CHAPTER VI

CONCLUSION AND RECOMMENDATION

Ultra4 HGA cell capacity improvement started from planning for system design and implementation, following the plan from identifying the bottleneck of operation through the product standard UPH, data analysis of the existing operation capacity, designing the proposed methods, evaluating the proposed method including taking corrective actions, and implementation new methods. During this period, the case study gains many experience and knowledge of improve HGA assembly process as follows :

- How to apply method study on HGA manufacturing process.
- The major factors in manufacturing process affecting the implementation.
- How to use appropriate statistical tools to data analysis.
- Suitable conditions for implementation.

The objective of this chapter is to summarize and conclude these valuable experiences that will be references for case study for future actions and for other HGA Models.

The application of method engineering is mostly referring to a technique for increasing the production per unit of time and, consequently, reducing the unit cost. However, methods engineering is to entail analysis work at two different times during the history of a product. Initially, the purpose of methods engineering is to respond for designing and developing the various work centers where the product will be produced. Second, the method engineering is to continually restudy the work centers to find a better way to produce the product

and/or improve its quality. The more through the methods study made during the planning stages, the less the necessity for additional methods studies during the life of the product. Method engineering implies the utilization of technological capability. Primarily because of method engineering, improvements in productivity are a never-ending procedure. The productivity differential resulting from technological innovation can be of such magnitude that developed countries will always be able to maintain competitiveness with low-wage developing countries.

When method studies[1] are made to improve the existing method of operation, experience has shown that to achieve the maximum returns. Analysis advocates these steps to assure the most favorable results :

1. Make a preliminary survey.
2. Determine the extent of analysis justified. Develop process chart if necessary.
3. Investigate the approaches to operation analysis.
4. Make motion study when justified.
5. Compare the old and the new methods.
6. Present the new method.
7. Check the installation of the new method.
8. Correct time values.
9. Follow up the new method.

Method engineering can be defined as the systematic close scrutiny of all direct and indirect operations to find improvements making work easier to perform and allowing work to be done in less time with less investment per unit. Thus, the real objective of method engineering is profit improvement.

[1] Benjamin W. Neibel, Motion and Time Study

6.1 Results of Evaluation and Implementation

From surveying the existing operation with % Efficiency and capacity of each existing operation, there are totally six operations that have the highest percentage of efficiency. The reasons why those six operations were selected are their efficiencies are the similarly highest percentage.

1) ***Tack tail*** is the bottleneck of the Ultra4 HGA assembly line because this operation performs with 100% efficiency. Although tack tail operation is running with 91% utilization that is more than other operations running with 90% utilization but this operation can produce only 10,549 HGAs per day (three shifts). That is because its standard UPH is 276 but it contains 2 operators per cell per shift.
2) ***ET (Electrical Test)*** is the one operation that is in the top two % efficiency in six operations. Its efficiency is 99% that can test 10,594 HGAs per days with seven electrical testers. The electrical testers are set at the special lines containing electrical testers only and the stations can be added to support the unlimited capacity. This operation, therefore, is not the critical operation that needs improvement Therefore, this study will not cover the electrical test.
3) ***Surveillance1:*** This operation is to inspect the HGAs in term of mechanical defect. The operators at this operation will inspect as many parts as they can. With the standard UPH of 160, they can inspect 3,024 HGAs per day or 1,008 HGAs per shift. Because this operation performs with sampling plan it is not, therefore, concerned with the capacity improvement.
4) ***Surveillance2:*** This operation performs as Surveillance1. Therefore it is not concerned with the capacity improvement too.

5) ***Flex Bond*** contains 3 stations operated by 3 operators per cell per shift. The standard UPH of this operation is 193. In one day, this operation can assemble 10,943 HGAs. So that this operation is the top five of high %efficiency which was running with 96% efficiency.
6) ***Gimbal Bond*** also contains 3 stations operated by 3 operators per cell per shift as same as Flex bond operation performs. The standard UPH of this operation is 195. This operation can assemble 11,057 HGAs. So that this operation is the top six of high %efficiency which was running with 95% efficiency.

