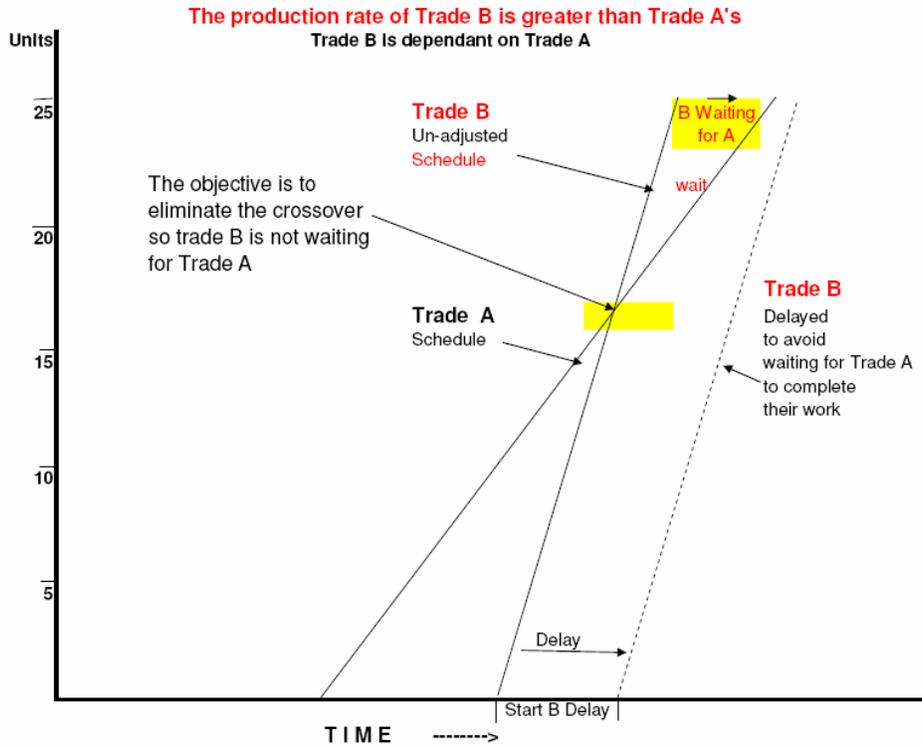
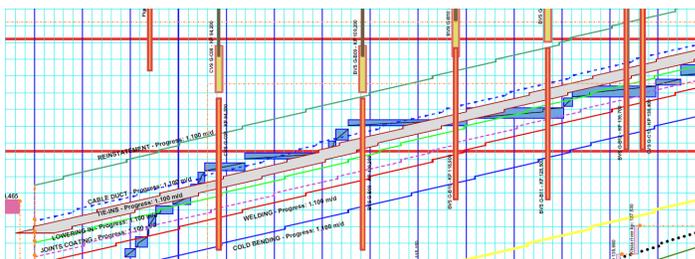


Line of Balance

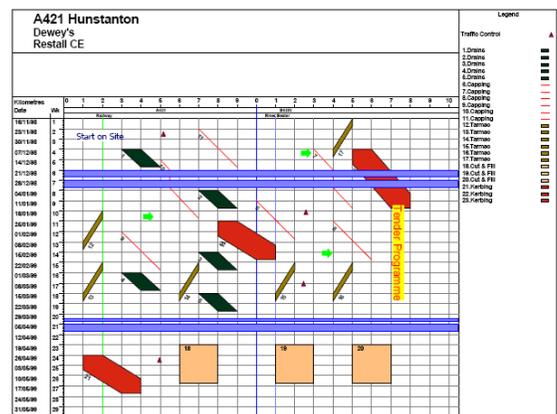
Line of Balance (LOB¹) is a method of showing the repetitive work that may exist in a project as a single line on a graph. Unlike a Bar Chart, which shows the duration of a particular activity, a LOB Chart shows the rate at which the work that makes up all of the activities has to be undertaken to stay on schedule², the relationship of one trade or process to the subsequent trade or process is defined by the space between the lines. If one group is running behind schedule, it will impact on the following group and this is shown by the lines intersecting.



