Project Schedule Visualization
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Abstract
At Steelray Software, we develop project schedule analysis tools like Steelray Project Analyzer that work with Oracle Primavera and Microsoft Project. Because our focus is schedule analysis, project schedule visualization is at the forefront of our research efforts. This white paper presents some topics that are related to that research.

Henry Laurence Gantt brought us the Gantt chart in the 1910’s, and in 1958, the use of the PERT method brought us PERT network charts. In almost a century, there have been very few innovations in the science of project schedule visualization. With major advances in visualization in so many other fields (e.g. medical, manufacturing, data mining), why have advances in project schedule visualization been so few and far between? Are Gantt Charts and Network Diagrams sufficient to the point that no additional insights might be gained via other charts and diagrams? How can new approaches in schedule visualization help the project manager in their day-to-day work? This presentation will examine these questions and provide an introduction to the work of Edward Tufte, who has been described by The New York Times as “the Leonardo da Vinci of Data.” With Tufte’s work as a backdrop, new ideas and approaches will be presented, with the goal of stimulating discussion and real advances in project schedule visualization.

Envisioning Information
What’s wrong with the chart in Exhibit 1?

Tree Exports, 2007
(in millions)

4
Region A

2.5
Region B

3
Region C

Exhibit 1- A Poorly Designed Graphic

If it’s not obvious, ask yourself the following questions:

- How much information is the chart trying to convey?
- Are the pictures, colors, text, and numbers being used in an effective way?
- Could the information have been charted more succinctly (using less ink)?
- Is the curvy line a part of the chart, or is it a mountain range background?
- Based on the numeric values, was a chart even necessary?
There are a large number of types of charts, graphs, and informational pictures that we encounter every day, from an “infographic” in a newspaper to subway maps. Some are quite effective in delivering their message, while others convey their intended meaning poorly if at all. In the chart above, a lot of ink is used to convey a very small amount of information. The colors used do nothing to contribute to the explanation of the results. The mountain range line looks similar to a plotted graph, which confuses the reader. Little thought has been put into explaining the results clearly and succinctly.

For the project manager, there are a limited number of choices available when visualizing project schedules. Aside from the Gantt chart and the Network Diagram, there are few charts or graphs that are consistently used to convey the information contained in a project schedule and the performance of that schedule. And yet, there are several problems and deficiencies with these two charts. The science and art of information design can be applied very effectively to project management, and the aim of this paper is to examine drawbacks to current methods and suggest new ideas and methods.

**Edward Tufte’s Research: the Visual Communication of Information**

Edward Tufte taught courses in statistical evidence, information and interface design at Yale University, where he is Professor Emeritus. Although he is the author of eight books, the three books of most interest to our topic are *The Visual Display of Quantitative Information* (Tufte, 1983), *Envisioning Information* (Tufte, 1990), and *Visual Explanations* (Tufte, 1997). The best way to categorize these books is this way: VDQI is a study of pictures of numbers. EI studies pictures of nouns. For example, maps can be thought of as pictures of city locations. VE studies pictures of verbs, representing mechanism and motion, or cause and effect. (Tufte, 1997, p. 10)

These three books show excellent examples of the history of data visualization, including techniques used centuries ago. Tufte looks at the central problem of visualization: we're frequently trying to show information with multiple dimensions on screen and paper (Tufte calls this “flatland”), which have exactly two dimensions (Tufte, 1990, p. 12). How do we overcome this obstacle to truly explain information in a way that is simple, obvious, helpful, and insightful?

He shows how color can both help and distract from explaining information, and more importantly, how it can help easily reveal detail and complexity (Tufte, 1990, p. 81-96). He teaches us to focus on the data, and not the container, when presenting information visually. He shows how clutter and confusion are failures of design, not attributes of information.

In VDQI, we learn about data-ink, the "non-erasable core of a graphic, the non-redundant ink arranged in response to variation in the numbers represented" (Tufte, 1987, p. 93). How much of the ink used is used to measure quantities? How much of the ink cannot be erased without losing information? The amount of ink that is data-ink compared to the amount that is useless is the data-ink ratio.

