# Design Structure Matrix analysis: Better product design through a simple square chart

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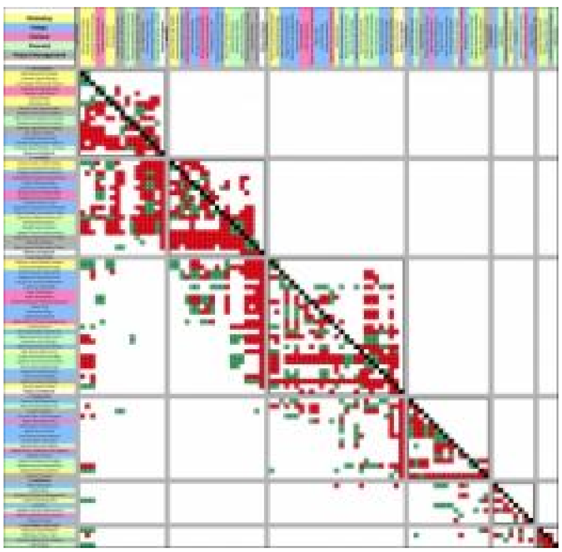

A DSM model showing the real estate development process. Image courtesy of MIT Press

Suppose you were asked to streamline the process of real estate development. Or to better organize the offices of an international manufacturer. Or to explain how the parts of a digital printer interact. The complexities of all these tasks would likely seem daunting.

Now suppose someone said you could accomplish these assignments by drawing a simple square chart on a piece of graph paper. No need for buggy software systems, labyrinthine flow charts or bloated Venn diagrams. Sound appealing?

Welcome to the world of Design Structure Matrix (DSM) modeling, a management exercise that forms one branch of MIT's long-running institutional fascination with the analysis of complex systems. A DSM chart is a way of simplifying complex engineering tasks — say, the design of computer hardware or engines — in order to make them more efficient.

Specifically, DSM analysis helps firms turn product design into a productive routine, rather than an ad-hoc process continually being reinvented — a point MIT management professor Steven D. Eppinger emphasizes in his new book, *Design Structure Matrix Methods and Applications*, co-written with Tyson Browning of Texas Christian University and recently published by MIT Press. It is the first such book, outlining DSM techniques for a general audience of engineers and managers, published in three decades.

"Engineering work is procedural and repeatable," Eppinger says. "People think of engineering as a matter of always developing something new, unlike business operations, where you do something over and over again. But we've learned that, no, maybe you repeat engineering work five or 20 times in your career instead of 100 times a day, but there's a process there. And if you can write down that process, you can improve it."

## Repeat after me

DSM modeling, as Eppinger and Browning see it, applies to three main areas of business: the design process, organizations and products. The "matrix" in DSM refers to the fact that a DSM analysis is represented by a square chart with boxes inside — much like a piece of graph paper. A DSM chart, with units of a system listed along the x-axis and y-axis of the chart, simply maps the intersections of those elements, with simple observations or data about the way the units interact.

Consider a DSM chart of the entire process needed to develop a piece of commercial real estate. (Using DSM to analyze the design process, Eppinger notes, is the most popular application of DSM modeling.) In 2009, for instance, MIT graduate students Benjamin Bulloch and John Sullivan created a DSM chart for nearly 100 different activities that the real estate development firm Jones Lang LaSalle needed to complete in order to finish a project. By listing those activities along both axes of the chart, the researchers were able to see how many part of the project interacted with each other — how many specific steps directly related to the leasing process, say.

In some engineering projects, this means repeating steps in order to make sure they are performed properly. In fact the distinction between necessary repetitions in engineering and wasteful ones is, Eppinger says, one of the most important insights to emerge from DSM analysis.

"Not all iterations are bad," he says. "You might think of rework as waste, but some iterations are fundamental and have to be built into the process, due to the cutting-edge nature of the design work and the uncertainty inherent in it. On the other hand, there are iterations that are slow and painful and frustrating and should probably be avoided. Those are the ones that derive from making mistakes or not having the right information when it's available."

Tracking the flow of information is one aim of applying DSM modeling to organizations. In one case, Eppinger worked with managers at the Timken Company, a global manufacturer, to assess where various parts of the business — product design, technology development, business development and oversight of its manufacturing development — should be physically located at its offices in Ohio. This DSM chart helped the firm decide where to locate the managers of its units so they would interact most effectively.

When applying DSM models to products, Eppinger notes, the aim of the analysis is to visualize the "difference between modular and integrative elements" of an object, to see which of these interact. One paradigmatic DSM chart from 2007, created in part by former MIT doctoral student Eun Suk Suh, listed 84 components of Xerox's iGen3 digital printing system, on both the left-hand side and top of the chart; color-coding the squares in which parts interacted enabling the company to see all the connections within its product, and helped Xerox update the technology for the next generation of the product.

## Tomorrow, biotech?

Soon after joining the MIT faculty in 1988, Eppinger became interested in DSM after reading an article about it in an academic journal. "I said, 'That's interesting, I wonder why nobody uses this?'" he recalls. Companies, he found, generally did not know about DSM — but became interested after learning about it.

Today, engineers say they appreciate the work of Eppinger and Browning. Georges Fadel, a professor of mechanical engineering at Clemson University, says they "do an excellent job" explaining DSM modeling.

The term DSM itself was coined in the 1970s by Don Steward, a professor at California State University at Sacramento. But Eppinger, Fadel says, helped "put DSM on the map. He took it and showed it's important to see if we can understand complexities visually."

And while DSM modeling has been adopted most widely in the automotive, aerospace and electronics industries, Eppinger says he is optimistic that it will spread further. "I'd certainly like to see more applications in medicine, health care devices, pharmaceuticals and biotech companies," Eppinger says. "I'd like to see more applications in energy. There is still lots of work to be done in those areas."

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