Alfredo Angrisani, CDDP Instructor

Just how mean can an average be?

A visual inquiry on queue dynamics and lead times in supply chains.

Cave canem (Beware of Dog) - Mosaic at the *House of the Tragic Poet*, Pompeii, 2nd century BC

The charts depicted are from the ***Queue simulator*** accompanying program.

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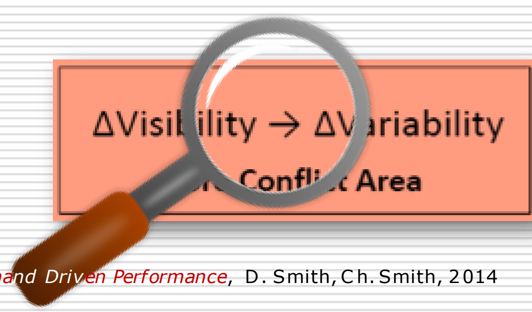
Challenging lead times

The aim of this inquiry is to clarify a key aspect of the ***Core Conflict Area*** (*): **make visible** how **variation** affects queues and **impacts the performance** of a supply chain.

As queues are the largest contributors to lead times, under **what conditions** are stated lead times **relevant information**?



(*) From *Demand Driven Performance*, D. Smith, Ch. Smith, 2014

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The Doctor's orders

A *System of Profound Knowledge* (*)

Appreciation for a system (S)
Theory of knowledge (K)
Knowledge about variation (V)
Psychology (H)

(*) Dr. W. Edwards Deming (1900-1993) in *The New Economics* (1994).

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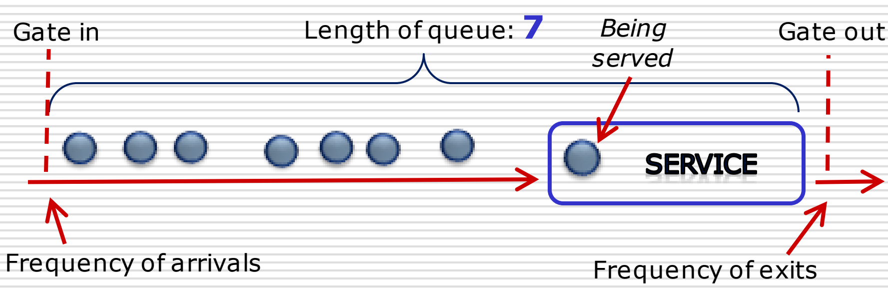
The simplest case

One queue, one service (*)



$$Utilization = \frac{frequency\ of\ arrivals}{frequency\ of\ exits}$$

(*) G/G/1, in Kendall's notation: both arrivals and service General distribution, 1 server, First Come First Served discipline.

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A primary question

If, at your **post office**, the operator **serves each client in one minute sharp, how many clients** can he/she serve **in 1 hour?**

60 clients, you say?

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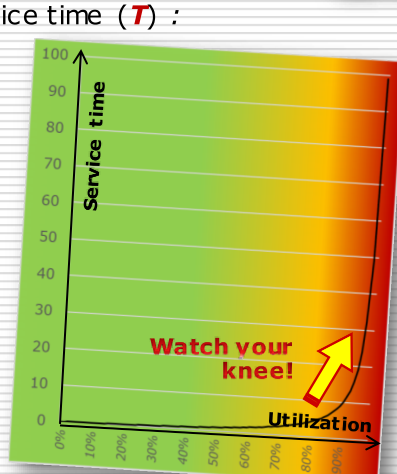
A dangerous relationship

The **Little's Law** defines (*) the relationship between utilization (***U***) and the overall service time (***T***) :

$$T \approx \frac{U}{1-U}$$

The Law predicts the **long-term, steady-state average** length of the queue.

After a point, service time **increases sharply with utilization.**



(*) Applies to M/M/1, First Come First Served queues

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Let's check this out!