We also learn about chartjunk: "conventional graphical paraphernalia routinely added to every display that passes by: over-busy grid lines and excess ticks, redundant representations of the simplest data," or put more succinctly, "ink that does not tell the viewer anything new" (Tufte, 1987, p. 107).

With respect to project schedules, Tufte's research can be brought into play by asking three questions.

1. How can we redesign existing project schedule graphics to maximize data-ink and make the graphic chart clearer?
2. What information, do we want to really want to explain, extract, or analyze in a project schedule?
3. How can we most effectively present that information visually?
Application to Schedule Visualization

The primary methods that project managers use to visualize project schedules are the Gantt chart and the Network Diagram, portions of which are shown in Exhibit 2. These particular views were created using Oracle Primavera P6, but other project management applications like Microsoft Project will display views similar to these.

The Gantt chart is a two dimensional chart. Along the X axis, time is shown, left to right. The scale does not typically extend much before the start of the project or after the end of the project. The X axis represents a linear scale (time), and the Y axis is simply a list of tasks. The order of these tasks is typically determined by the WBS (Work Breakdown Structure). The main part of the chart shows bars, drawn from the start and end dates of a task, aligned horizontally with tabular information representing the task. Progress is sometimes shown by shading the bars proportionally to the percentage of the duration or work that is complete.

Exhibit 2 – Portions of a Gantt chart (left) and Network Diagram (right)

The Network diagram shows nodes representing tasks and arrows between the nodes showing dependencies between tasks. There are no scales along either axis. Tasks starting at the beginning of the project are typically shown in the left part of the diagram, with successor tasks displayed to the right of those tasks. Tasks near the end of the project are typically (but not always) found near the right side of the project. For a given task, a rectangle is drawn, with incoming arrows arriving from predecessor tasks, and outgoing arrows leading to successors. The contents of the rectangle show key information about the task: name, start date, duration, etc.

These methods of visualizing project schedules have been in use for decades. The Gantt chart has been a common feature in almost all project management software tools in use today. Without the ability to render a Gantt chart, a PM software application is considered by many to be incomplete. The use of the Gantt chart has been promoted by their widespread adoption by popular project management tools like Oracle Primavera and Microsoft® Project.

While the Gantt chart is better than a simple list, I have always found it to be sorely lacking as a method of visualizing a schedule.

What's wrong with the Gantt chart?

My first problem with the Gantt chart: it is very difficult to view a Gantt chart in its entirety. Viewing a Gantt chart on a computer screen involves heavy amounts of scrolling. When you "zoom out" on a Gantt chart, you'll eventually have something in front of you (on paper or screen) that encompasses the entire project, but the pixel resolution of the display or printer is not up to the task of rendering something that is comprehensible. At resolutions or font sizes that are readable, you are looking at a small portion of the project or taping pages of a printout together. Aside from
the time that is spent aligning and taping pages, Gantt charts rarely assume a rectangular overall shape, so some of those pages are invariably blank.

A Gantt chart doesn't show the key indicators of project performance, the ones that executives want to see. It is not easily discerned whether a project is on schedule, behind schedule, or ahead of schedule when looking at a Gantt chart. Matters related to budget are usually missing. Gantt charts do not highlight deliverables. Gantt charts do not predict the future based on the past, trends, momentum, external factors. Gantt charts are based on tasks, and show little information related to resource allocation on a project.

Gantt charts show no history (how did we get here?). Variants of the Gantt chart can overlay a task's start and end dates as they were planned with how they actually happened. While this is insightful on a task by task basis, it's difficult to comprehend how viewing an entire project's accumulation of these overlays would produce anything insightful, particularly since one task's lateness will cause downstream tasks to be late as well, through no fault of their own.

