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FORD'S POWER TRAIN OPERATIONS - CHANGING THE SIMULATION ENVIRONMENT

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ABSTRACT

This paper discusses the changes that were required to Ford's Power Train Operations (PTO) simulation environment to ensure the maximum benefit was gained from the investment made in simulation. Three key elements have been identified as essential to maximizing use. These were Availability, Support, and the right Tools for the Job. The background driving the change was that Simulation had been a key tool in the planning and process improvement of Power Train Manufacturing Engineering facilities since the early 80's. The original deployment allowed user areas to be responsible for the selection, purchase and maintenance of their own systems. This approach resulted in low utilization, a high unit cost and a diversity of products used. The achievement was to transform an isolated approach taken on two continents into a single one across 5 continents while significantly reducing the unit cost. The method was to select a single software solution that could be distributed across the Ford Intranet to anyone in PTO.

1 INTRODUCTION

Historical practices resulted in an inefficient use of resources and conflicted with Ford Motor Company's Globalization strategy. As a result, in 1999 Ford's Power Train Operations (PTO) Simulation Technical specialists were set the following objective: Without incremental operating costs, increase the utilization of Simulation while ensuring your customers get the appropriate support to be able to model every new manufacturing line within the group.

1.1 PTO Manufacturing Engineering

The function of this group within Ford Motor Company is to plan and install production facilities in any one of the forty-four plants across the world that manufacture engines, transmissions or castings for Ford vehicles.

Up until 1999 the functional areas within the group were:

- Inline and Diesel Engines.
- "V" Engines.
- Manual Transmission.
- Automatic Transmission.
- Casting.

Each group comprised of the following engineering departments: Production, Layout and Equipment, Productivity and Manufacturing planning. Each group operated independently and was regionally focused.

In 1999, the PTO organization underwent a radical transformation with the five separate group staffs being amalgamated into one global organization named Manufacturing Engineering.

1.2 Simulation in PTO

Modeling of manufacturing facilities has been an approach used by Manufacturing Engineering since the seventies. Consultants and Ford's Operational Research team undertook the first simulation studies.

With the advent of Discrete Event Simulation in the early eighties with such packages as SEEWHY (Fiddy 1981) the focus began to change. Improvements in the visual and interactive capabilities of the models allowed the Manufacturing Engineers to be directly involved in model development. This involvement took the form of specifying the functionality of the model, collecting data, validating the model and running experiments.

From these early roots, simulation has evolved into a tool the Manufacturing Engineer relies on to address day-to-day planning problems. This requires that the tool be as readily useable as any spreadsheet or word processing package.

Typical facilities modeled are automatic machine transfer lines. The lines are comprised of between 10 and 50 machines with interlinking conveyors. A machine could be a single spindle grinding machine or a 30-station transfer machine (Ladbrook 1998). Operations performed by these machines vary from milling faces, drilling and tapping bolt holes to finish honing various bores. The number of machines in the process varies, dependent on the type of component being manufactured and the volume required.

Within PTO simulation developed separately in Europe and North America and within these confines development was fragmented. Different groups and plants used diverse software packages and approaches, which varied from building models in house, to purchasing consultancy services to doing nothing.

The authors believe one of the main reasons for the fragmentation stemmed from the approach that it was better to use any simulation tool than dictate a policy. Originally this aided the growth of simulation within Ford Motor Company because those that could model were able to use the tools that they knew. It has been said that it is easier to use a tool one knows than using the best tool available (Kay 2000).

After the transformation within PTO, one of the leaderships goals was to develop a common practice and engineering method (Ozias and Zaccardelli 1999). The purpose being to identify the best practices (Profozich 1997 and Banks 1999) from within the groups which everyone could follow. Simulation was one element that had to be addressed. A team of internal experts from the five group staffs developed such a practice that aligned itself to key timing checkpoints (Januszczak 1999).

2 TRANSFORMING SIMULATION PRACTICE

The common Engineering practices served to instill a discipline in the approach to modeling. This was regardless of the tools used and the availability of those tools. Too many barriers had been built up that had to broken down.

2.1 Issues With Previous Approach

In reviewing practices prior to 1999 the following issues were identified as restricting growth, increased utilization and reduced cost.

