

The following presentation was given at:

SCAF Workshop
**“Where has all the cost data gone:
Do we need it?”**

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Rolls-Royce Learning & Career Development Centre, Derby

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Benefits – Do we always need to know the cost?

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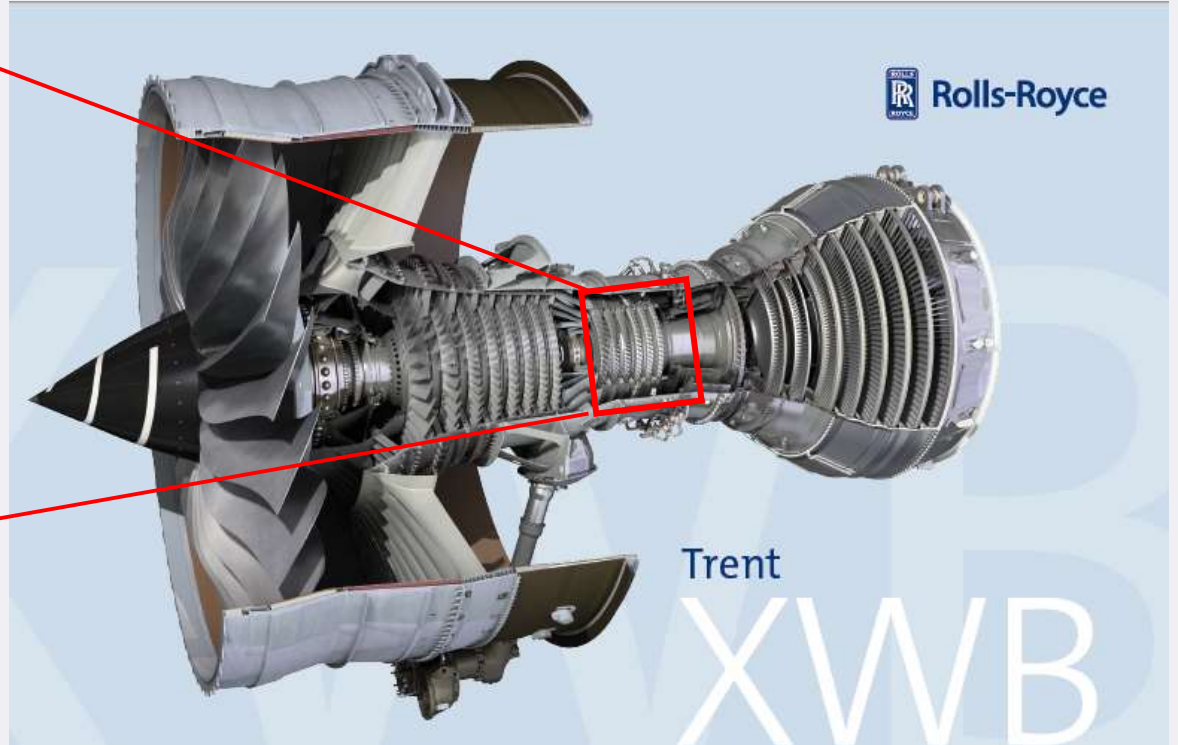
What was the situation?

- Rolls-Royce is currently increasing production rates of its Trent XWB engines from the existing 5 per week in Derby to 7 per week in Derby.
- An opportunity to reduce the assembly time of the Trent XWB engine by removing certain stages of the High Pressure Compressor, HPC, assembly process was identified.
- A benefits estimate of removing these stages was required to see if it was a viable change.



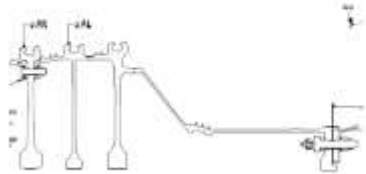
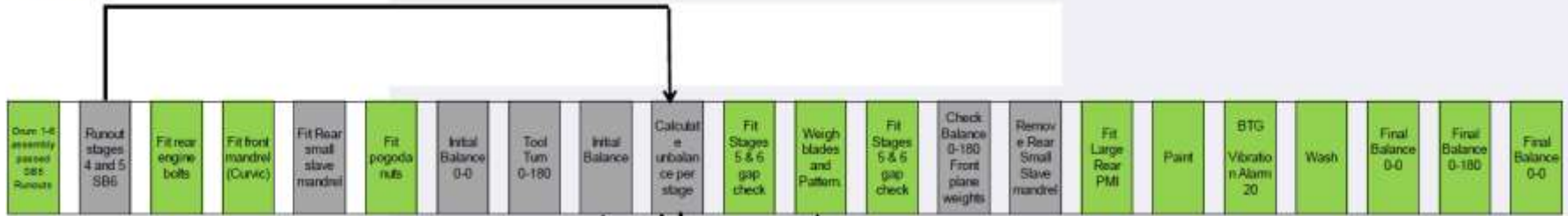
What is the HPC?

