why early involvement?

At first sight a strange title. Those who have known tbp for a while, know precisely what it means. What early involvement yields for a client and what this concept means in practice, we will explain here. We will do this on the basis of the life cycle of a product, in this case a pcba), seen through the spectacles of tbp.*

**) pcba = printed circuit board assembly, electronics consisting of a printed board containing all of the components*

From the beginning to the end we see the following stages:

- drafting of the block diagram
- design of the (electrical) diagram
- design of the print layout of the copper line plan (the electrical "wires")
- compilation of the list of components
- purchase of the board and components
- indication of where the components are to be placed
- assembly process (the placement and soldering of the components on the pcb)
- optical quality inspection
- quality testing
- transport and further processing
- operational use
- completion of any repairs or modifications
- decommissioning.

Everyone who uses electronics will have to take these aspects into consideration. All of these factors also have a direct effect on costs - including "hidden costs" - indicated by the term Total Cost of Ownership (TCO). Naturally the user wishes to keep this low.

the EMS company

Just like the design of electronics, their assembly is a separate discipline. The assembly of modern electronics requires specialist machinery and qualified personnel. That's why in most cases designers outsource production to a specialised EMS company, Electronics Manufacturing Services. An obvious solution to keep the costs of this assembly as low as possible is to find an EMS partner which charges low prices. Do these companies exist? “Yes!”, says tbp. There are various EMS companies which are able to assemble a pcb with the motto "you demand it, we'll supply it”. Whether the client will achieve his objective, is doubtful. Very often no attention is paid to the question: “ Will the product fulfil quality requirements over its expected lifecycle?”.

faults

The answer is easy: probably not. The cause can be traced to the existence of faults. Numerous fault-sources ensure that the slip through - the percentage of pcb's manufactured and delivered to the client which potentially still contain faults - is high. This is due in part to the lack of optimum test coverage. In fact: sometimes it appears impossible to produce a board due to faults. A client who subsequently uses assembled electronics in his product will then discover the consequences. Often with (high) extra repair costs (so-called "hidden costs"). Cheap suddenly becomes expensive! What faults are likely to occur? A summary:

- a fault in the diagram
- a fault in the area and connection of the components "shapes (footprints)"
- a fault in the line diagram
- a fault in the digital information for production
- a fault in the chain from manufacturer to EMS company, the *supply chain* (faulty, damaged components)
- a fault in production
- a fault in the distribution and handling of the product.

According to conventional opinion the role of the EMS company only begins with assembly. tbp's thinking on this is completely different. tbp is convinced that it is impossible to make a good product if the designer does not take assembly requirements into consideration (in accordance with IPC). A low slip through rate is inconceivable if there is no cooperation between designer and manufacturer at an early stage. Naturally an EMS company must have at its disposal state-of-the-art machinery and qualified personnel but this alone cannot prevent numerous potential faults. For reassurance: Not a single EMS company is in a position to make an absolutely perfect product in only one production run; the so-called Production Yield is always lower than 100%. The way in which a good EMS partner distinguishes itself is by keeping the slip through referred to as low as possible.

DfX

All efforts to be able to make a good quality product are summarised by the term Design for eXcellence (DfX). It is the sum total of a number of methods which contribute to the quality of the product. DfL, Design for Logistics, considers the availability of components and at the same time the liabilities for residual values are minimised. DfM, Design for Manufacturing, considers to what extent the EMS company is able to manufacture a good quality product. DfT (Design for Test) determines the preferred test strategy to enable a product to be tested at the earliest possible stage during assembly in order to maximise the quality of the product and to minimise any repair costs.
DfX only has a chance of success if the EMS company and the designer combine their efforts at an early stage with the aim of creating a high quality product. tbp refers to this by the term early involvement. Cooperating with the designer's thought processes on feasibility and testability