Using the **simulator**, we try first with **30** clients ***(utilization 50%)*** and a **perfect clerk** who always takes **exactly** 60 seconds per client.

During the whole 8-hour opening, all clients are served in **1.3 minutes** in average.

Apart for a **few peaks of 3**, the line is always **very short** and **predictable.**

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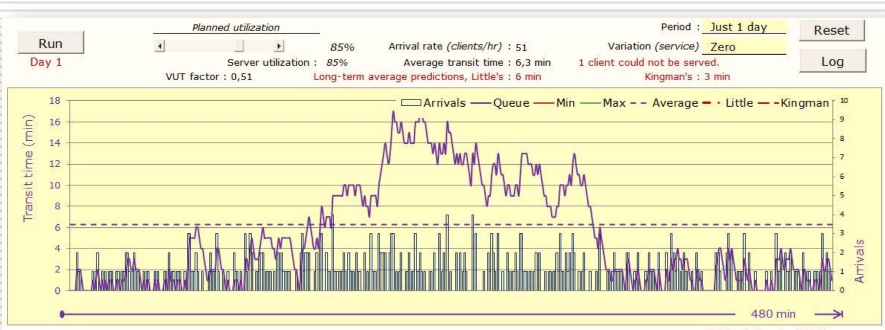
A tripping point

Utilization **85%**: several clients experience a wait two times the average (**6.3 minutes**), and one **cannot be served at all** during the opening hours (the clerk is absolutely reliable but strict!).

Instability gets worse and the **average doesn't seem to be a useful indicator any longer.**



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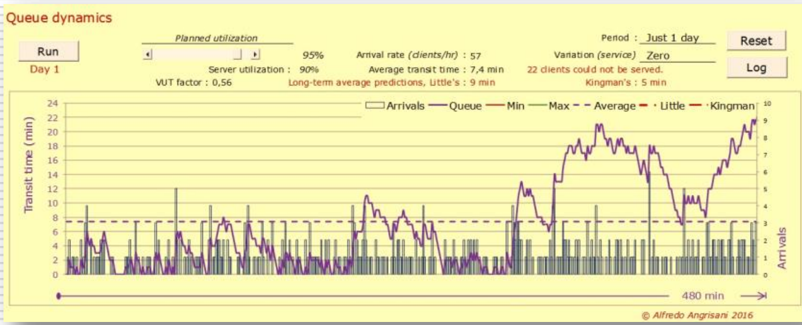
Let’s raise the stake!



Utilization **95%**: clients wait **7.4 minutes** in average (several of them more than **twice as long**) and **22 will not be served at all today**.

Average is definitely **misleading for most practical purposes!**

From Sir John Frank Charles Kingman:

The **VUT Equation** defines(*) the combined effect of ***Variation, Utilization*** and ***Time*** for heavily-utilized services:

$$T_q \approx \left(\frac{c_a^2 + c_e^2}{2}\right)\left(\frac{u}{1-u}\right)$$

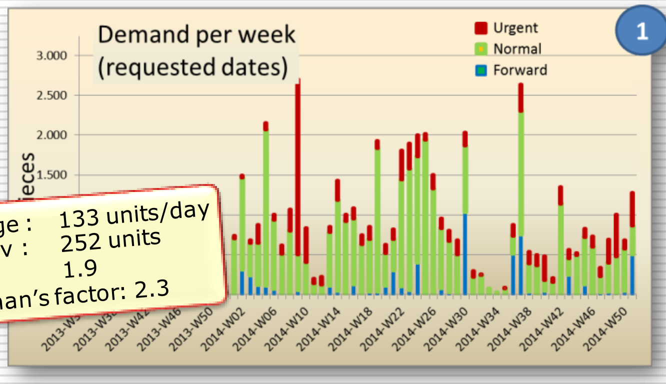
The **coefficients of variation, CoV(**)**, of arrivals (c_a) and exits (c_e) have a **quadratic effect** on service time.