HPC without casing



The current Trent XWB-84 HPC Assembly Process

The Current HPC 84K Build Process



- Production was 7 per week on average.
- Time taken to complete balance process was 7 days on average.



The Proposed Process

The Proposal

Unbalance entered as Zero



This process removes steps which:

1. Check the initial balance of the rotor – Used to calculate the blade pattern which will give the most balanced assembled rotor.
2. Check the rotor balance after blades assembled onto rotor but before they are painted, polished, and washed.



Estimate Planning

Assumptions	Benefit Metrics	Risk/Costs Metrics
1. The only changes would be removal of steps, no changes to steps.	1. Benefit is measured as time saved to assemble one HPC and increase in throughput.	Removing the steps in the process will lead to rotors being produced which are more unbalanced and could increase the number of engines failing their pass off vibration test.
2. Time taken to complete a step is independent of other steps.	2. A reduction in cost is desirable but not necessary – Management were happy to have a cost increase if significant time reductions were to be gained. I.e. pay 10% more to reduce time by 40% and increase throughput by 35%.	This would increase the number of engines being returned to shop and stripped.
3. Acceptance criteria remains unchanged against existing standard.		
4. All steps are robust and mature with no risks associated with them.		This would delay deliveries and potentially reduce throughput.



Quantifying the Benefits

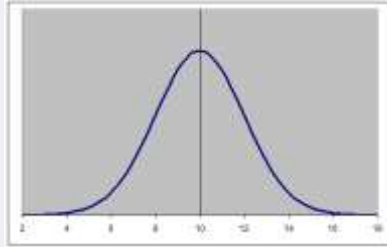
What do you think the best approach is?

Monty Carlo Method For Time Saved

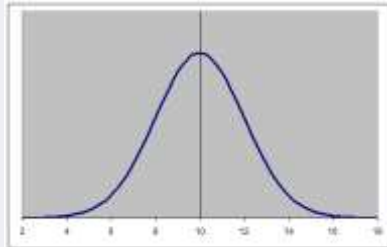
Data recording how long a HPC spent in each step of the process was readily available for over 200 HPCs from the assembly records.

Distributions were fitted to these for each step in the process and these were then input into the Monty Carlo Analysis.

Step 1



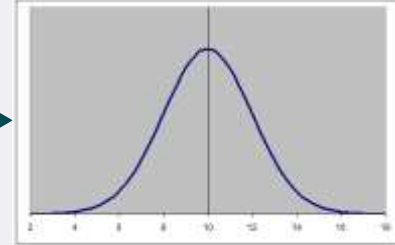
Step N



Randomly generate time taken for each step and sum them together.

