Dashboard Design: Beyond Meters, Gauges, and Traffic Lights

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Dashboards have become a popular means to present important information. Everybody wants one, but not always for the right reasons, and often with little clue as to what is needed. Like all new means of business intelligence (BI) delivery, dashboards are surrounded by hype and confusion. Once you clear the fog, however, something substantial remains that can deliver genuine benefits worth pursuing.

Dashboards provide a distinct and powerful means to communicate information, with specific benefits, but they also pose a specific set of design challenges. Very few dashboards today come close to realizing their potential achievements. This is because very few dashboard designers (or even dashboard vendors) have fully understood, appreciated, and responded to the unique challenges and opportunities of dashboards. In their rush to bring products to market, eager to capitalize on the popularity of dashboards, many software vendors have cobbled together pieces of existing products with bailing wire and loads of spackle. Caught up in the race to out-gizmo one another, few have taken the time to gain more than a superficial understanding of effective dashboard design. Without this knowledge as a foundation, dashboards are destined for the BI trash heap.

If something is worth communicating, it is worth communicating well. This article introduces keys to designing effective dashboards.

Dashboards Defined

New fads in the BI space are often nothing more than new packaging of something that already exists under a different name. Dashboards relate to several technologies and approaches to information delivery and use that preceded them.

Remember the Executive Information Systems (EIS) that emerged in the 1970s? Their intent was to provide executives and managers with an integrated view of the information needed to manage the business. Despite a great deal of interest in the concept, it was just too hard in those early days of computing to build effective solutions without the advances in processing power, database technology, and data warehousing methodology that arrived in later years.

Some people currently use the terms EIS and dashboard synonymously, but this is misleading. Dashboards can be used to achieve the promises of EIS, and in this respect they are related, but they are not the same.

Another term that is often used synonymously with dashboard is portal, but once again there are significant differences. A portal, as the name suggests, functions in BI as a single point of access to information. Dashboards can serve quite nicely as points of access to further information, but nothing in their definition demands that they do so. Dashboards are not a specific type of information for a specific audience, unlike EIS, nor must they necessarily serve as portals to additional information, nor do they require a specific technology—they are a specific type of display, a prescribed means to present information.

So what is a dashboard? If you search the Internet for examples, you'll find a mix of phenomena that is too eclectic to fit a single definition. If you search through BI literature for a definition of the term, you'll discover that, while much is said about dashboards, few people define them. Those who do define the term do so differently, generally in ways that conveniently fit the software they're promoting.

I've been working with dashboards for years, but have no ties to any particular product, so I can suggest a definition that is relatively unbiased, practical, and rooted in real-world experience. Here's my definition:

> A dashboard is a visual display of the most important information needed to achieve one or more objectives, consolidated and arranged on a single screen so the information can be monitored at a glance.

The information is presented visually as a combination of text and graphics. As such, the design challenges are largely challenges of visual design. The process of actually implementing a dashboard may involve any number of technical challenges associated with your software, data, and computing environment, but the fundamental design challenges are visual in nature. How can you best present the information so that human eyes can take it in quickly and human brains can derive the correct and most important meanings from it easily? To design dashboards effectively, you must understand a bit about visual perception—what works, what doesn't, and why.

Dashboards include the most important information one must know to achieve specific objectives. To achieve even a single objective often requires a collection of information that is not otherwise related—information that comes from diverse sources and is related to different business functions. The information is of whatever type needed to do a job. Dashboard displays are not just for executives and managers—they're for anyone who has objectives to meet. The information can be (and often is) a set of key performance indicators (KPIs), but other types of information can also be needed.

The information fits on a single screen, entirely available within eyespan so it can all be seen at once and at a glance. If you must scroll around to see it all, it isn't a dashboard. If you must shift from screen to screen to see it all, you've crossed the boundaries of a single dashboard. The objective is to have the most important information readily, effortlessly, and immediately available so you can absorb what you need to know very quickly.

Must the information be displayed in a Web browser? That might be the best medium for most dashboards today, but it isn't the only acceptable medium, and probably won't be the best medium 10 years from now.