LOB is used on repetitive work such as constructing multiple dwelling units, when used on linear work such as roads and railways the technique is more accurately called Time/Location Charts or Chainage Charts which include 'blocks' to mark out chainages such as bridges and culverts that require substantial time to build and interrupt the general flow of work.



Section of a pipeline project - TILOS time-location planning software



¹ The generic term for this type of chart is 'Elemental Trend Analysis'.
² Multiple-Activity Charts can be used to determine the rate of progress (or cycle times) used in the LOB chart, set https://www.mosaicprojects.com.au/WhitePapers/WP1025_Multi-Activity_Charts.pdf

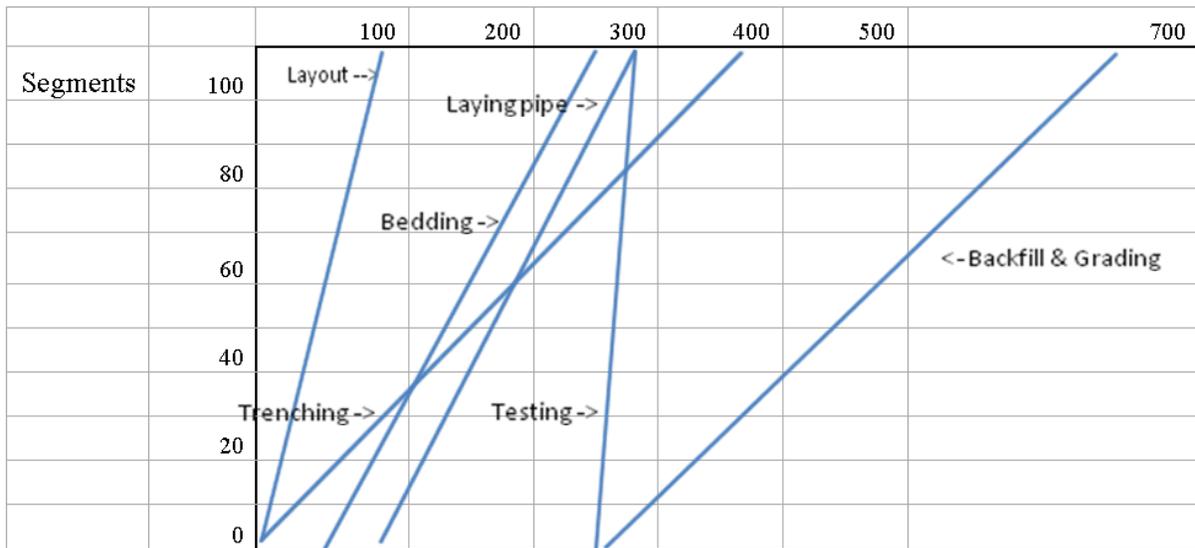


A Simple Example³

Let’s look at a 100 segment pipeline project and the process of planning and scheduling a realistic, feasible, and profitable work plan.

For the 6 activity types we initially plan the following for a project with the same soil type:

Clearing, Survey, & Staking	5 man crew, 1 segment/day	100 days
Trenching	3 man crew, ¼ segment/day	400 days
Placing Bedding select material	3 man crew, ½ segment/day	200 days
Laying Pipe and connecting joints	6 man crew, ½ segment/day	200 days
Hydraulic Testing of 1 segment	2 man crew, 4 segments/day	25 days
Backfill and Grading	4 man crew, 1/3 segment/day	300 days



Crew Interference: Stop & Wait

The Project will take almost 700 days due to completion of Bedding and Laying Pipe until all of the Trenching is done after 408 days and the start of testing delayed until the 383rd day with multiple crew interference.

Doesn’t look so smart, does it; so what can we do?

