

Leverage of Project Training & Mentoring to Enhance Business Value

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Northrop Grumman

- 75,000 Employees
- 2017 Sales of \$20 Billion
- 5th Largest US Defense Contractor
 - Northrop Grumman is a leading Designer and Manufacturing Supplier of Advanced System Solutions to the US Department of Defense.

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- The data in this presentation is representative of the actual work and results, but details have been revised to protect proprietary and restricted data.





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- Northrop Grumman's Advanced Technology Labs (ATL)
 - Performs a critical role through production of a wide range of Integrated Circuits that contribute to Northrop Grumman's continued performance
- What questions will be discussed by this presentation?
 - How to Leverage Training Projects to Enhance Business Value?
 - How can you implement Mentoring to improve engagement of employees?
 - What can you expect Process Improvement to do for you?







6th Grade Class at PS121 in Harlem NYC, 1981





- In 1981 Eugene Lang was invited to give the graduation speech to a group of 6th graders at PS121 in Harlem NYC.
- Lang was a successful businessman and had attended PS121 as a child.









He was prepared to give a "Work hard and you'll succeed" speech until he took a tour of the school with the Principal.









He learned that the High School Graduation rate was 1 in 4, with only 1 or 2 likely to attend college.







Lang made an impromptu change to his speech. He promised to personally finance the full cost of a college education for every student that graduated from this class.









He purchased books and library materials and enlisted community support for after school mentoring and tutoring.









54 of the original 61 students remain in contact

- More than 90% Graduated High School
- More than 60% Pursued Higher Education



We see similar challenges with Green Belt Training





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Northrop Grumman - Green Belt Training

- Green Belt Training at Northrop Grumman is conducted as an intensive 40 hour (one week) class.
- Green Belt Class is offered twice per year.
- Class size is generally 30 people largely from the Baltimore area, although there will be students from other US sites.

Poor return on Green Belt training investment



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Northrop Grumman - Green Belt Projects

- Green Belt Certification requires completion of a project.
- Historically only 1 in 4 Green Belt Candidates complete their Certification Projects.
- Seven (ATL) employees take Green Belt Training.
- This represented an opportunity and a challenge.

Only 1 in 4 Complete Projects

Poor return on Green Belt training investment



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Northrop Grumman - Initial Problem

- ATL was challenged with increased demand for a key new product (E2D).
- The E2D program presented growth challenges.
- Increased production throughput would be required.





Identify Program and Business Needs





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E2D Program Requirements

- Program Requirements doubled.
- Production Operations were capacity constrained.
- Equipment purchase lead time was over one year.
- Limited Engineering Resources and Investment Capital





Need an alternative solution





Opportunity

- Combine employee development, through Green Belt Training & Project completion, with program needs, to increase the business value.
- Focus Green Belt projects on the identified program needs.
- Test impact of a mentoring investment on outcomes.





Can Mentoring make a Difference?







Integrated Circuit Overview



A typical Integrated Circuit Die Measures between 0.125 and 0.250 inch square and can contain 100,000 to 1,000,000 transistors.

16 Association for Manufacturing Excellence.

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- A 6 inch Wafer can contain 2,500 Integrated Circuit Die
- There are ~200 process steps in the production of a Wafer

Sub Plan #	Sub Plan Name	Sub Plan Steps
1	Initialization	7
2	Mask 1	16
3	Mask 2	15
4	Mask 3	16
5	Mask 4	15
6	Mask 5	16
7	Mask 6	15
8	Mask 7	16
9	Mask 8	15
10	Mask 9	16
11	Mask 10	15
12	Mask 11	16
13	Mask 12	15
14	Inspect and Test	7
Total		200

- Process steps are grouped into multiple Sub Plans
- Process steps are performed sequentially to complete each Sub Plan
- A typical Sub Plan contains 8 to 10 Photo Litho steps plus 5 to 10 deposition or etch steps
- There are also inspection steps in each Sub Plan.



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E2D Program Objectives

- Increase Integrated Circuit Throughput rate by 2X
- Decrease Cycle Time by 1/2X
- Increase Yield by 2X
- Demonstrate Ability to achieve Increased Production Requirements





Improvement Process

- Identify a series of Improvement projects that will impact E2D Program Objectives
- Assign the projects to students seeking a project to complete their Green Belt certification
- Provide Mentoring and project support
- Implement and track improvement outcome



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Metal Evaporation Process

- Two Metal Evaporation machines were working near full capacity.
- The metal is deposited on the wafer by an electron beam from a ceramic crucible inside the machine.
- Presently it takes 2 hours to run a complete batch of 10 wafers.
- Basic Process
 Unload and Reload
 Setup
 Vacuum Pump-Down
 Process
 Cool down and Re Pressurize

 With 2 Machines, and 2, 40 hour shifts this
- With 2 Machines, and 2 40 hour shifts this limits production to 80 batches per week
- (80 hrs x 2 machines / 2 hrs) = 80 batches



Metal Evaporation was identified as an area with potential for a Green Belt process improvement project



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Metal Evaporation Process

- A crucible that is full of metal will last 3 runs before it must be refilled.
- It takes 1 run to refill and purify the metal in a crucible.
- 25% of the process runs (20 batches) are used to refill and purify crucibles.
- 80 20 = 60 batches
- <u>Effective Net Throughput is limited to</u> 60 batches per week.