Must the information constantly be refreshed in real time? Only if the objectives it serves require real-time information. If you are monitoring air traffic using a dashboard, then you must be informed immediately when something is wrong. On the other hand, if you are making strategic

decisions about how to boost sales, a snapshot of information as of last night or perhaps even as of the end of last month would work fine.

Although information about almost anything may be displayed appropriately in a dashboard, there is one characteristic that describes almost all of the information found in dashboards: it is abbreviated in the form of summaries or exceptions. You cannot monitor in a single view all the details needed to achieve your objectives. A dashboard needs to point out quickly that something deserves your attention, that something might require action. It needn't provide all the details necessary to take action, but if it doesn't, it ought to make it easy and as seamless as possible to get to that information. Getting there might involve shifting to a different display beyond the dashboard, using navigational methods such as "drill-down." The dashboard does its primary job if it tells you with no more than a glance that you should act. It serves you superbly if it directly opens the door to any additional information that you need to act fully.

The Fundamental Challenge of Dashboard Design

Given our definition of a dashboard, ask yourself: "What aspect of dashboard design presents the greatest, most fundamental challenge?" You will certainly face a variety of challenges during a dashboard implementation project. One of the earliest and most critical is determining the right information to include on the dashboard. In this document, however, we're focusing exclusively on visual design.

The fundamental challenge of dashboard design is to display all the required information on a single screen, clearly and without distraction, in a manner that can be assimilated quickly.

If this objective is hard to meet in practice, it is because dashboards often require a dense display of information. You must pack a lot of information into a very limited space, and the entire display must fit on a single screen, without clutter. This is a tall order that requires a specific set of design principles.

Among the characteristics required for dashboards to meet this fundamental design challenge:

- Exceptional organization
- Concise, clear, and often small display widgets
- Emphasis on summaries and exceptions
- Information that is finely customized for the task

Heed the wise words of Henry David Thoreau: "Simplify, simplify, simplify!" To achieve design elegance in a dashboard, you must strive for simplicity.

Common Types of Dashboard Information

Dashboards are useful for many kinds of work in many kinds of organizations. Whether you are a meteorologist monitoring the weather, an intelligence analyst monitoring potential terrorist chatter, a CEO monitoring the health and opportunities of a multi-billion dollar corporation, or a financial analyst monitoring the stock market, a properly designed dashboard will serve you well. In almost all cases, dashboards primarily display quantitative measures of what's going on (in the business, in the market, in the project, on the shop floor, and so on). These measures are displayed either by themselves or in combination with related measures that enhance their meaning, mostly by providing evaluative context—some way to determine if what's happening is good or bad.

Measures of what's happening come in different forms depending on what they measure (sales, productivity, customer satisfaction) and how they measure it (sales in dollars, sales in units, average delivery time). Measures of what's happening are often compared to related measures to enhance their meaning with evaluative context. Here are the most common comparative measures and an example of each:

- The same measure at the same point in time in the past (the same day last year)
- The same measure at some other point in time in the past (the end of last year)

■ The current target for the measure (a budget for the current period)

■ Relationship to a future target (we're at 75 percent of this year's budget)

■ A prior prediction of the measure (a forecast of where we expected to be today)

■ Relationship to a future prediction of the measure (we're already at 90% of this quarter's forecast)

■ A measure of the norm for this measure (monthly average or normal range)

■ An extrapolation of the current measure in the form of a probable future, either at a specific point in the future or as a time series (forecast as of the coming year end)

■ Competitors' versions of the same measure (either individual or multiple measures in a time series) (our top competitors' year-to-date revenues)

■ A separate but related measure (revenue compared to profit)

Measures of what's currently going on may be displayed either as a single measure combined with one or more comparative measures, as in the examples above, or as:

■ Multiple instances of a measure, each representing a subdivision of the measure into separate categories (for example, sales subdivided into regions or a count of sales subdivided into numeric ranges in the form of a frequency distribution)

■ Temporal instances of a measure (that is, a time series, such as monthly versions of the measure)

Time series in particular provide context for a richer understanding of what's going on and how well it's going.

