

ASAC 2009  
Niagara Falls, Ontario

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## FUNCTION BASED STANDARD ACTIVITY STRUCTURE (FBSAS) FOR COSTING IN MANUFACTURING

To estimate the cost of an activity, an analyst needs, first to define the functionality of an activity in terms of its structure and associated cost information as Input, to calculate the cost of performing the activity. In order to do so, a new module, termed as Function Based Standard Activity Structure (FBSAS) for Costing is developed and presented in this paper.

### **Introduction**

Activity Based Costing (ABC) is a popular costing tool used in many industries including manufacturing. ABC helps visualize a production process from top to bottom since the top part of the organizational process is more visible than the lower part. ABC is relatively more publicized and is also often used by managers working at higher levels of organizations. However, ABC has its limitations in terms of the involvement of subjectivity in costing process since it does not provide a systematic work and resource content in the form of a generic structure for costing. Therefore, different persons may end up arriving at different cost calculations for the same titled activity by using different work boundaries.

In order to reduce this subjectivity in costing Deo & Strong (2002) developed “Operation Based Costing (OBC), a bottom up approach that provides work and resource content structure to some level. They defined a set of eight cost elements (Material, operator, machine, space, fixture, contract, incentive and capital tied up in inventory) for an operation in manufacturing. These cost elements help provide a fairly objective picture of an operation cost.

However, on the other hand, OBC was proposed to fix the problem in the activity concept but the structure of the OBC does not specifically describe how an activity can be transformed to the operational structure described in OBC. In addition, both ABC and OBC do not specifically define ‘activity’ in terms of information and material flow within an activity. Both tools also do not provide a step by step approach to an analyst in terms of how to use them in practice.

In order to improve ABC and OBC, a new module, named as “Function Based Standard Activity Structure for costing (FBSAS)”, is developed in this paper. FBSAS integrates the concept of activity in ABC with the concept of operation in OBC through a “Standard Activity Structure (SAS)”, which is the middle piece that connects the concept of ‘activity’ to the concept of ‘operation’. The resultant hybrid structure (FBSAS) provides a systematic way to formally develop the structure of an ‘activity’ in the context of an ‘Operation’.

FBSAS makes the system of activities more visible to an analyst from both angles, top-down and/or bottom-up view of manufacturing or services related processes. More specifically, FBSAS first defines an activity in a generic way, which is SAS, by four activity elements, which are required for performing any type of activity. The corresponding cost information is attached to each of activity element in the form of 'Input' leading to a standard cost statement defined as the 'Output' of FBSAS. Another key point addressed in this paper is to separate the costing process from the activity analysis process in order to reduce the complexity and confusion. The way to do it is: 1) Build the concerned production flowchart, which is an activity analysis process; and then 2) Plug FBSAS module into each activity included in the production flowchart to obtain the cost statement in an objective manner.

## **Literature Review**

Two important issues are focused in the literature review, and these are the costing processes and the costing tools. Each one is discussed separately for the convenience of the reader.

### **Costing Processes**

ABC Forum (2008), described 4 steps for assigning production resources to end products in a costing process and these steps are: 1) Define activity groups that have a direct relation with end products; 2) Determine resource drivers that show the relation between production resources and activity groups and cost drivers that show the causal relation between an activity group and a type of end product; 3) Assign the costs and resources to activities based on the resource drivers; and 4) Assign the costs of activity groups to end products based on the cost. It is also observed that it is essential to make the decision about the level of detail that needs to be captured in costing process. At strategic level, about 100-150 activities are most commonly considered and at a operation level the number goes up to 500+ activities to improve the costing process (ABC Form, 2008).

Shehab E M et al. (2002) used an object-oriented and rule-based system to estimate the product cost at an early design stage and in the initial process planning including the selection of machining processes and job sequence. Jha N.K (1996) observed costing in manufacturing as a complicated process and he also mentioned some cost elements that make up the production cost. These cost elements includes the inventory cost, penalty for due date violation, and the machining cost. He also mentioned that the normal approach to costing is to estimate the cost based on time required for the production processes, the costs of materials, plus some profit margin on top of it which may be pre-determined by the managerial judgment and experience.

### **Costing Tools**

In a broad sense, the costing tools in manufacturing could be grouped into Conventional Costing (CC), and Activity Based Costing (ABC). "The Conventional Costing is the tool to capture and distribute resource costs in terms of direct and indirect costs based on the organizational element or budgetary account" (Department of Defense, USA, 1995). The Conventional Costing is originally used for reporting purposes, but these reports are of little help to reduce the costs and improve productivity since they do not properly allocate the cost to the product and thus significantly distort the price of the product (Tage Skjott-Larsen, et al. 2007)).

Activity Based Costing (ABC) is the tool used to quantitatively measure the cost and performance of activity, resource, and cost objects including overheads whenever appropriate. ABC estimates the cost of activities required to produce a product including the administrative activities.

ABC is a very helpful tool if an analyst has clarity about ABC, as well as the process of production under consideration. It is also observed that ABC is the best way to find out the profitable customer / product as compared to the conventional costing (ABC Form, 2008). However, Innes, J. et al. indicated that the definition of activities involve subjectivity in the grouping of expenses for calculating costs. One of the reasons was that the cost drivers at the activity level are not clearly defined in ABC and as a result of it different people may end up using different cost drivers to estimate the cost of same activity and may come up with different cost numbers (Innes, J. et al., 1989).

In order to reduce subjectivity in ABC, Deo and Strong (2002; 2003) developed and proposed an “Operation Based Costing (OBC)” approach. This approach looks at an operation at a workstation in generic terms. In this approach a maximum of eight cost elements are identified. The resources used in an operation can be fitted to these eight cost elements, which are: 1) Material, 2) Operator, 3) Machine, 4) Space, 5) Fixture, 6) Contract, 7) Incentive and 8) Money tied to inventory of raw materials, work-in-process, and finished products inside the operation space.