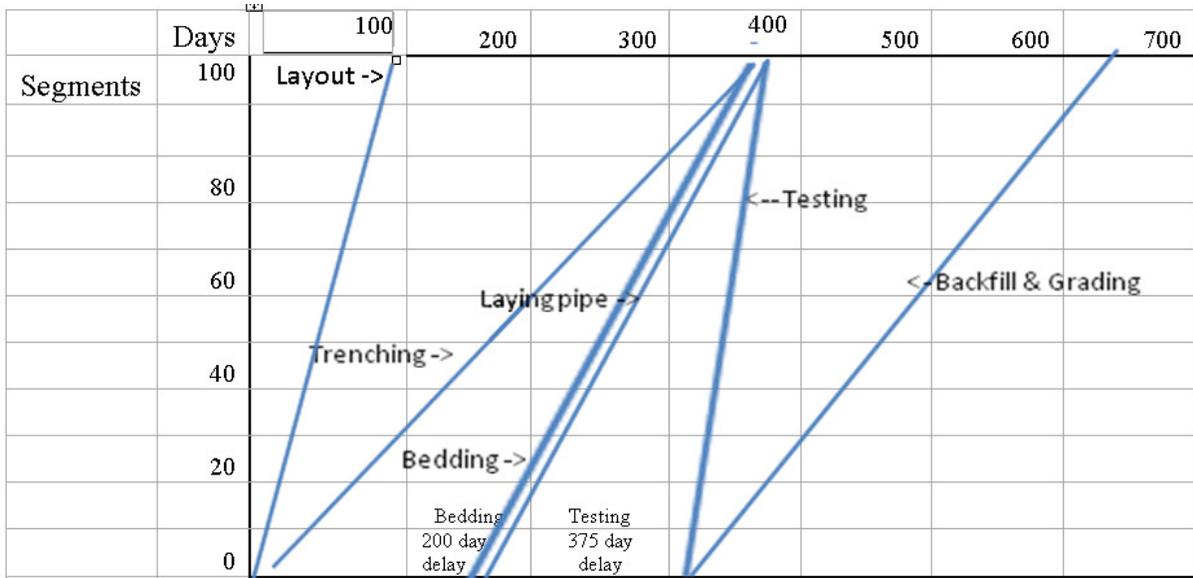
- Of course we might balance the production rates so they are all equal, but that is rarely practical.
- Perhaps we can delay the start of a following crew until there is enough work for them to work without waiting for the prior crew to provide them work areas. We do not want to have activity-crews standing idle waiting for the next work area.

This could be achieved by delaying the start of trade crews to avoid overlapping prior crews so that they will not be waiting for the next segment’s work area.

- The Bedding work is delayed 200 days so that it finishes just after the trenching finishes.
- The Testing work is delayed 375 days so it does not finish before Laying Pipe finishes.
- This is the Line-of-Balance or ‘Linear Scheduling’.

³ First published: PM World Today – June 2011 (Vol. XIII, Issue VI) as part of a series on construction project scheduling by Earl Glenwright,