Because a dashboard of data must be evaluated quickly, it is often useful to directly declare whether something is good or bad. Evaluative information like this may be encoded in a dashboard as special visual objects (for example, traffic lights) or visual attributes (for example, displaying the measure in red to indicate a serious condition). When

designed properly, simple visual indicators can clearly alert users to the state of particular measures without altering the overall design of the dashboard. Evaluative indicators need not be limited to binary distinctions between good and bad, but if they exceed the limit of five distinct states (for example, very bad, bad, acceptable, good, and very good) they run the risk of too much complexity for efficient perception.

Effective Dashboard Display Widgets

Many people, including dashboard vendors, believe the essence of dashboards is the presence of meters, gauges, and traffic lights. These display widgets are logical extensions of the automobile dashboard metaphor, but they carry the metaphor too far, using widgets that are much cuter than they are functional. Figure 1 shows dashboard gauges from Infommersion, Inc. that are rendered more beautifully than any others I've seen, but are nevertheless a sub-optimal means to display this sales information.
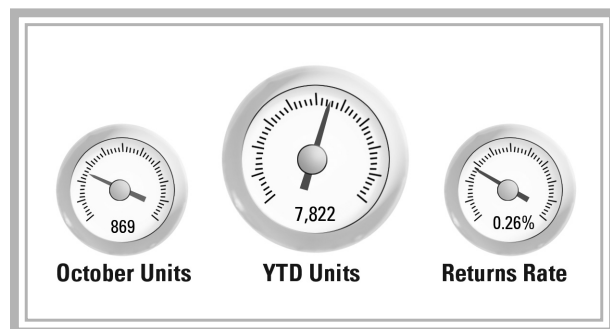

Figure 1. Typical example of gauges used in dashboards

Only a few widgets are required to display the types of information that typically populate business dashboards. Two fundamental principles guide the selection of ideal dashboard widgets:

■ The widget must be the best way to display a particular type of information that is commonly found in dashboards

■ The widget must be able to serve its purpose even when sized to fit into a small space

Several of the familiar tables, graphs, and icons work well in the context of dashboards, but I will focus on two new

forms of data display ideally suited to dashboards: *performance bars* and *sparklines*.

Performance Bars

Performance bars are my answer to the meters and gauges that have become synonymous with dashboards. Meters and gauges typically display a single key measure, sometimes in the context of a comparative measure (such as a target), and sometimes in the evaluative context of quantitative ranges with qualitative labels (such as good and bad). Although Figure 2 is rendered in grayscale here, both examples use varying colors to provide evaluative context for the key measures (green for good, red for bad, yellow for the range between good and bad).

Both examples also display the key measure in comparison to a target, which is represented by zero in the gauge on the right and presumably by the top of the thermometer on the left. Can you make sense of the thermometer on the left? Do sales increase as they rise or as they fall on the thermometer? Given the fact that actual sales are 75.93% of target and the mercury in the thermometer extends about 75% of the way to the top of the thermometer, we must assume that sales rise as the mercury rises, but then why is the red range at the top, assuming that red means bad?
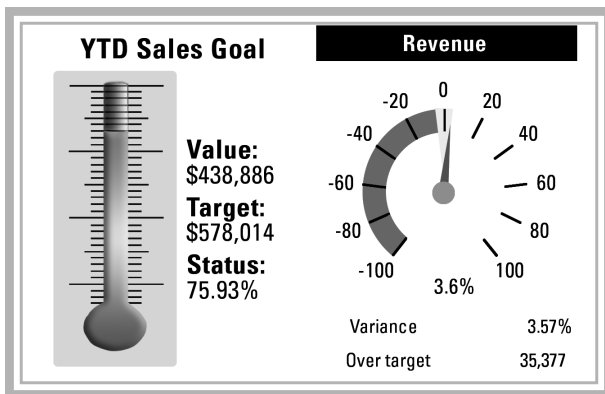

Figure 2. Typical examples of meters and gauges with contextual data. The meter on the left came from Corporate Radar's Web site (www.corporateradar.com) and the gauge on the right from Principa's Web site (www.principa.net).