Identify and Exploit Alternative Processes





Metal Evaporation Process

Alternate Crucible Refill and Purification Process

- An older metal evaporator is available.
- Its process control ability is not good enough for production, but
- The older machine can be used for refilling and purifying crucibles of metal.
- By using the older machine to refill and purify crucibles of metal we can recapture the 20 batches in the prime machines yielding 80 batches or a 33% Increase in Capacity



Identify and Exploit Alternative Processes



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Metal Evaporation Process

Accelerated Pump Down Process

- 60 Minutes are required to pump-down the vacuum chamber.
- By analyzing the pump-down process we determined that it could be improved.
- Replacing the vacuum seals and purchasing a new vacuum pump reduced pump-down time by 30 minutes, reducing the cycle time to 1.5 hrs.
- (80 hrs x 2 machines / 1.5 hrs) = 106 batches
- <u>The Accelerated Pump Down yields an increase in capacity of</u> <u>26 batches per week or an additional 33%</u>

Identify and Exploit Alternative Processes





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Metal Evaporation Process

Combine Both Process Improvements

- When the process improvements from the alternate crucible refill and purification process and the accelerated pump-down are combined the new capacity becomes 106 batches all of which are now used to process wafers.
- Old Process = 60 batches
- New Process = 106 batches
- <u>Net Improvement = 46 batches (77% increase)</u>
- This is like getting 1.5 new machines for free.

Combine Multiple Process Improvements







- The present process deposits Oxide over patterned metal layer with uneven coverage and inconsistent thickness.
- To optimize subsequent processes the Oxide layer must be smooth, flat, and maintain a specified thickness to a tight tolerance.
- The CMP process is used to remove excess Oxide material and to flatten the surface to improve performance of subsequent process steps

CMP was identified as an area with potential for process improvement







- The Engineer began by developing a process to measure the actual Deposition Thickness for each wafer.
- Subtracting the Final Oxide Target Thickness from the Actual Deposition Thickness determines the amount of material to be removed.
- Using a Design of Experiments (DOE) process the engineer determined the rate of material removal.

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Identify and Exploit Alternative Processes







Share • Learn • Grow

- Dividing the amount of material to be removed by the removal rate CMP run time can be calculated.
- The smooth flat wafer will continue onward to subsequent process.

Identify and Exploit Alternative Processes







- The new data shows the improvement in thickness control.
- The streamlined process also resulted in a time savings effectively increasing CMP Capacity



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Why are some Projects not completed?

- Root Causes for Project Completion Failure
 - Time
 - Clear Identification
 - Priorities
 - Funding
 - Got Stuck
 - Lost Interest
 - Accountability



There are many reason for not completing a project



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What can be done to help?

- Success Solutions
 - Target Project Selection on areas that address Real Program issues.
 - Limit Scope of Projects to Achievable Goals.
 - Focus Projects on present areas of Responsibility.
 - Implement an Effective Mentoring process.



Culture change comes from developing leaders not completing projects. But, by completing today's projects we often develop tomorrow's leaders.





Mentoring Process

- Group Mentoring
 - Bi-Weekly group meetings
 - Share Challenges and Success
 - Learn from each other
- One on One Mentoring
 - Weekly contact
 - Listening
 - Encouragement
 - Training







Initial Results

- Project Completion
 - 50 ATL students have completed Green Belt Training
 - 22 have completed projects
 - 5 are nearing completion
 - 15 are at earlier stages in the project process
- E2D Project Impact
 - Integrated Circuit Throughput rate Increased (4X)
 - Cycle Time Decreased (3/4X)
 - Yield Increased (3X)
 - Demonstrated ability to achieve increased production requirements.

Mentoring has improved Green Belt Project Completion rates and achieved Program Success





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Example Completed Projects

- Lap and Polish Process,
- Photo Lithography Process,
- Metallization Process,
- Transistor Package Assembly Process,
- Diffusion Tube Qualification Testing,
- Chemical Mechanical Planarization (CMP),
- Wafer Inspection Process,
- Assembly Wire Bonding,

50% increase in throughput 80% reduction in defects 50% increase in capacity 75% increase in capacity 26% reduction in cycle time 80% reduction in cycle time 10% reduction in cycle time 10% reduction in cycle time

Several small steps contribute to a large leap in performance





Lessons Learned

- Mentoring support can improve project completion rates and help to build future leaders.
- Project Value and Quality improved as we gained experience.
- Projects can make significant contributions to program and business issues.
- Some Green Belt candidates need more support than others.
- Not all Green Belt candidates will complete their projects.

We can always improve on the process







Lessons Learned

- Consider alternate Green Belt Training class formats
 - Offer more than 2 classes per year to accommodate more students
 - Offer Online or Self Paced Training
 - Offer expanded one day a month format
 - Include Project Completion in employee performance review

We can always improve on the process







Eugene Lang 60 Minutes Video

July 30, 2004 https://youtu.be/PSna9a16zxs







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