"Improving the collective capacity of managers to execute strategy and create value"

– A dynamic simulation-based approach to strategy communication and management training

1. Abstract

This paper presents a unique case study of the successful application of systems dynamics for large scale **management training** and **strategy communication**. It tells the story of how Novellus Systems, a Fortune 1000 company, with the help of an outside consulting firm, successfully trained managers over a period of three years to understand and execute the company's strategy using a system dynamics based simulation model.

The paper presents lessons learned from the simulation events organized to help Novellus achieve its objectives. It illustrates a unique context of system dynamics in action at a very high level. It further illustrates how system dynamics was used to foster dialogue, collaborative team learning and create a shared vision which profoundly affected understanding, influenced and even changed some management practices. It reveals how the simulation game enhanced management's ability to think systemically, communicate effectively, and collectively execute with confidence. This project has been so successful that Novellus continues to use it in its semi-annual management meeting for nearly three years now in a row and we are jointly working on presenting a paper in one of the industry's leading publications. The underlying simulation model has about 100,000 variable.

2. Introduction

During our first meeting to kick off the project in August 2000, the CEO of Novellus Systems, Rick Hill, said, "I want all my managers to experience what we the executives go through; I want them all to experience our decision making process, the stress we go through day-and-night to arrive at decisions. I also want them to understand that there are financial consequences to every decision everyone in this organization makes. They all need to learn to read and interpret items in the Balance Sheet, Income and the Cash Flow Statements." Rick's

problem was twofold: (1) how to communicate Novellus' strategic vision to the managers, and (2) how to get the managers who will implement the strategies to understand and trust those strategies.

Rick understood the fact that it is ineffective for a CEO or an executive team to formulate a plan in isolation and simply roll it out to employees. He was convinced that in order to set realistic targets, input is needed from the whole organization. He further understood that a good business can only make decisions for the present because whilst managers can anticipate the future, they cannot guarantee anything, so they need to be flexible and able to anticipate correctly and with confidence. They need to be able to imagine, experience, and manage the future before it even arrives, through experimental simulation.

Above all, Rick also strongly believed that a management simulation war game will help him solve his problems, so he invited Powersim Solutions, Inc., a dynamic business modeling and simulation company, headquartered in Herndon, VA, to initiate a simulation project.

Powersim's task was to create a simulation environment, which will replicate Novellus' decision-making and operating business environment for the managers to truly experience what it means to run a complex organization at all levels, with all of its manifestations without sustaining any real financial consequences. The purpose of the simulation tool was to help Novellus executives to communicate to the managers *what* their strategy is and for the managers to clearly understand *why* this strategy and *how* to execute it, while providing their own input at the same time to shape the final strategy to be adapted.

Powersim built an enterprise-wide system dynamics model with over 100,000 variables, connected it to a database and embedded it in a web-based application platform, Powersim ExTrain®. It was configured into an interactive business simulation game and used in a two-day management simulation event.

3. The project team

The project team was made up of Powersim consultants and Novellus staff. The team received input from many company executives, but driven mainly by the company's EVP & CTO and their CFO. The project team members from Novellus were drawn mainly from the finance and strategic marketing departments. They

provided the data for the model and participated in building, verifying and validating its structure and behavior. They also formed the core of the facilitators during the simulation event.

Other executive staff members who helped with information for building the model later formed the core of the constituted board of directors, whose job was to assist the teams to articulate and understand their strategies before they input and submit their decisions.

3.1 Building the model

The project team met several times during the process of building the model. Meetings were arranged virtually weekly to talk with thought leaders in the organizations, including the CEO on many occasions. There were also many review meetings to verify and validate the structure and behavior of the model. A lot of time was spent trying to get the shape of "response curves" of non-linear relationships and soft variables – table functions. This was an exercise which proved to be very rewarding for the client because it forced managers to quantify relationships that they know exist but could not measure.

3.2 Focus on key learning objectives

Throughout the model building process the team focused on the learning objective rather the tool and what it could accomplish. This helped us to always stay on course and within our scope. We balanced complexity with what is relevant to solving the problem. The model was complex enough to "kill" those who wanted to go solo without collaborating, but also simple enough to meet its learning objectives.