From reviewing six operations, there are finally only three operations that are the critical operations for capacity constraint**. Those three operations are Tack tail, Flex bond, and Gimbal bond.** Those operations are the value-added operations. That means that there may be the functional effect if there are some changes at those operations. Therefore, everything that will be changed or be developed must be evaluated the related functional effect.

Results from Gimbal bond improvement

Two proposed methods were evaluated on Gimbal bond operation;

1) New applying adhesive method by eliminating smearing adhesive on bond tab.
2) Eliminating turning Pie wedge over flexure.

- **Impact of new gimbal bond method**

1) Impact on preliminary evaluation

This evaluation was performed with new gimbal bond method on 40 HGAs in order to study the possibility of new method that will be performed at gimbal bond operation. The result shows **no defect found per Gimbal bond criteria.**

2) Impact on Functional factors

This evaluation was run with building 250 pairs of HGAs in order to study the effect of new gimbal bond method to functional factors as follows.

RSA

PSA

Fly performance

and Gimbal bond shear strength.

The result of each factor was run through Minitab Software with Homogeneity of Variance test and 2 Samples T-Test to see difference in each factor of both old method and new method. Homogeneity of variance test is performed with F-test in order to know whether there is a significant difference between two samples' variance. 2 Samples T-test is performed in order to know whether there is a significant difference between two samples' mean. Decision making was performed through P-Value of each test by considering them with 95% Confidential Interval. Both tests begin by specifying null hypothesis and alternative hypothesis for testing as the following;

Homogeneity of Variance

H_0 : New Gimbal bond method does not effect standard deviation of evaluation factor. ($6_{Old} = 6_{New}$)

Ha : New Gimbal bond method DOES effect standard deviation of evaluation factor. ($6_{Old} \neq 6_{New}$)

As same as the Hypothesis testing of standard deviation (Variance), In order to know whether there are any significant difference between both populations' means of evaluation factors. The test begins by specifying Null

Hypothesis and alternative hypothesis for testing mean of evaluation factors as followings;

Two Samples T-Test

H_0 : New Gimbal bond method does not effect mean of evaluation factor. (Mean Old = Mean New)

Ha : New Gimbal bond method DOES effect mean of evaluation factor. (Mean Old ≠ Mean New)

	Homogeity of Variance			Two Sample T-test		
Factors	**F-Test**	**P-Valu**	**Result**	**T-Test**	**P-Value**	**Result**
RSA_UP	1.160	0.241	Not Significan	0.370	0.710	Not Significant
RSA_DN	1.090	0.499	Not Significan	-0.780	0.440	Not Significant
PSA_UP	1.037	0.775	Not Significan	-1.300	0.200	Not Significant
PSA_DN	1.045	0.730	Not Significan	-0.970	0.330	Not Significant
FHID_UP	1.077	0.559	Not Significan	0.350	0.730	Not Significant
FHID_DN	1.078	0.554	Not Significan	0.360	0.720	Not Significant
FHOD_UP	1.008	0.949	Not Significan	0.070	0.940	Not Significant
FHOD_D	1.009	0.946	Not Significan	0.070	0.940	Not Significant
Shear Test	1.321	0.250	Not Significan	1.180	0.240	Not Significant

Table 6.1 Summarized results of each evaluation factors from Homogeneity of variance testing and two samples T-test

From considering hypothesis testing result of each factor using 5% significant level, P-value of all factors are above 0.05. **That means no significantly different between old method and new method as Table 6.1.**

3) Impact on Mechanical defect

This step of evaluation is performed by implementation new gimbal bond method on one assembly line for one week (six working days) to monitor mechanical effect in term of gimbal bond defect. The result from each day will be compared to data of that assemble line from three weeks before.

From monitoring gimbal bond defect every day, **% gimbal bond defect was running around 0.01% and mechanical yield was running around 99.34% that are comparable to data of old method between three weeks before.**

4) Impact on operation capacity

Capacity increase is the end result of this study that needs to be measured. Motion and time study is performed again by Industry Engineer to measure time that is used for each new element performed at gimbal bond operation. From this study, new method **can improve standard UPH from 195 to 251** and also increase **operation capacity from 11,063 units loading per cell per day to 14,254 units loading per cell per day**.