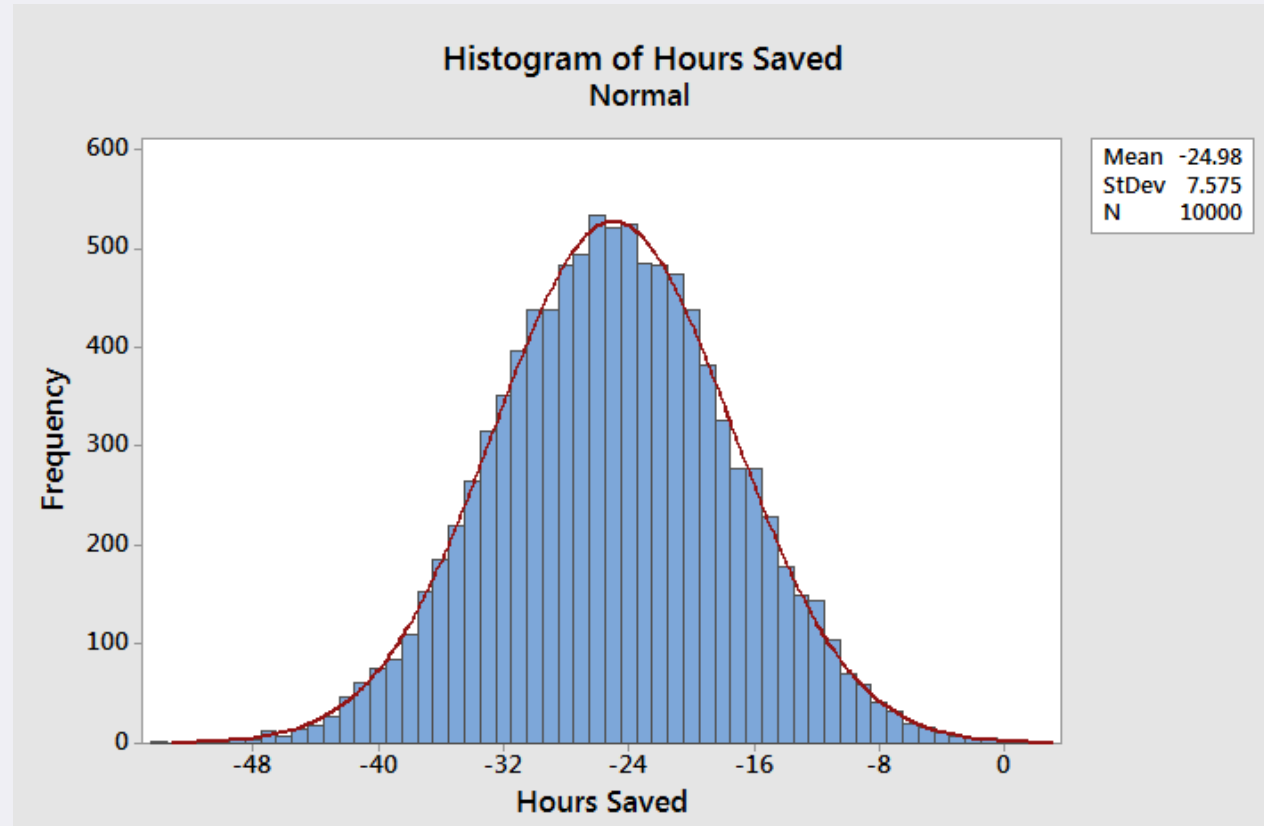


Time taken to complete process





Benefits Estimate – Time Saving Compared to current process





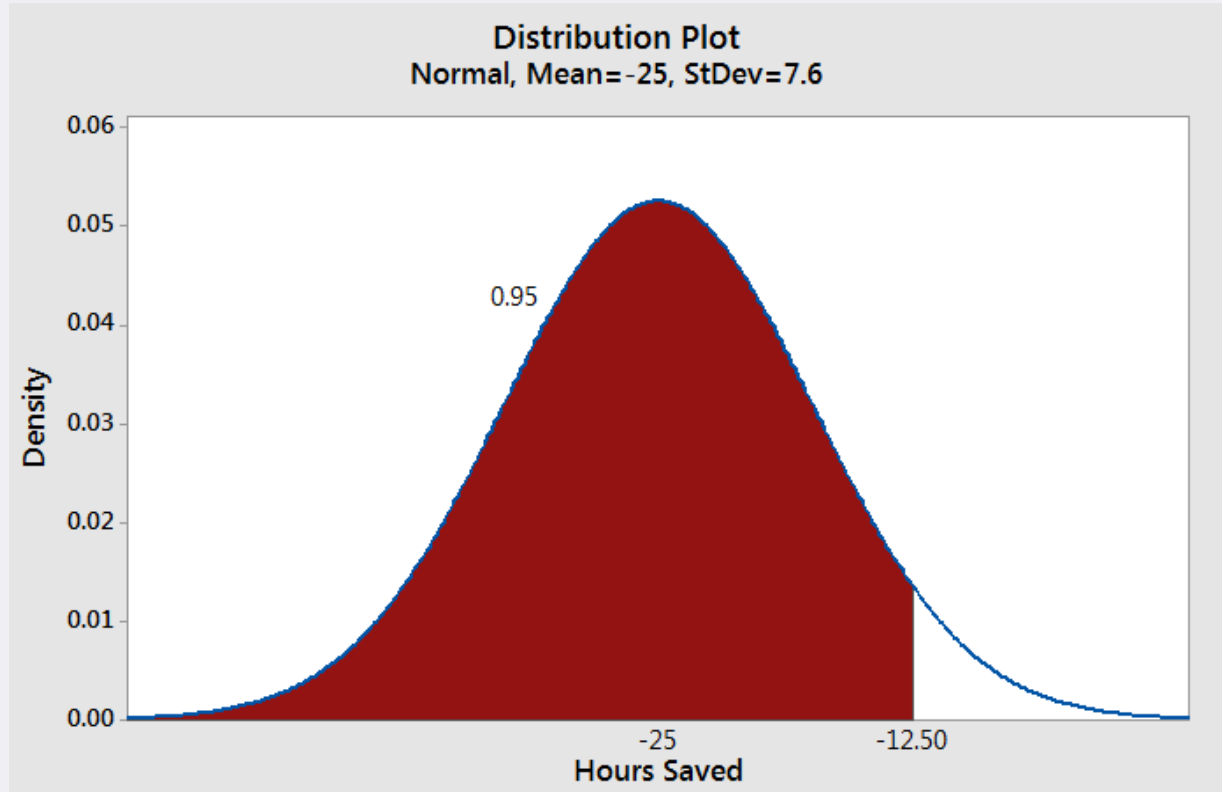
Benefits Estimate – Time Saving Compared to current process