4. The model

4.1 The company's operating environment

The company operates in the deposition, surface preparation and copper chemical mechanical planarization market segments, providing essential technologies used to fabricate today's semiconductors. In order to achieve this objective, a system dynamics simulation model is built to capture the intense dynamics of a semiconductor equipment company and its operating environment.

4.2 The model purpose, dynamic hypothesis and design

The purpose of the simulation model was to highlight the complexities of managing a semiconductor equipment company, which is subject to the

industry's cyclical nature of upturns and downturns. This being a very broad objective, we could not follow the traditional system dynamics approach of defining a single dynamic hypothesis in building the model. Instead, we identified some general and recurring operational problems in each of the functional areas and built the model structures around those issues. The model therefore had many dynamic hypotheses, which were scenario-based and the participants were required to develop their strategies to respond to those scenarios based on the short- and long-term objectives of the company as incorporated in the simulation model.

Since one of the key objectives of the whole project was to help the managers learn to read and interpret Balance Sheet, Income and Cash Flow Statements items; and also to understand that there are financial consequences for every decision taken by everyone in the organization, at the core of the model was a complete financial model of the company. The financial reports measured performance and revealed weaknesses in the strategies of the teams. It helped the managers to clearly see and understand the direct and indirect links between causes and effects in the context of dynamic complexity. Figure 1 below shows a cross-section of the finance sector of the model.
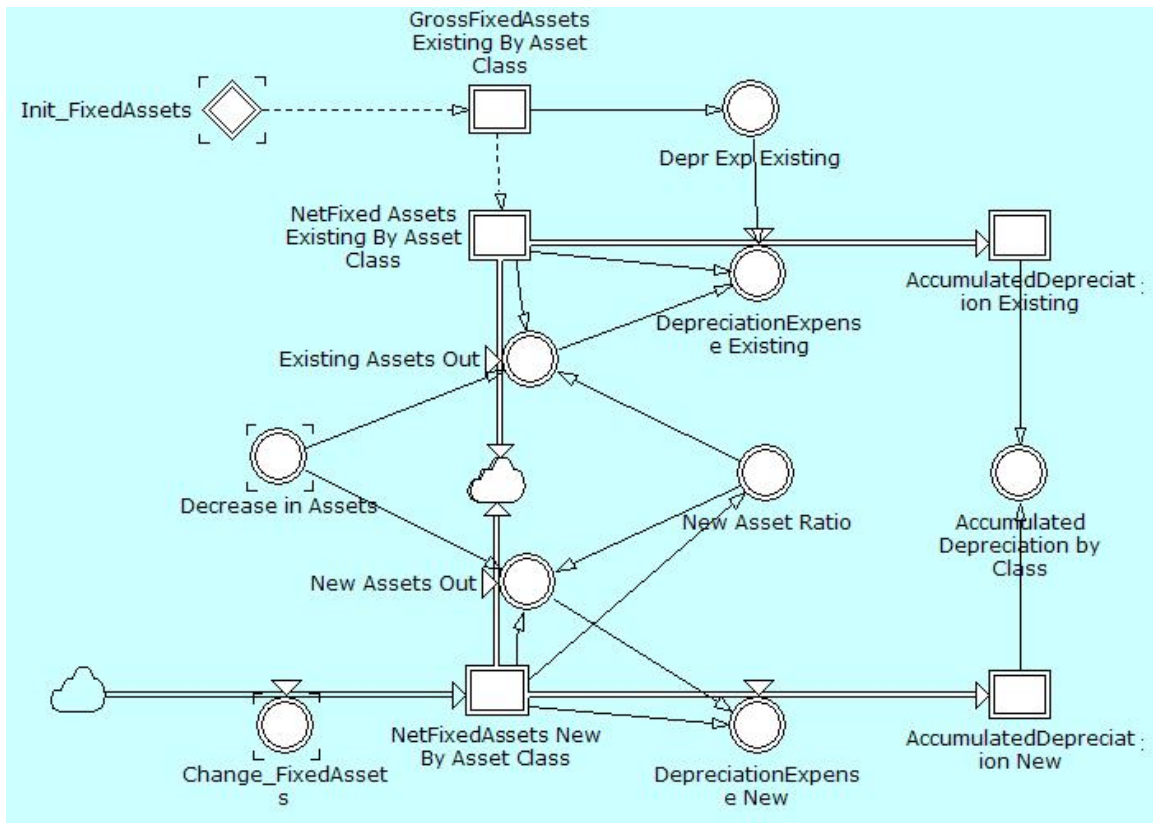
4.3 Focus of the simulation