- The use of four different software products precluded the transfer of models from one area to another. At its extreme the use of diverse software resulted in two models of the same facility to be constructed.
- Demand for simulation is very high at key stages in the planning process and therefore low at other times to the extent it was not used. This resulted in overall low utilization of the software.
- Use of some software was restricted by the need for a hardware key. This limited flexibility because users were extremely reluctant to share "their" key with others. On the global scale it was also illegal to transfer licenses from one country to another and also impractical because of the time involved.
- Over time users changed jobs or the requirement for simulation lapsed. This resulted in the hardware keys and/or simulation skills being lost not only to that area but also to the company as a whole.
- Having to justify the purchase of the simulation software also prohibited entry to the field of simulation. Simulation was a time consuming process and if the need was just for a small study then often any perceived benefits were outweighed by the high initial cost.
- Annual maintenance cost was also found to be a restrictive factor, especially in a tough economic climate. Funding was often cut because it was perceived there was no benefit in updating the software. The result of this was users perceived their software to be out of date and ceased using it.

2.2 The Challenge – Availability

We concluded from the issues with the previous approach that a single networked software was the key to increased availability and utilization. Too many software packages were under utilized and the concept of sharing was alien to most users.

With computer technology having advanced to the level where everyone in the company is connected to the Ford Intranet, the answer to our problem would appear to be a networked solution. The question we had to answer was would this be financially viable. The following summarizes the advantages and disadvantages that we foresaw at the time.

2.3 Advantages - Flexibility in License Availability.

A network license eliminates the need to purchase or transfer hardware keys and allows the legal transfer of software across international borders.

Transfer of models is feasible when using only one type of software.

New and infrequent users would have access to the software without incurring the high initial purchase cost.

It is feasible to track network utilization. This data can control exactly how many licenses are needed and the annual maintenance cost.

Use of Optimizer, a Witness add on module would allow more evaluations and selection of better alternatives. This is foreseen to increase utilization and improving quality.

We also took the radical approach of funding the annual maintenance centrally, the result being immediate access to the latest level of software.

2.4 Disadvantages of a Network System.

A need was identified that certain users would still require stand-alone hardware keys to carry out demonstrations or for working offsite. It was estimated 5 would be sufficient for the needs of the group and accepted that these would be under utilized.

It was envisaged that the use of Optimizer might be abused and as such would significantly extend the level of experimentation.

A risk was also foreseen in always purchasing the latest version in that it may be installed but the new functionality may not be used. Taking an approach of selectively updating could, over time, save cost. To alleviate this concern a review of past upgrades was made and we discovered no instances where we would have not upgraded.

2.5 Implementation

The objective was to transform an isolated approach taken on two continents into a single one across 5 continents. The result was a single software solution that could be distributed across the Ford Intranet to anyone in PTO.

Figure 1: the thin fluctuating solid line shows the number of users accessing the system each day while the thick line shows the average trend. We can conclude from Figure 1 that the action was successful in that in the first two months the average usage increased by 30%. However what was really significant was the number of users per day. Under the previous mode of operating this would have been capped at 31. The thin solid line shows on certain days the number of users accessing the system approached 50.

Achieving this prior to the network implementation would have been impossible because it was not possible to transfer licenses around the world that quickly and for certain the company would not have invested in purchasing an additional 19 licenses to support, what must be assumed from the chart, occasional users.

The chart does not capture all of the success because it does not show that users from Brazil and South Africa accessed the system as well as a number of interlopers from PTO.