- **Impact of eliminating turning Pie wedge**

Eliminating turning Pie wedge at gimbal bond operation has side positive effect to flex bond operation. Because flex bond operators normally have to turn pie wedge out of flexure before they attach FOS to flexure. From this proposed method, it results in eliminating turning pie wedge out before attaching FOS at Flex bond operation. Due to this evaluation is in order to study the impact of eliminating to lifted flexure from JIT Tool but it has side positive impact to flex bond, therefore, lifted flexure is planned to monitor at flex bond operation.

Results from Flex bond improvement

➢ Impact of eliminating turning Pie wedge

1) Impact on Lifted flexure

Lifted flexure was monitored on one assembly line for one week (six working days) The result from each day show **no lifted flexure found at flex bond bond at all.** That means there is no effect from eliminating tuning pie wedge over flexure at gimbal bond operation and removing pie wedge at flex bond operation. However turning pie wedge over flex after FOS is already bonded to flexure is needed to maintain. Because it still need force to push FOS over flexure for complete attachment among FOS, flexure and slider.

2) Impact on operation capacity

Capacity increase is the end result of this study that needs to be measured. Motion and time study is performed again by Industry Engineer to measure time that is used for each new element performed at flex bond operation. From this study, new method **can improve standard UPH from 193 to 204** and also increase **operation capacity from 10,943 units loading per cell per day to 11,567 units loading per cell per day.**

Results from Tack tail improvement

In order to initiate new idea for operation improvement, a questioning attitude was adopted on how each of these operations influences the time (cost), quality, and output of the product under study. The most important question that should be asked when studying the events on the HGA process flow chart is "Why?" Typical questions that were asked for improving Tack tail operation are:

" Why is tack tail operation necessary?"

From analyzing the purpose of tack tail operation, this operation is order to attach the tail of the flex to the load arm capture using Hysol LD227. On the

other hand, One idea is proposed to eliminate tack tail operation with the reason that tail will be normally held in arm slot of E-Block at HSA level and the flying leads will be soldered to PCC. This should be enough strong to hold the tail properly.

Due to the change in this operation is the major change, the operation was proposed to be eliminated from the current HGA process flow. This change may affect all levels of disc drive assembly process since HGA level through disc drive level. The evaluation, therefore, need to be run through drive level to study effect to all levels.

1) Impact on HGA level

- **Impact on Gramload**

Data was collected from 250 pairs HGAs per group. Control group contains HGAs with tack tail and evaluation group contains HGAs without tack tail. Incoming gramload data from 250 pairs of incoming flexures were measured to study effect of operations to gramload (Gram_In).

Gramload data were analyzed through ANOVA in Minitab Software. This analysis is to study difference in mean and standard deviation among raw flexure, HGA with tack tail, and HGA without tack tail.

From ANOVA, the result shows that P-Value is below 0.05. That means standard deviations among three groups are not equal. There is at least one group that its standard deviation does not equal to others.

Considering individual 95% CIs for Mean, the results show that mean of control group (Tack tail) is significantly higher than other two groups. And its standard deviation is also significantly higher than other two groups. While Mean and standard deviation of Evaluation group shows no significantly different from raw flexure.

Gramload of Evaluation group was compared to gramload target that is set at 2.5 grams with T_test of the mean in Minitab Software.

In conclusion, HGAs without tack tail shows better gramlaod performance than HGAs with tack tail group.

- **Impact on FOS tail is out of suspension capture (Loose tail)**

Loosen tail was monitored by FOI operators before those parts were submitted to QC. QC will take 20 samples per lot (280 HGAs per lot) for inspection. The result was shown as below;

Operation	Inspect	Defect	%Defect
FOI	2,719	2	0.11%
QC	200	0	0.00%

FOI operators found 2 units from 2,719 units (0.11%) that their tails are out of formed tabs. This number is acceptable with the reason that this number is very small and they can be easily reworked by weave it under formed tab with tweezers again. However, causes of defect will be found out in parallel.