The simulation design was focused on helping the managers understand:

- How to adjust business strategies to adapt to the varying market conditions inherent in the semiconductor equipment industry.
- How different business strategies affect the financial performance of the company.
- How changes in customer demand cycles and technology nodes affect the industry.
- How R&D, Manufacturing, Sales and Service decisions affect future revenue and financial performance.
- How Human Resource decisions, such as hiring and compensation affect productivity and overall profitability.
- How the analysis of financial statements influences overall business strategies and specific operations decisions.
- How strategic business decisions (i.e. facility infrastructure decisions) impact the Company's return on assets (ROA).
- How the overall capital structure impacts business and financial performance.

The participants were asked to make decisions in Research and Development, Human Resources, Manufacturing, Sales, Service, Facilities and Finance. Each team was advised to take some time to discuss all information made available to them in the simulation Handbooks and what was embedded online in the simulation.

4.4 Validity of and confidence in the model

Establishing confidence in the model was no mean task. However, anchoring the model around the company's financial records helped us to achieve this very important goal; since the model had to replicate all the financial reports they have and balance all previous financial statements.

Before each main simulation event, we also conducted one alpha and two beta tests. This gave us the opportunity to get feedback from both executives and the analysts involved on building the model from the client side. Each output is carefully scrutinized against actual data and or confirmed by evidence from their experience before acceptance. The simulation results into the future also had to

be within what could reasonably be achieved given their current resources and constraints, as well as the nature of their competitive environment.

4.5   Model assumptions

Making the assumptions incorporated in the model explicit was necessary for two reasons: (1) as with any model that represents a real-world business, assumptions must be made to simplify the complex details of the business while providing a reasonable representation of reality; (2) since the participants were not part of the model building process it was very important to make a clear distinction to them about what they know in the real business they manage and what was represented in the structure of the underlying business model. Therefore, the following high-level assumptions were made to simplify reality while maintaining the integrity of the model and participants' confidence in it:

- Only five product lines - PVD, Dielectrics, Strip/Clean, Cu CMP and Electrofill - were represented at the start of the simulation.
- At the onset of the simulation, the company is assumed to have developed a set of technologies in the above product lines and additional technologies are added to each team's product offerings as they are developed and become available for sale.
- If a team has not completed a needed technology by the time there is market demand for it, that particular technology will not be included in the team's served available market.
- G&A, Marketing and Executive Staff personnel are included in "other headcount".
- Industry growth is driven by end-user demand for smaller, faster, cheaper and more powerful ICs needed to build the advanced computing, communication, networking, and electronic systems. As such, demand for the Company's equipment tends to follow the cyclical nature of the end-user's demand for the aforementioned systems.
- The model made no adjustments for inflation.

In addition to these general high-level assumptions, the participants were also provided more detailed information about the assumptions made in each of the business functional areas listed above, including information about anticipated causes and effects. Causal loop diagrams were incorporated in the simulation Handbook given to the teams to help them clearly visualize the links between variables, functional areas and business units.

5. The offsite simulation event

There are about two hundred managers as part of 25 teams in the ballroom very busy plotting their next business move that will make their company beat the competition and be profitable. Each team is analyzing its business position before the deadline for making the next round of decisions. You can see the intensity, focus and energy among the participating managers. This is the atmosphere at the semi-annual management meeting of Novellus Systems. The managers are drawn from all the different business units and operational departments of the firm. They all rank from manager to vice president and make resource allocation decisions in their everyday jobs.

The event consists of four sessions – briefing and introduction to the objectives of the simulation, running the simulation, presenting team strategies to a constituted board of directors, and debriefing or performance assessment, where five of the best and worst performing teams are chosen to present to the rest of the audience.

The hands-on simulation experience introduces the participants to the concept of interactive learning environments. Through team learning, the participants share experiences, exchange mental models and multiple views on the nature of their business environment, develop a systems' perspective, and improve their competence in dealing with a complex business system. While engaged in action learning, they mutually shape a learning community.