Mean Time saved =
25 Hours. Approx
15% reduction.

Total throughput
increased to 8 per
week on average.

Average saving of
£1500 per HPC.

Approx £600,000
per year.



Quantifying the Risk





Quantifying the Cost

There were two aspects to the cost:

- Financial impact was measured in pounds. Due to rework and delivery delay penalties.
- Time lost due to strip and rework of engine. This could potentially reduce total through put if too many engines have to be stripped.



Cost of Strip = ????

Rework time = ????

Any suggestions on how you would proceed?

Quantifying the Probability

An engine will fail the final vibration pass of test if the vibration on the HPC is too high.

Vibration is caused by the rotor being unbalanced.

The less balanced the rotor the worse the vibration.





HPC Unbalance

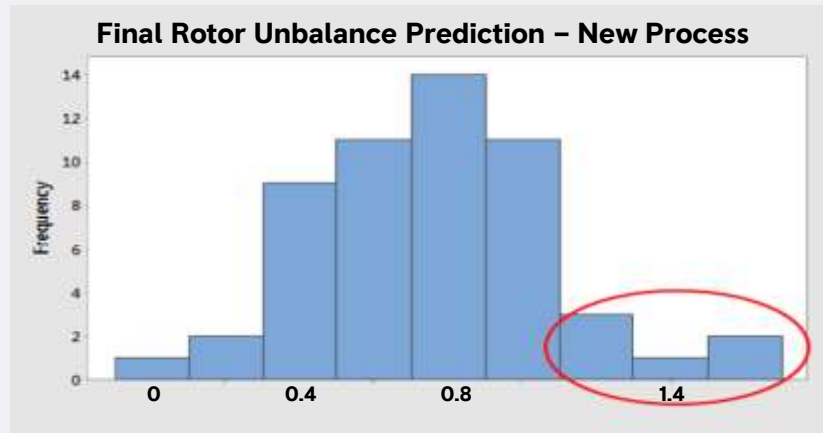
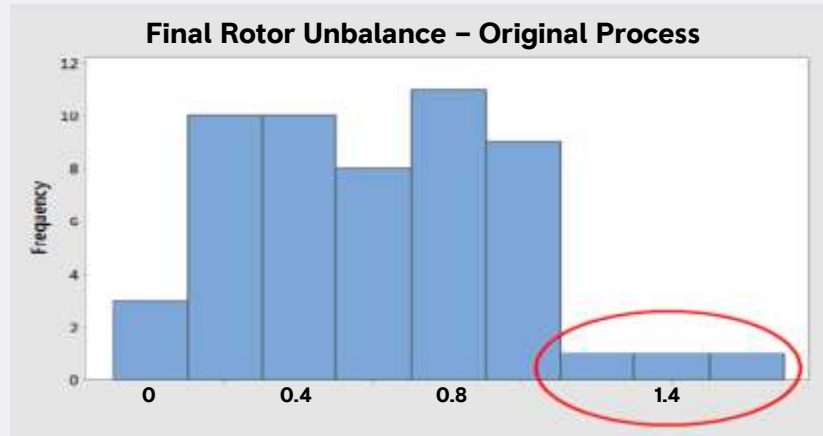
Rotor dynamics expert concluded that removing the steps would lead to:

1. An increase in mean unbalance to 0.8.
2. No chance to the maximum unbalance.
3. A higher proportion above 1.0.

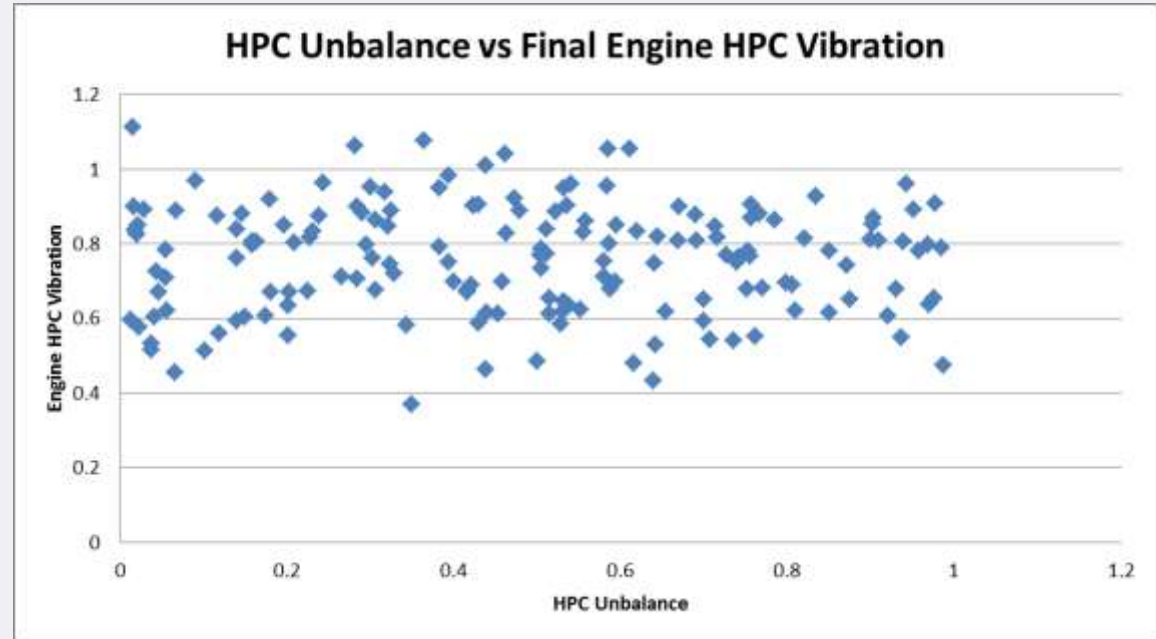
Acceptance limit was 1.8, maximum predicted was 1.6.

Any remarks about the new process?

Are we done?