Goals for Improvement

Restating the above problems as positives, I’ll set the following objectives for ideas on how to improve schedule graphics:

- The charts should present its data accurately.
- The charts should use ink effectively (high data-ink ratio).
- On a standard letter-size page, the graphic should be readable.
- The charts should show key indicators for consumption by executive management.
- The charts should seek to show history, trends, and help predict the future.
- The charts should concern itself with the triple constraints: time, scope, and cost.

Exploring Better Approaches

The One Dimensional Timeline

Why is it that so many project managers manually draw create timeline charts? All of the data needed is contained in the project schedule. Why can’t the application draw the timeline? The reason is that it is easy in principle but hard in practice to draw a timeline. First, the application isn’t smart enough to know which milestones belong on a timeline. Second, if too many elements are on the timeline, it becomes cluttered and difficult to read. When too few elements are on the timeline, the graphic may not be as informative as the project manager would like it to be.

Both problems can be solved by making the creation of a timeline an interactive process. The user should be able to choose the timescale (or zoom level), and then choose which milestones appear on the timeline. Neither problem is insurmountable, but very few applications offer this capability.

Using the Second Dimension

A timeline is a great start, but paper and screens have two dimensions, and we’re really only using one of them. What about the Y axis? The Gantt chart uses the Y axis to lay out tasks, but we could use the area underneath a timeline in a number of other ways:

- types and quantities of materials needed at specific times
- resource allocation by type of resource
• visual representation of the output of the product at each phase
• break down milestones by department or functional unit
• other timelines

Imagine a horizontal timeline that showed key milestones plotted along the timeline, with multiple timelines underneath showing cost, resource allocation, and explanations of key deliverables.

**Readability through “Smart” Zooming**

![Exhibit 3 – Two views of Chicago in Google Maps](image)

In Google Maps, I can look at a city from outer space and close enough that I can see a barbecue grill on a deck in a backyard. With annotations, I can see the names of towns, streets, and landmarks as I zoom in. Google Maps is smart enough to display the “right” information based on the zoom level. For example, in the left side of Exhibit 3, the names of neighborhoods are displayed. Displaying the street names would result in clutter. On the right side, we’ve zoomed into a neighborhood, close enough where major street names are displayed. Wouldn’t it be useful to have this “intelligent” display when viewing project management graphics?

**Using Animation to Predict the Future**

Exhibit 4 shows a thunderstorm in East Texas and entering Louisiana. Suppose you’re in New Orleans and contemplating a bicycle ride. Looking at this map, you’re missing two key pieces of information.
1. In which direction is the storm moving?

2. How fast or slowly is it moving?

If you were able to see the map in motion, both questions would be answered. Some weather-related sites offer “maps in motion,” which show you how the storm has changed over the past few hours.

How could project schedule graphics make use of animation to show “direction” and “speed”? What if I could map key variables like costs, total work, remaining work, and see how those variables change over time? Key insights that might be difficult to see by staring at numbers or charts might become apparent with the right animation techniques.

Controlling animation can be an effective technique to find an exact place in time. This principle is demonstrated in video editing software, where editors need to be precise to within a single frame of video. Exhibit 5 shows a screenshot from video editing software (Apple, p. 110). By dragging the play head left and right, you can locate an exact frame of video in a scene.

The same idea might be employed to locate a point in a schedule, such as the point where a certain amount of money has been spent, or the point when construction of a building has reached a critical milestone. Solution providers and
system integrators are increasingly offering 4D scheduling, where 3D graphic models of a construction project are shown along the fourth dimension (time). Imagine dragging a play head along a project schedule and seeing financial graphs and a rendering of the construction of a building animating in real time. For many static charts that shows project status at a certain point of time, it might prove insightful to see how those charts have changed over time.

**Conclusion**

The technology required to implement these ideas is already widely used today. The question of whether project managers would adopt these techniques and tools is not hard to answer either. I believe that if they were available, project managers would make use of them. Websites like *The Weather Channel* and *Google Maps* have proven that the “masses” will adopt sophisticated data visualization techniques if they are reasonable easy to use. It’s time for project management applications to catch up. At Steelray Software, our vision is to do exactly that.

**References**