5.1 Objective of the simulation exercise

Before the start of this simulation war game the teams are first introduced to the objective of the simulation by the CEO of the company, which is to learn to run the enterprise from the management's point of view. Training the managers to understand the corporate metrics and how their jobs impact them. Also because hiring from outside is not an option for the firm, management needs to develop internal managers to become the next executives; since their current jobs don't give them the experience that is needed to perform at the next level.

5.2 Facilitators

The project team members who participated in building the model constituted the facilitation team whose job was to ensure that each event was carried out smoothly. The facilitators are also took part in the testing and validation of the model. Each facilitator is usually assigned to at least two teams to help them clarify any ambiguities associated with the assumptions and behavior of the simulation model; as well as helping the teams resolve any technical problems.

5.3 Board of Directors

Board membership was made up of senior executives who have either directly provided some input in building the model or their participation is considered inappropriate due their executive positions in the company. The board members usually participate in an appropriate and more challenging simulation designed exclusively for their executive training event held once every two years.

5.4 Simulation teams

The participants of the management meeting are grouped into twenty-five teams, with seven to eight members in each team. One person on each team is pre-assigned and designated the CEO. The teams are further advised to assign each team member one of the top executive roles in running the company. Each team is also pre-assigned a login name and a password.

5.5 Duration of the simulation

The actual duration for running the simulation is two days, given the complexity of the model, number of decisions to make, number of reports to review, interaction between the sever and users' web browsers, and the horizon of the simulation, which was 10 years into the future. In each round players review reports, input decisions, and submit decisions, which lasts between one and two hours depending on the which round the simulation is at.

5.6 Running the simulation

The actual simulation activities are structured into phases. First, the facilitators brief the participants about the simulation, including its background, introducing the simulation Handbook or players' manual and the navigation windows. The participants are then given time to read the manual/instructions and prepare themselves for their respective roles, tasks and responsibilities. Finally, the players engage in playing the game.

As participants login to the simulation the following message is displayed in the introduction page: "You are part of the management team of X-Force, a semiconductor equipment company that focuses on deposition surface preparation and chemical mechanical planarization, essential technologies used to fabricate today's semiconductors. As the management team of X-Force, you must determine and implement various strategic and tactical decisions in Human Resources, R&D, Manufacturing Sales, Service, Facilities and Finance that ultimately affect earnings per share and stock price over the next eight years. At the end of each year you can see the reports that will show the performance of

the company based on your strategies. You will also get a score at end of each year reflecting your performance. The score takes in to account your teams' ...

1. Return on Assets
2. Revenue growth
3. Earnings growth

They also get this additional guideline: "The following diagrams will help you understand the main dynamics of the underlying simulation model."
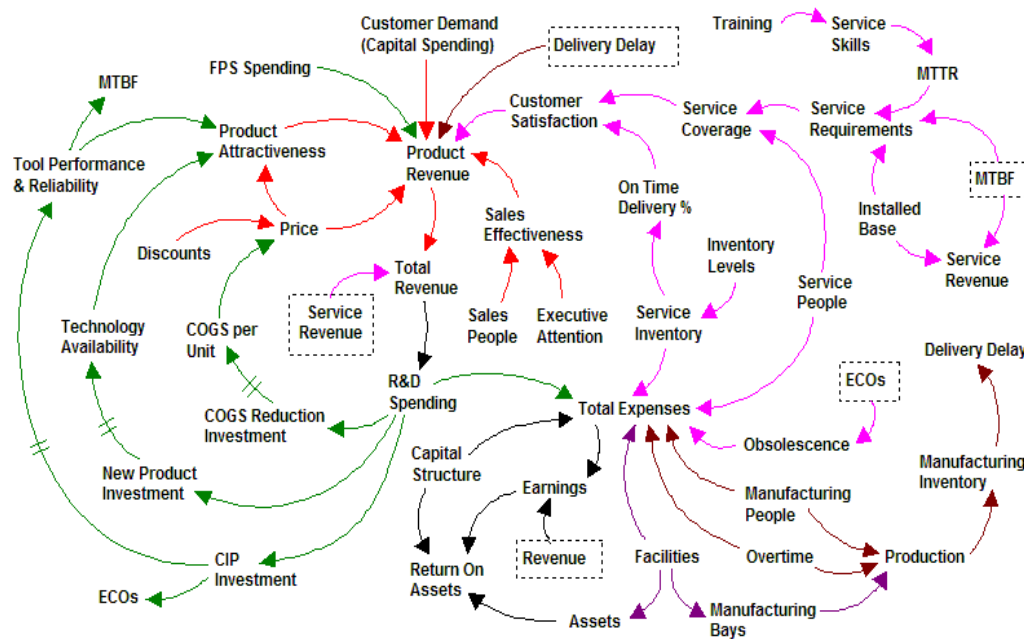