2) Impact on HSA level

- Concern: 2% of FOS out of capture and need to be re-adjusted
- Concern: FOS overhang over baseplate at various operations as data attached.

Before Reflow

Operation	IN	REJ.	% FOS Overhang
Swage	1167	24	2.05
Unload HSA	1167	1	0.08
FOS Preparation	1216	5	0.41

After Reflow

Operation	IN	REJ.	% FOS Overhang
HSA Clean	1230	2	0.16
S.E.T	1153	3	0.29
VMI	1195	5	0.41

The corrective actions were performed at two operations in HSAs level. The effect process was FOS preparation and Reflow soldering that will be control FOS sits in the slot. This is to optimize the FOS prepare position to properly sit the FOS in the E-block arm before reflow soldering and start train to operator. And the results after taking corrective actions are ;

Corrective Action Results

	Before Action	After Action
• FOS Over Arm slot 0-25%	20%	75%
• FOS Over Arm slot 25-50%	30%	25%
• FOS Over Arm slot > 50%	50%	0%
• Outgoing Data (FOS Overhang)	**270 PPM**	**0 PPM**

3) Impact on Drive level

	Eval Group 4025	Control Group 4064
• STW (Pretest)	96.8%	96.7%
• Cert Functional	89.5%	84.3%
• Final Test	99.19%	100.0%
• **Cumm**	**85.96%**	**81.48%**

Conclusion of eliminating tack tail Evaluation

Qualification performed on Ultra4.

- No statistical difference at HGA level between Control group and Evaluation group except mean of Gram_In is closer to target 2.5 grams that leads to decrease in gramload adjustment.
- FOS overhang issue was closed after taking corrective actions.
- No statistical difference at drive level between Control group and Evaluation group.
- In summary, Tack tail elimination at HGA level show no effect at all levels.

4) Impact on Operation Capacity

The capacity of Ultra4 HGA line is limited at 10,500 units loading per cell per day because of Tack tail operation. This operation is, therefore, proposed to eliminate from HGA assembly line because it is the bottleneck operation of HGA assembly process. After tack tail operation was eliminated from Ultra4 HGA process, cell capacity will not be limited with tack tail operation forever.

➢ Result from implementation

Improvement actions on Gimbal bond operation, Flex bond operation, and Tack tail operation were planned to implement across Ultra4 HGA manufacturing lines with new standard UPH as shown in Table 6.3. Standard loading of 11,500 units per day is also assigned to each assembly line. From this implementation leads to increase in cell capacity from 10,500 loaded units per day to 11,500 loaded units per day. And it results in increase in output from 62,800 HGAs per week to 68,600 HGAs per week as shown in Table6.2.

	Current Method			After Implementation	
	WW43	WW44	WW45	WW47	WW48
Loading	63,456	63,066	63,234	69,059	69,102
Mech Yield	99.35%	99.33%	99.36%	99.35%	99.36%
Output	**63,044**	**62,643**	**62,829**	**68,610**	**68,660**

Table6.2 The result in term of capacity, mechanical yield, and output increasing.