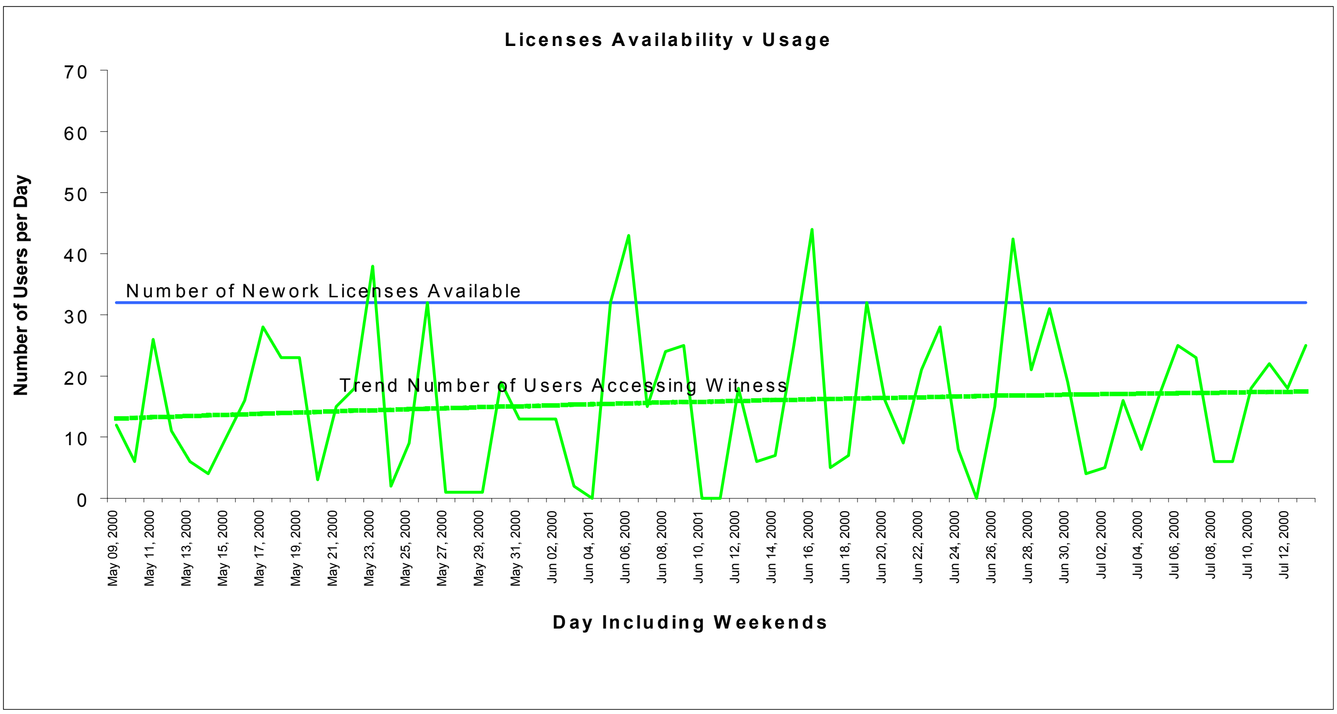

Figure 1: Licence Availability v Usage

3 SUPPORT - A KEY TO INCREASED USE

Although the user base increased after the initial launch of the system, the corresponding increase in utilization failed to materialize. What was lacking was support to resolve problems with the software and the simulation process.

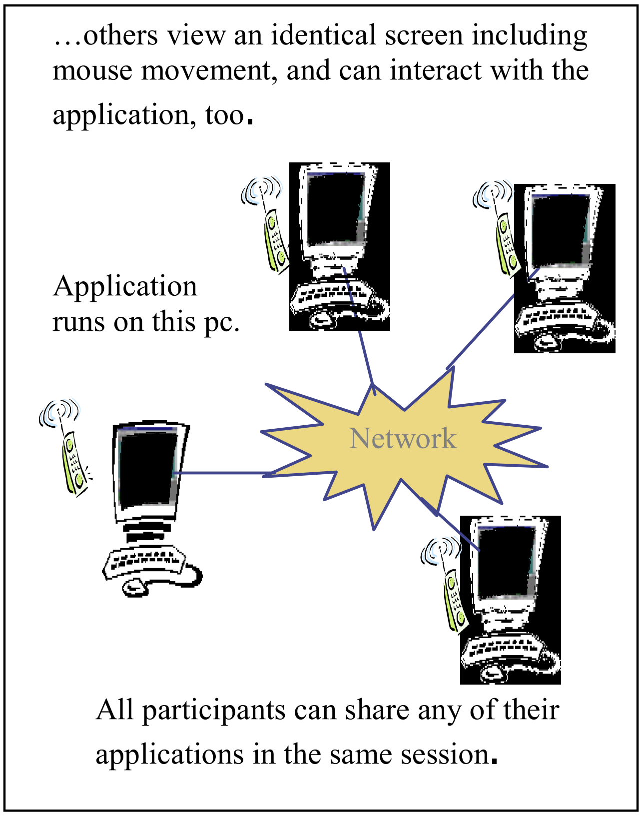

Figure 2: Sharing Applications via Net Meeting

The problem was how to support a growing global user base with only two technical specialists. Travel was a not an option because it was costly and wasted time, since all the time you are traveling you are out of contact with your users.