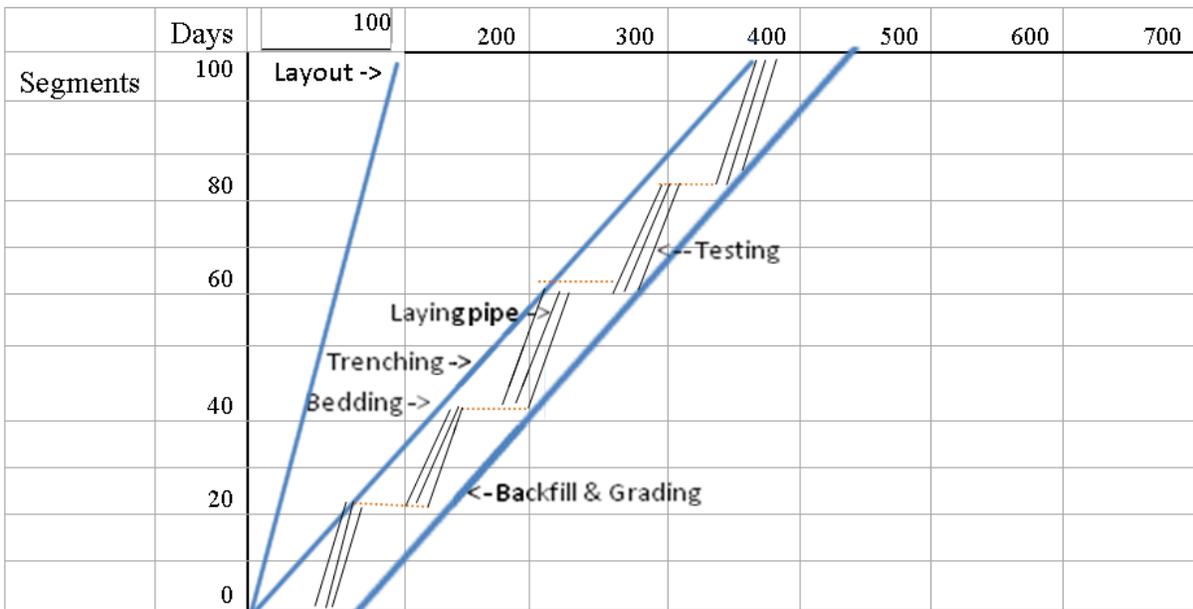




Continuous Crew Schedules

Where as we might have thought the project was going to take 110 days, at 11 days/segment, due to keeping the crews fully working once they start, it will take 684 days because the Backfill and Grading cannot start until the 1st segment is tested. Is this realistic? Probably not but that is what the Line-of-Balance process is.

If it is feasible for the various crews to work say 5, 20 segment sections and then leave the site until another segment is available, the project time can be reduced accordingly. The Line-of-Balance then would have a series of stair step offsets. Making those decisions is the job of the management team. Once the Bedding, Laying of Pipe, and Testing of the 1st segment to done, then the Backfill can begin and work continuously. And the project will complete 240 days earlier. By dividing the project into 5 20-segemnt stages for the Bedding, Laying Pipe, and Testing , each segment is completed sooner and the periods that the trench is open are reduced.