Standard UPH

Product: Ultra4 HGA

			Standard loading 11.5K				
Operation	**Samplin**	**UPH**	**H/C**	**%UTL**	**Capacit**	**%Eff**	**%Idle**
PRE-TRIM	100%	662	1	90%	12,512	84%	16%
LOAD HEAD	100%	340	2	90%	12,852	82%	18%
GIMBAL BOND	100%	251	3	90%	14,232	74%	26%
FLEX BOND	100%	204	3	90%	11,567	91%	9%
FLEX LEAD BOND	100%	236	3	90%	13,381	78%	22%
TACK TAIL (TACK FOS)	100%	0	0	90%	-	0%	0%
SURVEILLANCE 1	25%	160	1	90%	12,096	87%	13%
THERMAL OVEN CURE							
APPLY DAMPER	100%	248	3	90%	14,062	75%	25%
UNLOAD HGA FROM JIT TOOL	100%	382	2	90%	14,440	73%	27%
LOAD IAT TEST ARM	100%	372	2	90%	14,062	75%	25%
PUSH FLEX OVER PIN&CLEAN	100%	160	4	90%	12,096	87%	13%
SURVEILLANCE 2	25%	160	1	90%	12,096	87%	13%
HEAD SET	100%	730	1	90%	13,797	76%	24%
PRE LOAD	100%	178.5	4	90%	13,495	78%	22%
RSA/PSA	100%	175	4	90%	13,230	79%	21%
CUT FLEX	100%	870	1	90%	16,443	64%	36%
ET	100%	87	7	90%	11,510	91%	9%
SHUNT PAD	100%	524	1	90%	12,380	85%	15%
FLY TEST	1%	50	1	90%	135,000	8%	92%
UNLOAD IAT TEST ARM & FLAPPER	100%	331	2	90%	12,512	84%	16%
FOI	100%	170	4	90%	16,065	65%	35%
QC GATE (OBA)	20%	128	1	90%	15,120	69%	31%
PACK	100%	1500	1	90%	35,438	30%	70%
MRB SCREEN	8.10%	666	0	90%	-		
Total in line H/C			43				
			51				

Table 6.3 New standard UPH and operation capacity.

6.2 The suitable implementation conditions

6.2.1 Commitments

An important condition that is the first priority of key success of this implementation is commitment. The commitment for this implementation can be classified as the management commitment and the employee commitment.

The management commitment to this implementation is important because it is the most powerful supporting and driving force. From eliminating tack tail operation, there are some effects with HSAs level that need their cooperative actions from HSAs level. Without commitment, this implementation will lack good cooperation and required resources. This commitment should be achieved at the beginning of the project throughout the life of the project.

The employee commitment is the nest important condition. Even if the management has the authorization to force the employee, the work generated from commitment should have better results. Therefore, the implementation should have the employees' commitment by following the instructions provided to them.

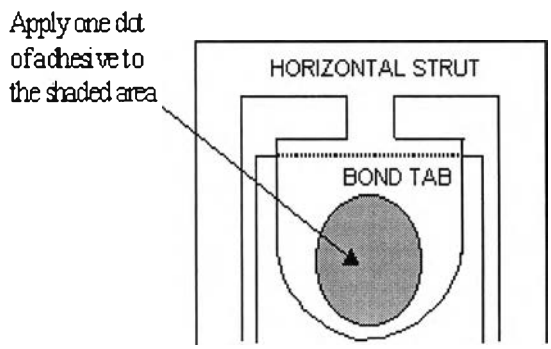
6.2.2 Training

Training is an important condition that impacts implementation. This is order to provide clearly process instructions of important operations at both HGA level and HSAs level to the operators and other concerned people.

- **New Gimbal bond method at HGA level**

In order to control the quality, process control plan is included in that PCA that is stated as following :

"Apply exactly one dot of adhesive to the center area of the bond tab, biased away from the horizontal strut. Do not spread or smear the adhesive dot."



- **Damper Application at HGA level**

Add element to insert the FOS tail into the capture of suspension with special tweezers for prevent sticky from damper which may be left on the tweezers to contact with FOS and then will be apply damper and self inspection for FOS tail out of capture during apply damper process.

- **FOS Trimming at HSAs Operation**

Operator will be aware when cutting down-tab HGAs, the direction of cutting will push FOS away from head and FOS tail may be out of capture.

- **FOS preparation, Reflow soldering at HSAs level**

The tails of the FOS are free to curl and move side to side once the HGA is installed in the E-block. This increased ability to move does seem to allow more 'tangling' of the FOS tails. The tails can be 'de-tangled' but it takes a little more operator awareness and care

Operator self inspection for "FOS tail out of capture" during prepare FOS and soldering process

The FOS prepare operator has to use two hands instead of one. One hand is at the FOS to weave the tail through the capture tabs (the tail comes out). The other hand is at the tail to perform the normal operation

6.3 Benefits

1) Increase cell capacity of Ultra4 HGA product.