The need was identified as being able to speak to the users, aid them in resolving their problems and if necessary solve the problems for them there and then. Verbal communication was no problem: there was the telephone. Viewing the models posed a bigger problem. Experience had shown that the delay from sending models to someone, no matter how quick, was unsatisfactory. The best in class service could only be delivered by solving the problems there and then.

One of Microsoft's software packages, "Netmeeting", was the answer to our concerns. The software allows two or more computers to be linked together and the applications on those machines to be shared See Figure 2. Use of this software enabled the technical specialist supporting someone in a remote location to see and amend the model that is giving the concern.

The benefit of using the existing software was that no additional hardware was needed. The software also includes such facilities as a chat line and white board that allows the meeting to be documented as it occurs. Should all else fail; there is a file transfer link, which allows almost instantaneous transfer of files.

Exploitation of this software allowed us to provide best-in-the-world support in the following ways.

- Resolution of modeling problems and concerns was instant. Even if the user did not have Net Meeting a session could be up and running in 5 minutes.
- Training sessions could be given on line as required and because this was tailored to PTO's needs it was very effective.
- Having established that links beyond the firewall could be made, vendor help desk support where required was made available in a similar way.

This solution captured users and kept them motivated and promoted continued growth.

4 TOOLS FOR THE JOB

In order to be completely effective manufacturing engineers need to use all the tools at their disposal. Discrete Event Simulation is one of those tools. There are many products available, ranging from the low cost low complexity to high cost high complexity. It has long been said that today's simulation tools are easy to use (Harrel 1990) and it is inferred by the suppliers that they are little more complex than a spreadsheet.

What is the reality of this in today's manufacturing environment where efficiency actions either reduce headcount or increase workload? If these claims are true, why is it then we do not see these tools being used by every Manufacturing Engineer?

Why is it then that PTO's Manufacturing Engineers, when given the software, are still striving to meet an objective they set in 1984? The objective being every Engineer would build and run the models they were responsible for.

You may say, and quite rightly, that the engineer should be dedicated full time to modeling because the proper use of a simulation tool should enable him to make decisions much more effectively.

However because of the time and concentrated effort required to build a model this infringes on the engineer's other duties and they cannot devote them selves to building detailed models. The option of employing consultants or full time modelers is expensive and not a viable option.

The whole cycle of model building, from defining the problem, gathering the data, through to presenting the results, is very time intensive. So even if today's simulation tools are easy to use they can in themselves only reduce the model building component of the simulation cycle. This may only be twenty percent of a typical study.

So to make the tools useable, actions are necessary to reduce the time intensive elements such as data collection, data input, interpretation and presentation of results. These reductions can only take place provided accuracy and integrity are maintained.

So is it possible to for an engineer to be able to build and run his own models?

4.1 Providing Tools to PTO

The first hands-on use of simulation by manufacturing engineers coincided with the launch of PC's into the Productivity department. This was achieved by translating the foreman's training program into basic. By modifying the method of data input, the model was capable of representing a cylinder block or head transfer line. The program was not widely used due to a lack of computers, no user interface and skepticism at that time of a new technology, simulation.

However, despite being non-visual it had an advantage. The manufacturing engineer had extensive knowledge of the data input to the model. Based on their experience they could judge for themselves if the expected outcome of the experiments was logical. In addition, because of ready access, the engineer had control of the experimentation, although this was limited due to the execution speed of the model.

Overall the lessons learnt from use of this software were that simulation could be a valuable tool in the planning of new facilities and such a tool could be used successfully.

After successful use of SEEWHY for a number of years a second generic tool called Mentor (Hawkins et al. 1984) was developed. The concept involved a menu driven user interface and embedded logic. It was possible to embed the logic because within a transfer line set up, 80% of the constructs follow the same form e.g. a machine feeding a conveyor. The other 20% of the occurrences being specific to more complex logic such as splitting into two routes, assembling parts together and feeding multi-machine operations.

The simplistic construction of the model and the method of data input and of listing the detail were believed to be the critical elements for a tool any engineer could use. Engineers were trained and wanted to use the tool but their efforts were hindered by lack of computer facilities. Even with this tool simulation was a heavy burden to workload taking a week to build and five weeks to complete the initial experimentation phase.