The question you should ask when considering typical examples of gauges and meters like these is: "Do they provide the clearest, most meaningful presentation of the data in the least amount of space?" In my opinion they do not. Radial gauges like the example on the right waste a great deal of space due to their circular shape. This problem is magnified when you have many such displays on a single dashboard, for radial gauges cannot be arranged closely together in a compact manner. The linear nature of the thermometer style of display potentially avoids this problem, but these are generally designed to look so much like a real thermometer that space is wasted on meaningless realism. If dashboard display widgets were designed by expert communicators, rather than by graphic artists who clearly haven't studied the communication needs, they would look much different.

The performance bar is my attempt to design a widget capable of displaying a key measure along with a comparative measure (for example, a target) and a qualitative scale to instantly declare whether the measure is good, bad, or in some state in between. Figure 3 provides a simple example of a performance bar.
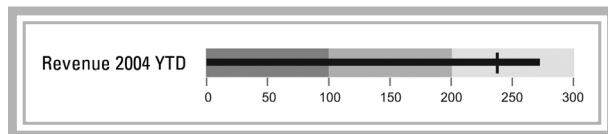

Figure 3. Example of a performance bar

Performance bars may be arranged horizontally, as shown in Figure 3, or vertically, depending on which arrangement fits best on the dashboard. Performance bars consist of the following components:

- **Text label** to identify the measure (positioned either left, right, above, or below the bar)

- **Bar** to encode the value of the key measure (in Figure 3, the bar is black and runs horizontally)

- One or more **short lines** running perpendicular to the bar to encode comparative measures, such as a target (in Figure 3, this is the short vertical line that intersects the bar at around 237 on the quantitative scale)

- **Quantitative scale** to place measures in the context of a range of potential values

- Background **fill colors** to assign qualitative ranges to the quantitative scale to communicate an immediate evaluation of the measure. In Figure 3, three distinct shades of gray are used to represent bad (dark gray), satisfactory (medium gray), and good (light gray)

In contrast to the performance bar in Figure 3, assuming that the revenue amount was expressed in units of thousands of dollars, it could be expressed as simply as:

Revenue 2004 YTD $275,000

Sometimes this is all you need, but more often you must provide context to assist the decision-making process. People need more than a number; they need a number that has been enriched with meaningful context to tell a compelling story and suggest appropriate action.

I know that performance bars work well because I've tested them with a variety of people. Although I haven't conducted the kind of rigorous experimental research that would pass peer review for a scientific journal, my tests compared the speed and accuracy of viewing and interpreting performance bars versus radial gauges in a manner that was carefully designed to eliminate any bias.

Conservatively stated, my findings show that performance bars work at least as well as radial gauges, and probably significantly better. Even if the speed and accuracy of performance bars merely equal that of radial gauges, it is certain that they take up less space, which makes them superior in the context of dashboards. Unlike typical gauges and meters, it is easy to see that many performance bars could be arranged to fit neatly next to one another on a dashboard. Performance bars can be squeezed down into a small space without losing clarity. This is because their visual design is simple, consisting entirely of straight lines, and can be reduced to a few pixels wide and still remain readable.

The qualitative ranges of bad, satisfactory, and good in Figure 3 are repre-

sented by shades of gray rather than red, yellow, and green, which is typical in dashboards. Rather than using distinct hues, I've intentionally opted for distinct intensities of a single hue. Any hue could be used, such as three shades of red. I choose this approach to avoid problems associated with color blindness. The most common form of color blindness, which affects roughly 10 percent of males and one percent of females, disables the ability to distinguish between red and green. This problem can be avoided entirely by varying the intensities of a single hue from dark to light or fully-saturated to partially-saturated. These are the kinds of concerns that dashboard designers need to address and dashboard vendors need to support.

I encourage dashboard vendors to make use of my simple invention, the performance bar.

Sparklines

Sparklines are the brainchild of Edward R. Tufte, a true master of data display. Tufte has dedicated a full chapter to their introduction in the book Beautiful Evidence, due out in 2005 from Graphics Press. Many of us who closely follow Tufte's work have previewed the chapter on sparklines, which has created quite a buzz in the information design community. Please don't consider my brief treatment of the subject in this article as definitive in any way. My purpose here is to describe them only to the degree necessary to demonstrate their valuable application to dashboards.

Figure 4 provides an example of a simple sparkline.