From implement new gimbal bond method, the operation capacity of gimbal bond operation increases from 11,063 units loading per cell per day to 14,254 units loading per cell per day. From eliminating turning pie wedge out from JIT Tool at Flex bond operation, the capacity of Flex bond operation increase from 10,920 units loading per cell per day to 11,557 units loading per cell per day. And the last one is eliminating bottleneck operation, Tack tail operation, from Ultra4 HGA manufacturing process, the cell capacity will not be limited from this operation. From improvement at those three operations, that leads to increase in cell capacity from from 10,500 loaded units per day to 11,500 loaded units per day as shown in Table 6.1.

2) Autogram operation reduction.

Every single HGA will be first measured gramlaod (celled Gram_In) and compared to 2.5 $\pm$ 0.10 grams called target limits. Any HGA gramload is out target limits, that part will be adjusted by autogrammer. Any HGA grmload is between target limits, such HGA will be passed to next operation. The measurement and adjustment process may be repeated from 1 to 9 times (depended on gramload after adjustment). Final measurement at tenth will be last and compared to HGA gramload spec at 2.5 + 0.4 grams. From eliminating tack tail operation, gramload (Gram_In) of HGAs is closer to target 2. 5 grams and its standard deviation is smaller. This benefits to preload operation

(Autogrammer) in case of the number of times adjusted and the number of units adjusts. Because most of them are in target limits that means the number of units and times adjusted will reduce automatically. Finally there is an opportunity to reduce preload stations that there are currently four stations.

3) Cost saving

From this implementation on Ultra4 product, Seagate can save its costs in term of Operators, Fixtures, Epoxy (Adhesive) usage, and space that are shown in Table 6.4. Main cost saving of tack tail elimination are wage and epoxy usage. From this implementation, Seagate can save at least $63.14 per cell per day.

Tail tacking	100%	Eliminate	Save	Saving Cost
Operator	2	0	2 Optrs/shift/cell	$35.4/cell/day
Fixture	2	0	2 fixtures/cell	$114/cell
Epoxy Usage	12.24 Tubes/k	0	LD227 (12.24 tubes/k	$27.74/cell/day
Space	120	120	120 cm2/cell	

*** Tube/k = Number of epoxy in tube used for 1000 units.

Table 6.4 Cost saving from tack tail elimination.

6.4 Recommendations

Continuous Improvement is planned for Ultra4 HGA assembly lines to improve both capacity and productivity of the product as followings ;

1. Non-value added operations Elimination

From studying the purposes of each operation, surveillance1 and surveialnce2 are to take some samples for inspection and feed back to front line

assembly operations. The operators have to take more concentration on self-inspection. That means the operators must ensure the parts that are produced by them before they are sent to next operations. So that those two operations, Surveillance1 and Surveillance2, can be eliminated from process line.

2. Preload operation

After tack tail operation was eliminated from Ultra4 manufacturing line, IE (Industrial Engineer) should calculate the UPH and capacity of Preload operation again. From doing that, there is high opportunity to reduce prelaod stations.

3. Gimbal bond and Flex bond combination

From studying Gimbal bond operation and Flex bond operation, both of them are performed with similar elements and similar fixtures. Therefore there is opportunity to combine those two operations together. Because Flex bond operation is now the bottleneck of Ultra4 HGA assembly line. Cell capacity is limited at 11,500 units loading per cell per day after first improvement. This combination is to balance the capacity of those two operations. But its constraint is the method how to control types of adhesive. Due to Ablebond 8385 adhesive which is conductive adhesive is used for Gimbal bond while LD227 adhesive is used for Flex bond.

4. Increase stations of value added operation

From improvement activities above, there will be more free stations in Ultra4 HGA assembly line. Therefore, stations of some critical value added operations can be added to assembly line to increase capacity of such operations and cell capacity can be more increased that will be benefit to Seagate.