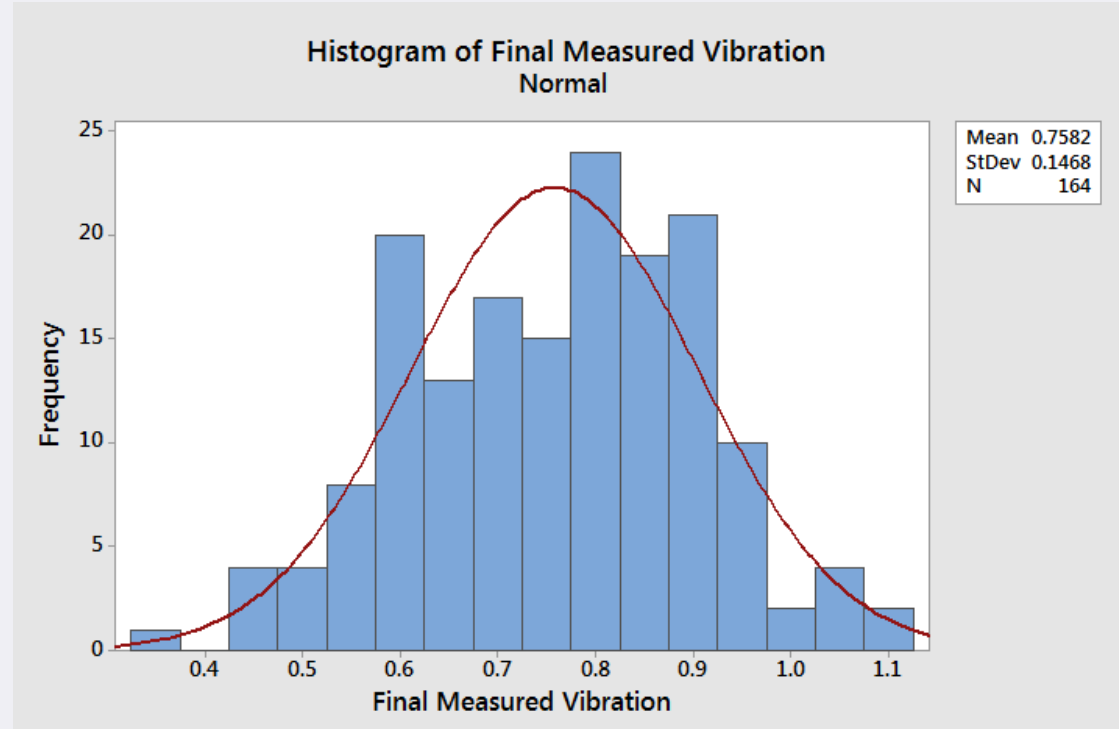


HPC Unbalance vs Final Vibration





Final Vibration





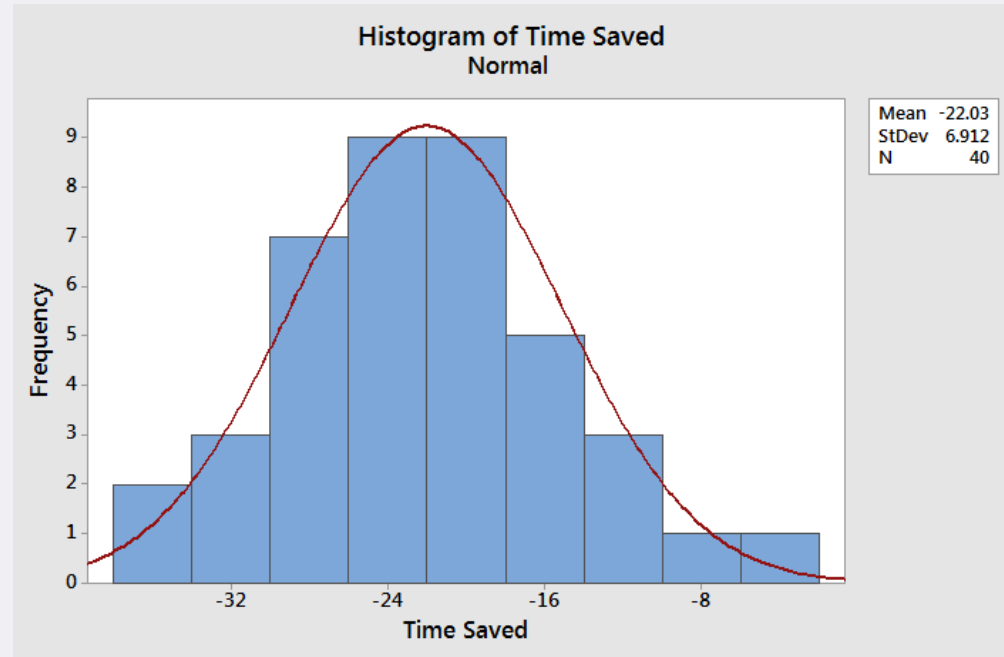
Conclusion

The conclusions of the estimate were:

1. 95% Chance of reducing assembly time by 12.5 hours or more per HPC.
2. Average output increase of an extra HPC per week and saving of £600,000 per year.
3. Risk of rework and delay no worse than today.

Was it right?

A trial of the new process using 40 HPCs took place.



No engines failed pass off vibration tests.



Any Questions?