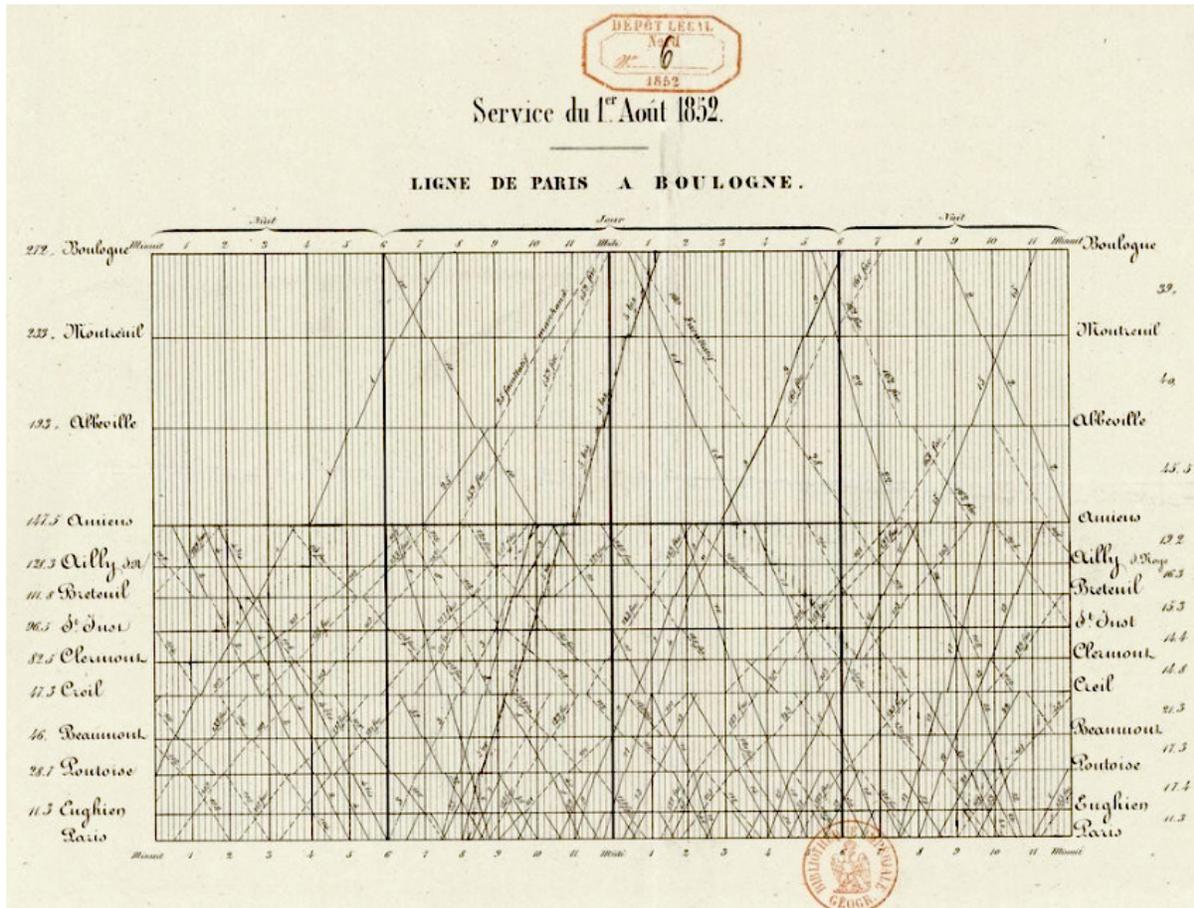


Crew work interrupted and delayed



From this starting point, a contractor after looking at the above Line-of-Balance chart would instinctively look at reducing the time of the Trenching. Perhaps 2 trenching crews can be mobilized thereby reducing the trenching time from 400 to 200 days. That's worth consideration. If Trenching is reduced to 200 days, then Bedding and Laying Pipe can be done without interruption because all 3 tasks are planned to work at the same pace. Backfilling crews would also be studied to see if their production might be improved.

Origins of LoB / Location Based Scheduling



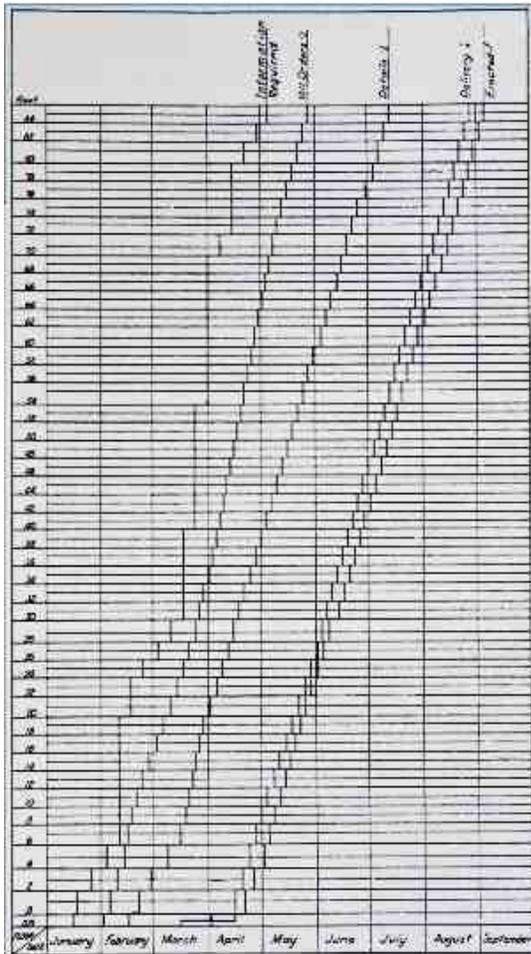
The general method appears to have been invented in the mid-1840s by Mr Charles Ibry, an engineer with the French Northern Railroad company. He was in charge of managing traffic on the route from Paris to Rouen, which had been operating since May 1843. The diagram has the geographical route of the railway line inscribed on the vertical axis, and the hours of the day inscribed on the horizontal line. Therefore, the slope of each line shows where each train is headed, how fast it travels and where it pauses, an elegant and efficient way to visualise all of the train movements⁴. Some examples are enhanced by a geographic profile of the route shown along the vertical axis, and encode further information by differentiating between different types of lines.