Other advantages of using such a product was that it was much easier to train someone to use rather than picking up a model and trying to understand its construction by referring to the documentation. Documentation was limited because the inherent coding followed a rigid structure so all that had to be documented was the data used in the model. Model validation often a cause for concern (Carsen 1986) is more improved through repeated use of the same logic. This approach not only saves on the building time but also reduces the overall process time.

4.2 The Generic Approach is the Answer

Despite three previous failures it was considered that a generic model was the best enabler for Productivity Engineers to use simulation. Advances in software developments such as OLE links and a computer on every desk helped to launch another attempt. It was believed significant gains could be had if a rough cut Witness model could be constructed via an interface that nearly all Engineers are used to using, such as Excel.

Before this could be done, data input methods had to be rationalized and developed. The multiple time and frequency inputs for each operation were rationalized to a one-line input.

Breakdown data was rationalized by developing a typical Ford distribution, which had over many years proved to have a common profile. By using this distribution, the user then only need input the breakdown percentage. The breakdown percentage was selected rather than the mean time between failure, as management and the shop floor better understood it.

It was also established that the logic could be simplified and the necessary run speed could be attained that would make a rough-cut Witness model useable. The logic simplification included a machine(s) feeding a single buffer element with no delay time, which represented all the storage facilities between successive operations.

Other actions taken to reduce the execution time were to ensure that if any function was not used then that function was excluded from the model. It was found that if the functions were included with nil values they slowed the model. The execution time of a model was one hour for one year's evaluation.

From the experts viewpoint it is essential to have confidence in results but from the engineers point of view it is essential to get away from this confusion. Capitalizing on the run speed and recommending a very long run time achieved this. This was found to be true for management as well. They don't like to be confused by added baggage. They just want to understand the direction to take.

After determining that the results from such a rough-cut model were comparable to that achieve from a detailed model and changes in both models showed the same trends, it was decided to pursue this approach.

The interface was named FIRST, Fast Interactive, Replacement Simulation Tool. The name of the software has many hidden meanings i.e. first tool to be used. The name itself being a replacement for detailed simulation but above all even after all this the first tool that will be used by all Manufacturing Engineers because it is easy to use and quick to run.

4.2.1 The Advantages of This Approach Are: -

Although not representative of the layout there is a pictorial view of the model that can be examined to identify problem areas and ensure the model is functioning correctly.

Because it is based on Witness, if there is any functionality not available within the generic model, it is possible to have this added by someone with the expertise. However, the model can still be run from the original interface and the results presented in the same way.

In addition, by creating a rough cut model in Witness, it is then possible to convey this into a detailed model. This saves considerable time in the development of such a model.

The interface not only holds the data of the model, but due to the structure of the macro's, it also builds the model in the Witness software. As far as the user is concerned because results are also presented in the interface, he or she does not even have to see the model. As far as the user is concerned he or she is just entering data into an Excel sheet and some time late the results are available.

The advantage of this is that it removes the mysticism of simulation and hence the fear to use the tool because the user now no longer perceives it a long and arduous task.

4.2.2 So What Do Engineers Need:-

- Ready access to a computer and the software.
- A simple method of constructing a model.
- A model that gives results quickly.
- No statistical baggage to frighten them away.
- Confidence that the underlying logic is correct, thus eliminating much validation.
- Flexibility in the model and support to model complex situations.

4.2.3 What They Do Not Need Is:-

- To spend time collecting data. They can make use of what they already have.
- To spend time transferring data from one package to another.
- Spending hours on validation and sorting out modeling problems.

There are dangers with this approach. It is not possible to remove the thought process and it is still necessary to analyze the results and understand them. But it is all too easy for someone to think all they have in front of them is a complex spreadsheet and ignore all the good information that is being shown to the user. At the end of the day the user must still have a passion for the task and he must be a SIMULATIONIST at heart.

Answering questions may be 20 times faster than before, however, the manufacturing engineering still cannot respond quickly enough. To answer the questions he or she still has to change the model and evaluate the effect.

5 CONCLUSION

Making simulation available to all of PTO personnel and providing them with the correct support and the tools for the job where proved to be key elements. After installing a network to make the software available, using NetMeeting to deliver instant support and providing a software tool that allows models to built easily and run quickly the following results were achieved: -

- Number of users has quadrupled.
- Utilization has increased by 30%
- Unit cost cut by 66%.
- Accessed across the globe.
- Support and Training given on-line.

Benefits not quantified were the time saved in traveling and the effect of supporting the decision making process with data.

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