engineers can apply their cost reduction efforts where they will have most impact, and product managers can build more robust business cases for the development of new versions or the integration of new features, to name but three examples.

All too often, however, those actual costs aren’t clear. Suppliers rarely want to reveal too much about their own manufacturing processes and costs, for example, and even internally, factory accounting systems often group many activities together into cost centers (for example, “machining”, “heat treatment”) which makes it hard to identify the true costs of individual components or features.

Bottom-up cleansheet target cost calculations have risen to prominence in recent years as a tool to deliver exactly this information. A cleansheet calculates the cost of each step during the creation of a product, component or service using a database of information on the materials, labor, factory space, equipment, time and energy required to complete each step and the implications for the desired product volumes on the utilization of those resources.

A “cleansheet” is not only the result of a cost engineering process; the name also defines the approach used to calculate target cost. The calculation starts with a “clean” “sheet” which is populated with a fully optimized manufacturing scenario, not just the reverse-engineered cost structure of an existing manufacturing process.

Cleansheet cost models help companies in two basic ways. First, they provide a “should cost” figure for a product, allowing purchasing teams to understand how much room they have for negotiation with suppliers, and letting product management staff see whether a proposed design can be sold at an appropriate margin. Second, because it indicates the principal sources of product cost, Cleansheet cost transparency helps companies to generate ideas for design and process improvements, for example by adopting a different process flow, production technology or manufacturing footprint.

**Building a cleansheet**

Building a cleansheet is like telling the story of the journey of a product under ideal conditions through its manufacturing process. Just like a historian, or a journalist working on a story, the team responsible for the cleansheet cost model may have to cope with varying amounts of
primary evidence on which to base that story. The skill in building an effective cleansheet, is understanding where and how to find the vital missing information, and making educated assumptions for the rest.

The first step in the process – the creation of the basic outline of the story – is visualizing the manufacturing flow. This may be known, in the case of products already being manufactured within a company’s own facilities, or it may be hypothetical in the case of products not yet in production or manufactured elsewhere.

The second step is to populate that outline with the detail required to bring it to life. This detail includes raw material requirements obtained from a product’s bill-of-materials, and, for each production step, the equipment and tools used, staffing requirements, cycle time, scrap and rework rates. Sometimes, companies may be able to use data from their own on-going manufacturing activities here, or from their experience with similar parts. In other cases they will have to use their production expertise to make estimates for novel production processes or those used by suppliers.

With the process description in place, the third step is the allocation of resource costs for material, labor and equipment. Companies may use their own or a commercially-available database to do this. As the validity of the final cleansheet target cost depends fundamentally on the use of high quality, current source data it is vital that companies trust their chosen data source, and that they understand its limitations.

Finally, often using the same databases and tools, overheads are added to the model. These include the indirect resources needed to run the plant; the amortization of one-off investments in R&D, equipment and tooling, and the effects of currency exchange and taxes. If some or all of the process it to be outsourced to a supplier, an appropriate profit margin must be incorporated too, to make the work worth their while.

**Getting the detail right**

Newcomers to the cleansheet process often struggle to understand the right level of detail with which to build their models. On the one hand, the more detailed the model, the more useful it is, offering more opportunities to look for process and design improvement potential, and acting as an extremely compelling supplier negotiation tool. One cable supplier was surprised and impressed, for example, when its customer revealed that their cleansheet model even took account of the additional manufacturing time required to wind additional strands into heavier-gauge cables.

On the other hand, the effort required to build a model can reach a point of diminishing returns at a certain level of detail – instead of modeling simple parts like fasteners or spot-market driven material cost items, resources are better invested into the analysis of additional products or the generation of improvement ideas.

In practice, it is often best to use a pragmatic approach, in which all cost contributors are estimated initially, with only the expensive items and those with high uncertainty calculated in detail. In the manufacture of hydraulic cylinders, for example, accurate calculations on the cost of the steel used to make the parts and the processes used to machine and finish that material are likely to be much more important than activities associated with handling components during manufacture. Sometimes it
can be useful to use an iterative approach in which a simple model is built to identify the parts of the process with the highest cost sensitivity. These can then be modeled in more detail.