Tufte invented the sparkline to provide bare-bones and space-efficient time-series context for measures. Assuming that the sparkline in Figure 4 encodes a rolling 12-month history of an account balance, the ups and downs are presented in an instant for those who wish to consider histor-

$137,384.28   Checking Balance 09/20/2004

Figure 4. Example of a sparkline, based on the work of Edward R. Tufte

ical context to better understand the meaning of the current balance.

Tufte describes sparklines as "data-intense, design-simple, word-size graphics." (Tufte, 2005) As such, they are ideal for dashboards and anything else that requires highly condensed forms of data display, such as medical diagnostic reports that include patient histories.

You may be wondering: Where's the quantitative scale? It's nowhere to be seen, and that's intentional. Sparklines are not meant to provide the quantitative precision of a normal graph. Their whole purpose is to provide a quick sense of historical context to enrich the meaning of the measure. This is exactly what you generally want to do in a dashboard—instead of providing details, display a quick view that can be assimilated in a glance. The details can come later, if needed, in the form of supplemental graphs and reports.

Putting It All Together

Figure 5 combines the two widgets that we've just examined—performance bars and sparklines—to better illustrate how well they can work together on a dashboard. Think of what you're seeing in Figure 5 as a section of a larger sales dashboard.

Each of the key measures (a.k.a. metrics) in Figure 5 are enhanced by the following comparisons:

- Percentage of its target (encoded as horizontal bars)

- Direct evaluation of performance (encoded as varying shades of gray behind the bars)

- Even more direct alerts (encoded as simple circles, similar to traffic lights, with varying shades of red or another color [although it can't be displayed here] to indicate degrees of urgency)

- Historical context (encoded as simple line graphs of the past 12 months)

This figure illustrates how effectively you can display a rich set of information in a small amount of space on a dashboard if you pick the right data and display it using appropriate visualizations.

Concluding Thoughts

This is by no means an exhaustive treatment of visual dashboard design. It is but an introduction to the unique characteristics of dashboards and to a few of the design principles and practices that are tailored to the unique challenges and opportunities of dashboards. Other topics that deserve attention include the arrangement of data on the screen to promote clarity and an ideal reading sequence, and visual techniques for highlighting the most important data—both topics worthy of their own articles.

Always remember that when you are presenting data, whether in a dashboard or any other medium of display, the bottom line is communication. As Tufte exhorts: "Above all else show the data." (Tufte, 1983)

REFERENCES

Tufte, Edward R. **The Visual Display of Quantitative Information**, Cheshire, CT: Graphics Press, 1983.

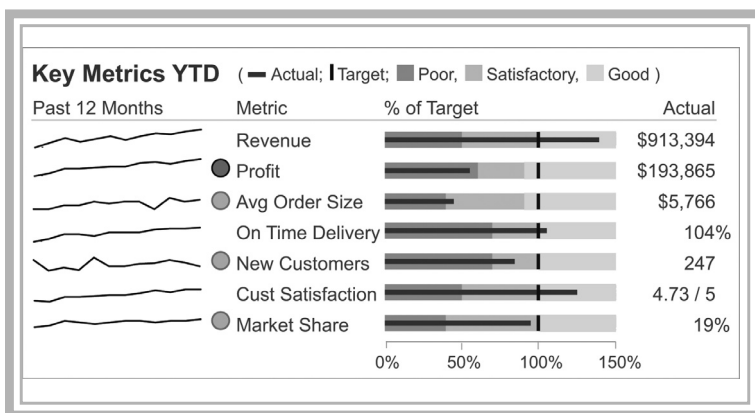Tufte, Edward R. **Beautiful Evidence**, Cheshire, CT: Graphics Press, 2005.

Key Metrics YTD	(▬ Actual; ❘ Target; ■ Poor, ■ Satisfactory, ■ Good)		
Past 12 Months	Metric	% of Target	Actual
	Revenue		$913,394
	● Profit		$193,865
	● Avg Order Size		$5,766
	On Time Delivery		104%
	● New Customers		247
	Cust Satisfaction		4.73 / 5
	● Market Share		19%
		0% 50% 100% 150%	

Figure 5. Example of a rich display of information in a small space, without waste.