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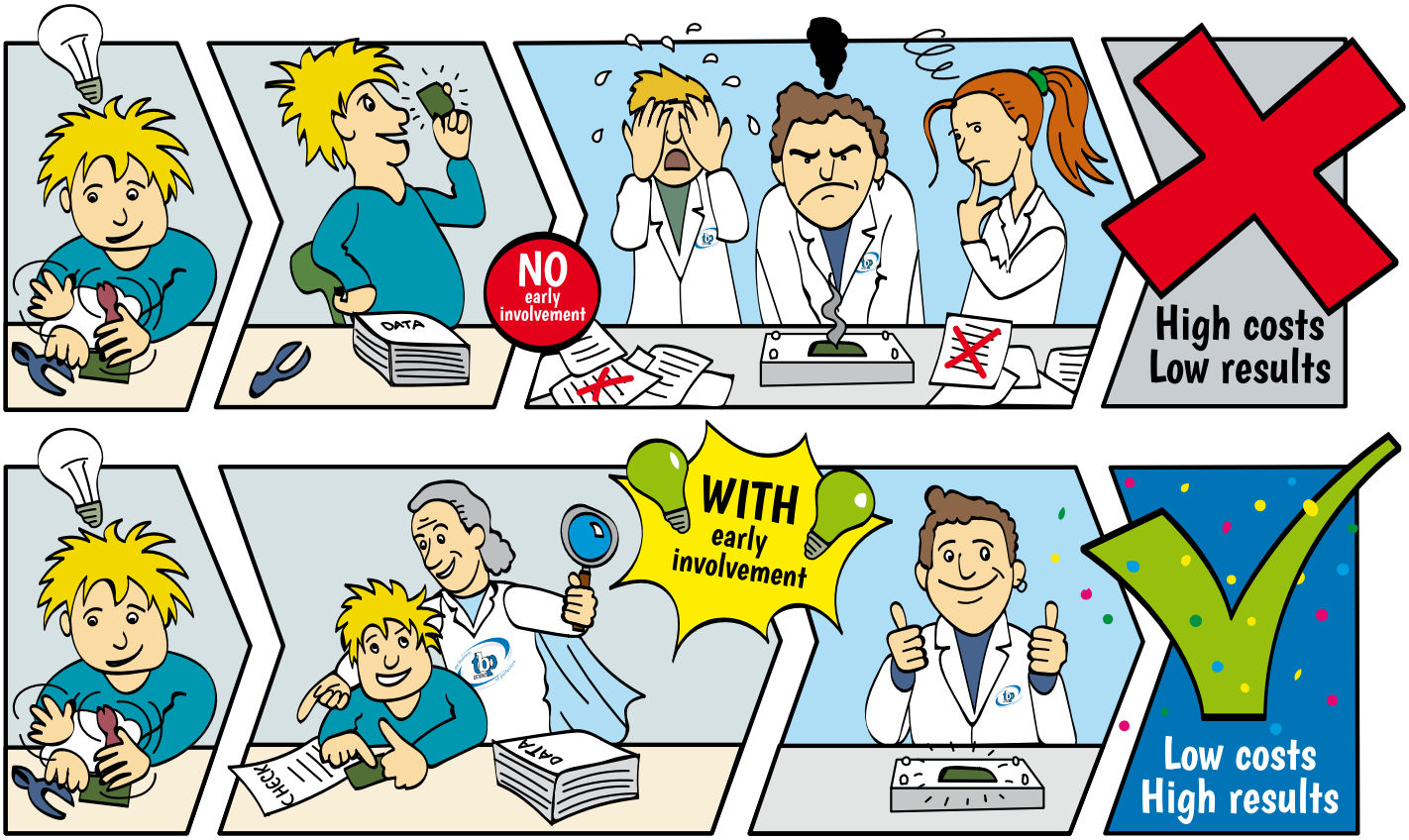