Figure 2: Overall dynamics of the model

The teams interact with the computer simulation model by reviewing the information available to them, making decisions and submitting them for the facilitator to run or advance the simulation and then retrieving their results.

6. The impact and some key lessons learned

Over the last three years that Novellus centered its management meetings on the simulation games, it has had and continuous to have tremendous impact on the culture of the company. Many have come to regard it as a tool for selection to management succession, which is unfortunate and detrimental to the conditions for learning. It has become a tool that many love and some few hate. Those who have consistently done well in the simulations love it and those who have not

had much luck with it hate it. At the end of each management meeting we distribute survey forms to the participants and 95% of all responses have always been positive, particularly those coming from managers of the acquired firms. Some of these responses can be found in the appendix verbatim.

6.1   Cultural integration

Besides meeting its primary goal of communicating strategy and training managers, the tool also played an important role in integrating other managers into the company's culture from the two firms Novellus acquired in the last three years. The simulation helped the managers from the acquired firms to understand Novellus' processes, priorities, management style and practices, decision making process, and organizational and financial structure. As a matter of fact the last simulation event, which was held in October 2003, was won by a team whose leader comes from one of the acquired firms.

6.2   Some key revelations of the simulation model

- **Changed the way they value their programs** - Although management had always believed that they needed to start a certain number of simultaneous Concept and Feasibility (C&F) programs in order to produce one successful product, they never fully practiced it until they started seeing how realistic it is and its impact from the simulation.
- **Changed their understanding of industry business cycles** - Management and the industry as a whole used to believe that the sales cycles in their industry was due to macroeconomic factors, but realized through the continuous use of the simulation that it is in reality caused by their customers' behavior.
- **Changed the way they value management training** - Management started thinking of management training, which traditionally has been considered a support function, as a tool for strategic and competitive business advantage. Namely, a component of Learning & Growth which can give a company some kind of strategic advantage.
- **Forced managers to quantify their decisions** - Building and running the simulation some managers, who were hitherto averse to quantitative analysis, were forced to learn to quantify their decisions and assess their tangible impact on the business model.
- **Value of system dynamics** - Management was very impressed and overwhelmed by the ability of the system dynamics method to represent all their thoughts in a mathematical model.
- **Assessment of learning** - By scoring the teams based on how they performed in the simulations, management was able to assess whether

participants have learned something or not. Management was therefore able to give immediate feedback for remediation. The participants really acquired experience by learning through their own mistakes.

- **Focus on "Performance Goals" rather than "Learning Goals"** - Initially the participants focused on "Performance Goals" rather than "Learning Goals". All they wanted to know was whether a 2% or 5% input will give them the right answer or not. They were more concerned with being judged as competent and impressing by others, preoccupied with the end results, or having higher scores than improving ourselves. After the first simulation event they gradually shifted their attention to wanting to know why the answer should be 2% or 5%.

- **Value of enterprise-wise models** - For us as consultants, it showed us that a useful enterprise-wide model can be created and used. It can also be made an integral part of an organization's critical management tools, both as a methodology and information technology system.

- **Shortcoming** – One of the key shortcomings of all these events turned out to be fear of failure. Because it turned out to be like tool for selecting candidates for promotion, many participants feared to make mistakes, which key to a successful and meaningful learning.

7. Conclusion

The success story narrated above is not exclusive to Novellus Systems; in addition to them we have also successfully built system dynamics based simulation models and run similar management meeting events with companies like Microsoft and Discover Business Service among others. Some of the events had as many as 6,000 managers running the simulations at the same time in one place, whereas others had only as many as 30 managers at a time.