⁴ For more on Charles Ibry see: <https://sandrendgen.wordpress.com/2019/03/15/data-trails-from-paris-with-love/>



Flowline

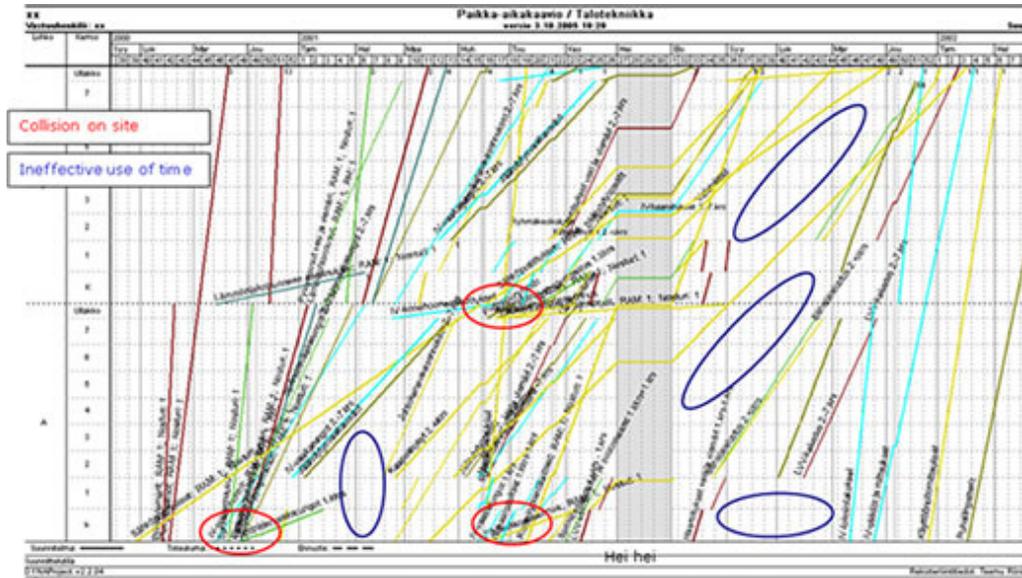
An early version of this technique was called ‘Flowline’ the most famous application being the construction of the Empire State Building in 1931, the rate of construction peaked at four and a half floors per week. In 1940, George E Fouch used Line of Balance (LoB) to monitor production at the Goodyear Tire and Rubber Company, the technique was later used in other contexts.



Location Based Scheduling

The modern version of Flowline is Location Based Scheduling (LBS). The illustration is from the Vico Location-Based Management System. LBS varies from LoB in that the amount of time allocated to each work location varies based on the volume of work required in that location. The objective remains same, synchronising the progress of different work crews to optimise the overall project delivery.

The location-based management system measures the progress of work crews as they flow through a building preserving the crew's productivity rate as they move from location to location – the time in each location is adjusted based on the quantity of work involved. Each line represents one crew as they move through the building. The slope of the line marks their planned productivity rate and dotted lines that they are not operating optimally.



The number of data points needed to build and manage a LBS chart is a small fraction of the number needed to develop a CPM network to the same level of detail⁵.



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⁵ The concept of location based scheduling (LBS) is well established as a planning process; future developments may include linking LBS to 3D BIM models in an interactive 'virtual reality' environment to develop a new scheduling paradigm for project controls. This idea is discussed at: <https://mosaicprojects.wordpress.com/2016/11/26/the-future-of-project-controls/>