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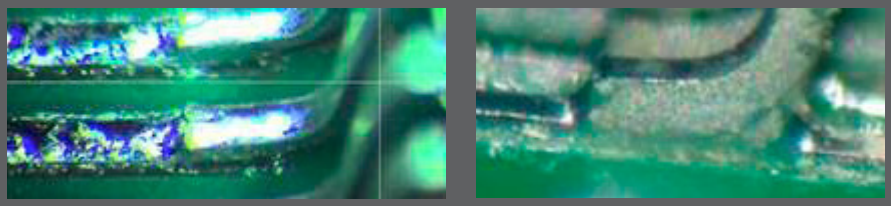
from the very start in order to enable the creation of a top product. That is tbp's main strength. On balance - and this can be supported based on calculation examples - this operating method also delivers a lower TCO ("the best buy"). The benefits are twofold! As far as we can judge the market, this service appears to be unique. Furthermore, we require our clients to cooperate with our DfX engineers to achieve a good result. That's why we have a team of DfX-engineers on standby to support clients when they start a project and when they have only the first idea (the block diagram) of the product to be designed.

DfM

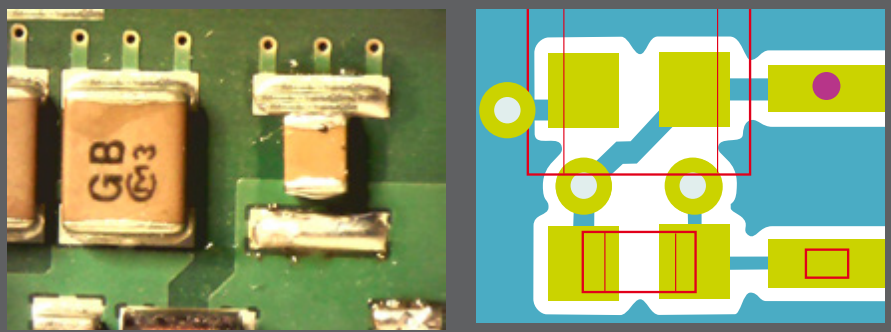
We want to make it quite clear that early involvement is not a superfluous luxury by providing a brief insight into the many factors in designs which negatively affect feasibility. Issues which arise on the design bench and for whatever reason remain unnoticed. Such issues are uncovered during the analysis included in DfM. These examples are drawn directly from practical experience:

- weak solder joints. The strength of the solder joint is determined to a great extent by the flow of solder to the rear (heel) of the foot. Figure 1 shows on the left a faulty path design (paths too far from each other) as a result of which flow to the rear has not succeeded. The image on the right shows the correct path design;
- component is too large for the footprint. The physical dimensions of the planned component (figure 2) differ from the component used. However certain types occur in different casing sizes;
- thermal imbalance. Because too great a thermal imbalance between the paths occurs, the solder paste melts more quickly on the right path than on the left path. As a result the likelihood that a component on one side of the path raises up and stands vertically on one side of the path (3: the tombstoning effect).

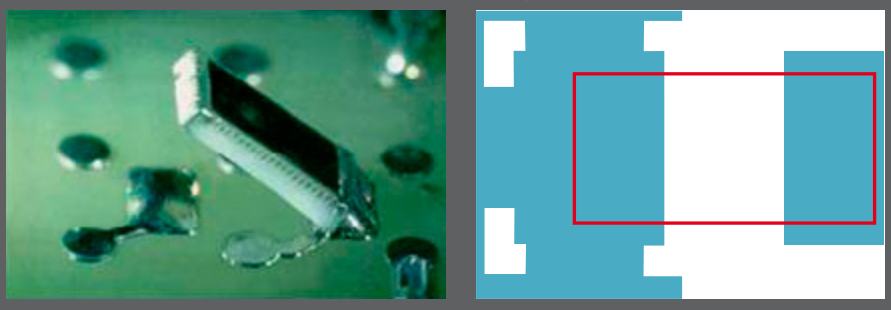
1. example of a weak (l) and good (r) solder joint