For complex products and processes, a number of rules-of-thumb can help modeling teams to make sensible compromises:

- **Detail.** It is often sufficient to model only those items with significant cost uncertainty. A purchased part for which there is a limited supplier base, or one manufactured using a new technology might be modeled, for example, while commodity products and those with high levels of supplier competition, like DRAM chips or simple metal castings might be entered as direct material cost, or material cost plus mark-up.

- **Number of items.** A single cleansheet cost model should be small enough to be manageable by one dedicated cost engineer. Usually there are sensible breakpoints along the value that allow this to be achieved, for example the scope of a sub supplier, or process along a single manufacturing line. Single cleansheets can be created for each of these sub-categories. These can be combined in a tree structure to give the total cost of the product.

- **Cost categories.** Really complex products like complete vehicles can be disaggregated into commodities – sheet metal, cast parts, machined parts, electronics, plastic parts etc. – which can each be modeled by personnel with expertise in that particular category. This approach increases the speed of the process, since activities can take place in parallel and make use of skilled resources, but combining and coordinating the results requires care to ensure that all sub-cleansheets use comparable assumptions and a similar level of detail and analytical rigor.

One medical products company used these rules when it defined the cleansheet architecture for a complex piece of imaging equipment. The company disaggregated the complete product into mechanical, electrical and imaging sub-systems, and assembly parts. Each sub-system was modeled by a dedicated team in its own cleansheet and, within each cleansheet, components were divided into A (complex, bespoke), B (simple, bespoke), and C (standard) categories. The C-component costs were obtained from a database of standard parts, B-component costs were estimated using expert judgment and the cost of electronic assemblies was outsourced to specialist service provider. A-component costs were calculated in their own sub-cleansheets. By breaking down the problem in this way, a team of ten cost engineers was able to sum 11,000 separate cost items to estimate the target cost of the design in just one week.

**Using cleansheet insights**

Once built, a cleansheet provides an estimate of the production cost of an item under a specified set of assumptions. This can be useful for supplier negotiations or for checking the validity of the basic business case for a new design. One company used cleansheets to identify the target cost of the power cables that were an important component in its products. Product teardowns at the beginning of the project initially revealed that the company was paying its supplier for more material...
than was actually used in the cables. Over the years, the supplier had managed to improve the material performance of the cables and reduce the amount of expensive copper used in them while maintaining the overall weight of the product with heavier insulation. A switch to lighter cable specifications delivered an immediate saving, even before the target cost was calculated. When the company went on to build a detailed model of the cable manufacturing process it was able to understand the most important drivers of cable costs. Not only did this analysis reveal that the true manufacturing and assembly costs were lower than those assumed in initial contract negotiations, it also allowed the company to test the impact of several design ideas that simplified manufacturing and assembly processes even more, further reducing costs.

Another hugely powerful aspect of the cleansheet approach is delivered by the ability to modify the assumptions within the model and explore the effect of different production scenarios. Will a proposed offshore manufacturing location remain economic if oil prices rise, or exchange rates swing? Should low volume components be accommodated by reducing batch sizes or by ordering less frequently and keeping more parts in inventory? How do the full costs of simple labor-intensive assembly compare with a high-tech automated solution? When is the right time to switch manufacturing methods as production volumes rise? With the right model in place, and with the skills and data to use it effectively, the cleansheet can become a tremendously powerful decision-support tool and an integrated pillar of the business case.

One company compiled a high-level cleansheet to estimate the projected target cost of a new electromagnetic actuator, for example. Initially, even the most optimized design failed to meet the company’s market-price target for the device. When the company changed the cleansheet assumptions to consider manufacturing in a low cost country, it found that the additional logistics costs outweighed the advantage of the move. Only when the company tried a third approach – shifting to another low cost location and switching to an alternative assembly method, which traded equipment investment for higher labor inputs – did it find a way of meeting its targets. The business case became even more robust when the company refined the assembly concept again to allow labor and capital resources to be scaled as production volumes ramped up. Finally, the footprint of purchased components was optimized to allow changes in the supply chain to be used as a hedge against currency variations. Having used the cost transparency to refine and proved its business case, the new product has moved into production and the cleansheet model has gone with it, now helping the company to make its ongoing supply chain hedging decisions.

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