(*) *Applies to G/G/1, First Come First Served queues*
(**) *For a given set of data, CoV = standard deviation / mean*

The shape of demand

Mechanical assemblies: 35,000 groups, 286 PNs as sold worldwide to 400+ OEMs (*)

*What the clients **wanted**:*



Average : 133 units/day
Std dev : 252 units
CoV : 1.9
Kingman's factor: 2.3

(*) Example and graph, real data from the **DDMRP–DBR Simulator Demo - Gears**

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Waves you surf, tsunamis you just don't!

Some shaking consequences

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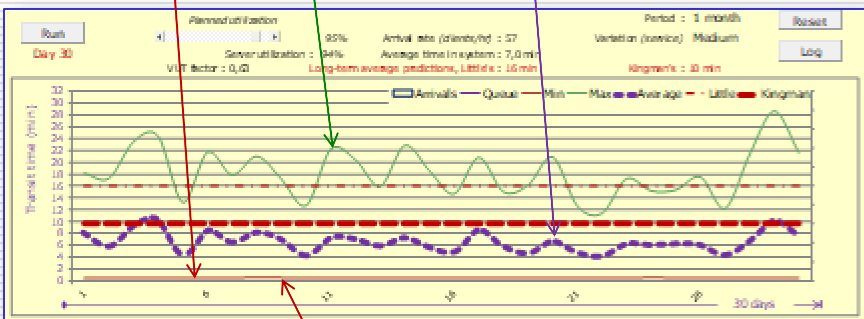
Long-term stability, daily rodeos

The simulation run over a month shows the range of variation (min and max) and the average length of the queue each day:



Although the average transit time is 7 min, the queue goes as high as 28 and is **zero** -at some moment- **every day!**

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Drawbacks

What do these **highs & lows** cause in **daily management?**

Highs:

- *Erratic priorities,*
- *Bad multitasking,*
- *Expediting, overtime costs*
- *Loss of service performance.*

Lows:

- *Potential work disruptions,*
- *Potential loss of market opportunities,*
- *Misjudgments about the real process capability.*

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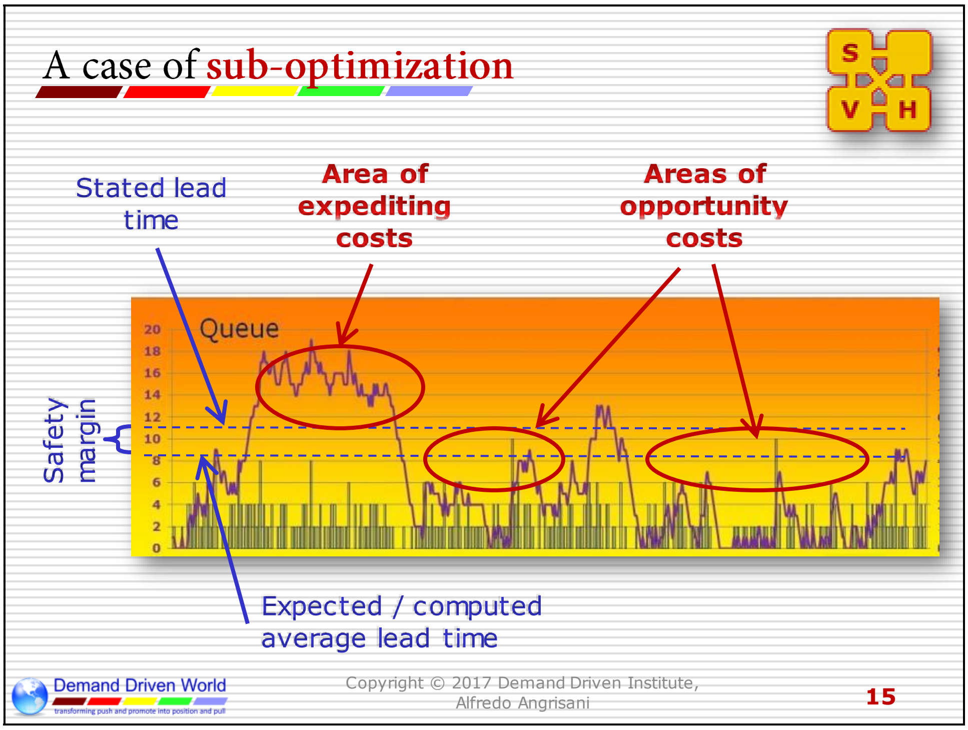

Lead times: self-fulfilling prophecies?