2. the area reserved on the printed circuit board does not match the selected component



3. due to thermal imbalance (difference in dimensions of the paths) there is a risk of tombstoning



DfL

As stated previously an EMS company puts together or assembles. That assembly consists mainly of soldering parts or components on a printed circuit board. The designer who creates the electronic diagram and decides the layout on the pcb, determines which components are necessary. In principle every electronics designer can select from a huge market offering. The wise choice depends to a great extent on the logistics process. Imagine a designer makes use of components with which tbp is not familiar. The buyers must then check availability, perhaps contend with an MOQ (minimum order quantity), reserve space in the warehouse and hold stock according to the order size. The work planners must then provide instructions for all sorts of production processes, from pick-and-place through to testing. That is a time-consuming and expensive task. It is better for a designer to make use of the usual components which tbp stocks as standard. This prevents problems and yields financial benefits to the client. In this logistics process tbp uses three categories of components, indicated by the letters A, B and C:

A. standard components which tbp keeps in stock itself
B. specific components used by two or more clients. Agreements apply to these components regarding the stock to be held and the purchasing commitments for each client

C. specific components which are only used by one client. Conditions apply to these components for stockholding and purchase obligations.

And then there are the components which have not yet been classified. In contrast to the components in categories A, B or C these are components which are unknown to tbp which require further study before they can be used. It is no surprise that such activity increases cost.

Quite apart from the holding of stock there is another facet which plays an important role, that of traceability. It is a process which runs through all steps from the start of manufacture of a component right through to decommissioning. As is already customary in the food chain, the circumstances in which a product is handled are recorded. Traceability is important in order to discover the history in the event of a defect. And we are talking about all phases in the supply chain. Who made the product, when, how was it transported, when was it processed, what were the environmental conditions, using which machines? Only with reliable information about these sorts of things can conclusions be drawn if the life cycle of a product is not achieved.

DfT

In addition to issues in the design sphere, faults can arise in the production environment. The production machine may contain a faulty component, it may be installed incorrectly, damaged or not functioning properly, it has not been correctly soldered etc. Sometimes these faults can be detected visually (using the 3D AOI (Automatic Optical Inspection)), but often they are only discovered when the board undergoes an electrical test. Electrical tests give a better impression of whether the board is functioning. Various techniques are available for this purpose. At tbp we have at our disposal the most diverse inspection and testing methods: visual inspection, 3D AOI, flying probe, in-circuit testing, (extended) boundary scan, a generic (functional) test platform (GTP) and ESS (Environmental Stress Screening, or burn-in test). They all have their own specific features with advantages and disadvantages.

GTP: Generic Test Platform

The importance of testing is beyond doubt. But testing must be feasible. A designer must therefore take into account the testability of the product in his design. It is not without reason that as early as the design phase the DfX engineers at tbp advise which test facilities and test *coverage* are desirable and necessary. It is these people who propose the right combination of test techniques at this stage. The test strategy is determined by a mix of parameters, such as the (specific) costs of each test, the diagnosis time (the time required to track down a fault, the test time and last but not least, the test coverage (coverage: which components are tested and to what degree).

Testing at an early stage of the assembly process exposes faults more quickly and allows them to be corrected more quickly than faults which are discovered at a later stage. In other words, the production process runs more efficiently and slip through is greatly improved.

not just a slogan

That the umbrella term DfX is inseparably linked to assembly stands to reason. Each client naturally wants a product with a high level of reliability. Even in the longer term. A machine builder who takes several hours to track down a defective board during the production of a machine and has to go to the trouble of replacing that board, pays the bill indirectly. Replacing a pcba at a distance (for example offshore or overseas locations) is also a costly exercise. It is better to ensure that both the designer and the manufacturer work together to create a reliable product, thereby avoiding any hidden costs. Early involvement is not just a slogan, but a condition for creating a successful product!

In other words, all pcba's are not created equal!