If you are **late,** you will:

- *Do your best to recover the delay and thus incur in the* ***costs of expediting,***
- *Accept a* ***loss in service*** *or in* ***product quality,***
- *If delays are frequent, you may* ***increase the slack*** *without being aware of the consequences on the* ***flow of cash*** *and* ***materials*** *and on the* ***response to market.***

If you are **early,** you will:

- *As the* ***Parkinson's Law*** *indicates, delay the work and, having used up the safety capacity, risk* ***to be late*** *if anything goes wrong,*
- *Don't exploit the advance, and incur in* ***opportunity costs.***
- *If these delays are frequent, possibly deem that the lead time in use is* ***too long*** *and* ***reduce it!***

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Make a long queue short

A way to solution in
8 easy (*) recipes

(*) Well, maybe not always so easy!

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A recipe in 8 easy steps – Part 1

1. **Reduce the number** of critical resources in your flow
   - ***Identify*** *the resources that exhibit capacity issues*
   - ***Optimize*** *the work of actual or potentially constrained resources*
   - *Consider* ***Lean initiatives*** *like* ***SMED****.*

2. **Feed** critically constrained resources from **controlled sources**
   - *For this and the next points, follow the prescriptions of* ***DDMRP***
   - ***Place buffers in front*** *of them and release the work* ***orderly****, at the* ***maximum rate allowed*** *by the resources themselves*

3. **Don't plan** for utilization **above 85%**
   - *Don't go after* ***misleading efficiency KPIs!***
   - ***Look ahead*** *for potential overloads*

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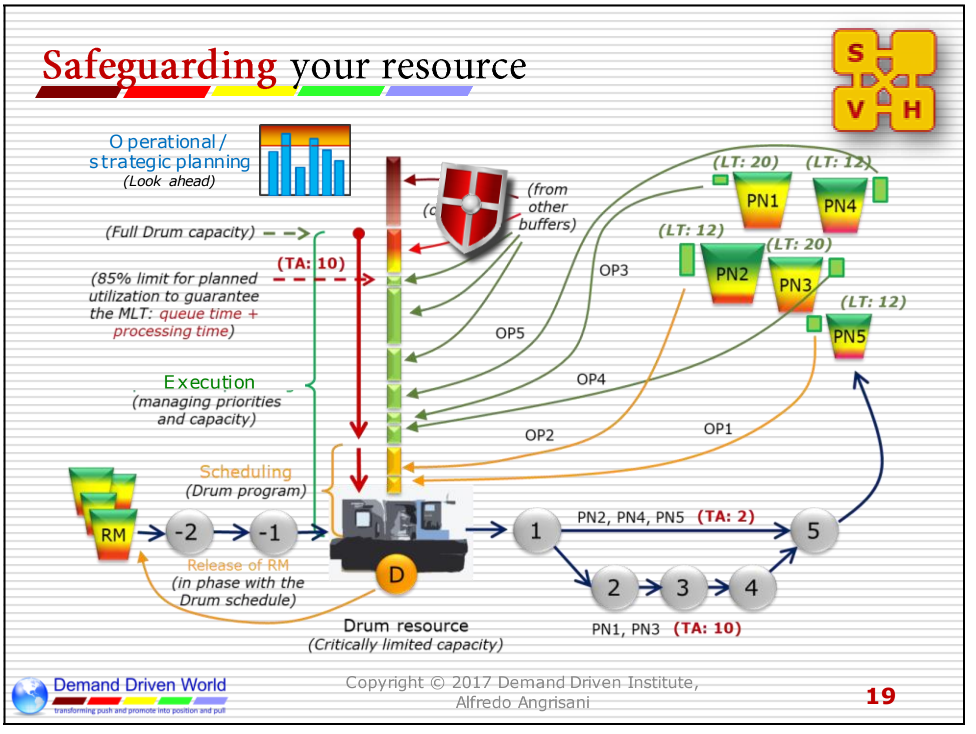

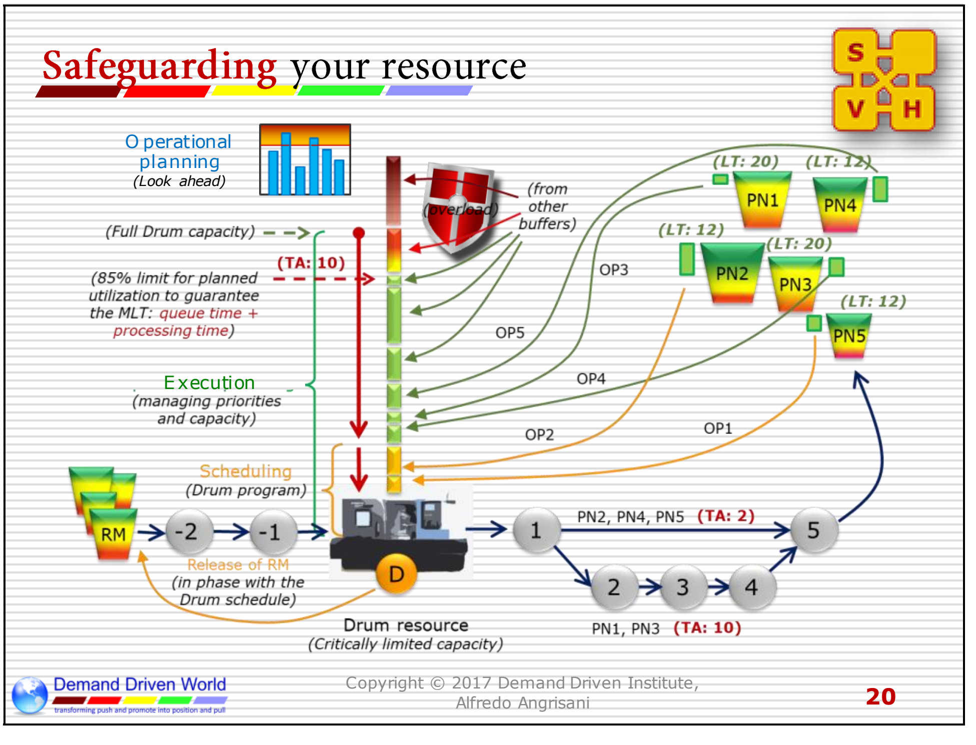

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A recipe in 8 easy steps – Part 2

4. **Shorten** the lead times **by system design**
   - ***Position buffers*** *so to* ***'slice' cumulative lead times*** *into shorter, independent segments.*
5. **Stifle** the overall **process variation**
   - ***By system design*** *using strategic buffers.*
   - *Consider* ***6 Sigma*** *initiatives.*
6. **Reduce dependence** on lead times
   - ***Shift the sequence*** *of control and appraisal* ***from compliance*** *with lead times (due dates) to the ability* ***to coordinate order priorities to the actual demand***
7. **Reduce variation** in **demand**
   - ***Engineer the sales process*** *with* ***SPE***
   - ***Enquire*** *about the* ***origin of peaks*** *and* ***mitigate*** *through the appropriate sales/supply chain* ***actions like VMI.***
   - *Perform the* ***S&OP*** *process*
8. **Adopt** flow-based, ***Smart Metrics***
   - *Use these outcomes to drive the* ***PDCA improvement cycle***

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