- 1) Material is the stuff that goes through the system and changes into product, which includes raw material, component, assembly, supply and scrap. Material could be half of the cost for most secondary manufacturing processes and up to 95% of the cost for factories that make medium to high volume, complex products and contract out parts and assemblies.
- 2) Operator is a person who does the job to change the material. Operator is fairly flexible, and is all prone to making mistakes, and requires a lot of support.
- 3) Machine is equipment used for changing the material into semi / final product. Machine is the less flexible, fast and reliable such as mill, drill and NC machine.
- 4) Fixture is a tool to assist the machine to do the job. It is inflexible, reliable and used for holding parts in place for operations such as machining or welding.
- 5) Space is the place for the operation such as workstation, buffer and storage. Space is usually not a major cost in manufacturing, though it may be for storage.
- 6) Contract is an outsource for production such as transporting material, parts and product from place to place.
- 7) Incentive is an agreed upon incentive to provide a quality product as and when required on “Just in Time” basis.
- 8) Money tied to product is the interest paid for keeping and storing the materials in and around an operation.

### **Function Based Standard Activity Structure (FBSAS) for Costing**

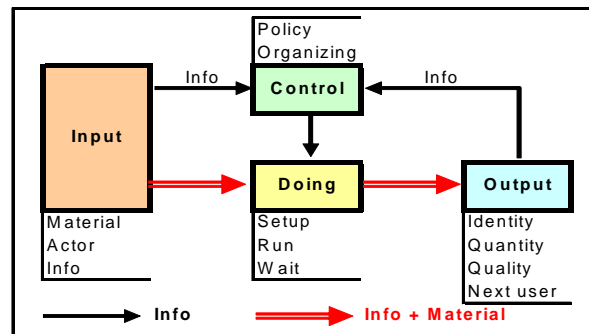
ABC and OBC do not provide a generic structure to describe how an activity is to be transformed or fitted to the concept of an operation in terms of information and material flow.

Both tools are also silent about the step by step approach of using them. In order to overcome these limitations a module termed as “Function Based Standard Activity Structure” (FBSAS) for costing is proposed in this section. The major contribution by FBSAS for costing process is the “Standardization” in three aspects: 1) Standard activity structure (SAS); 2) Standard cost information; and 3) Standard costing flow.

### Standard Activity Structure (SAS)

Standard Activity Structure (SAS) is a generic module that has a standard topology to describe how an activity is performed by showing material and information flow, which basically answers the question “What are the basic requirements to perform an activity?” By borrowing the concept of “Closed loop control” from automatic control theory (Benjamin C. et al. 2002), four elements are defined as the activity elements in SAS, which are “Input, Control, Doing, and Output” as shown in Figure 1.

**Figure 1**  
**Standard Activity Structure (SAS)**



**Activity Element “Input”:** “Input” is any resource required to perform an activity. It could be physical resource and or information. Physical resource is further separated into material and actor.

- Material is the consumable resource that is transformed to the output, which includes the raw material, new purchased parts, sub-assemblies and other inputs such as energy (e.g. water, electricity, gas and compress air etc.).
- Actor is the non-consumable resource that contributes the effort to transform the material, which includes the labor, machine, fixture, space and contract.

Information is the information for performing the activity includes Specifications, BOM (Bill of material), Shop order and Operation sheet.

- Specifications are the details of the quantity or quality of the component or assembly to be built.
- BOM is the sheet that gives the complete product description, and includes quantity of materials, parts, components required to make a unit of output.

- Shop order is a form that provides an authorization to proceed with production in terms of quantity, quality and time.
- Operation sheet is a detailed instruction statement for performing the job in terms of part routing and job sequence.

**Activity Element “Control”** : “Control” is the effort to manage, guide or regulate the “Doing” activity element, for example, an administration effort such as meeting. Control needs information from both Input side and Output side. If a difference occurs between two sides, an appropriate control action will be launched to reduce the difference until the expected output is reached.

- Information from Input includes planned information such as plan and policy. Plan is a predefined course to show what, when, where, how and who performs the job, and it may include BOM, shop order and operation sheet etc. Policy is a management rule applied in production such as penalty to pay for the late delivery or poor quality product from Input or Output.
- Information from Output includes actual information such as quantity, quality and time information.

**Activity Element “Doing”**: “Doing” is the effort to actually transform the material to output by actor under the instruction from Control activity element. The “Doing” includes Setup, Run and Wait.

- Setup is the effort to make a machine, and sometimes operator, ready to do the job, which includes collecting the tool and material, removing the last fixture used, installing the next fixture, and changing tools.
- Run is the effort to transform the material from one stage to another, for example, drilling, cutting and welding.
- Wait is doing nothing while consuming the resources. For example, operator waits for a part coming.

**Activity Element “Output”** : “Output” is the outcome after performing the activity, which includes the physical item (e.g. part) and related information such as the quantity and quality of the product, and time spent.

- Quantity provides the throughput like “1000 parts/day”.
- Quality provides the quality information like “damaged”.
- Time provides the time information like time for busy or idle.

Work Flow inside SAS: In Figure 1, everything that enters an activity, including material, operator, machine and space goes into “Input”. “Doing” includes setup, run, and wait. The other effort, such as organizing, is in “Control”. Everything that comes out as a result of performing activity is in “Output”, which includes part, scrap and related information. Generally speaking, SAS is a generic structure to describe any activity in a consistent way and reduce the variations in recognizing the activity.

### **Standard Cost Information**

The standard cost information means the factors to measure are standardized. In order to standardize the information, two key concepts are discussed here, which are “Cost driver and Waste”.

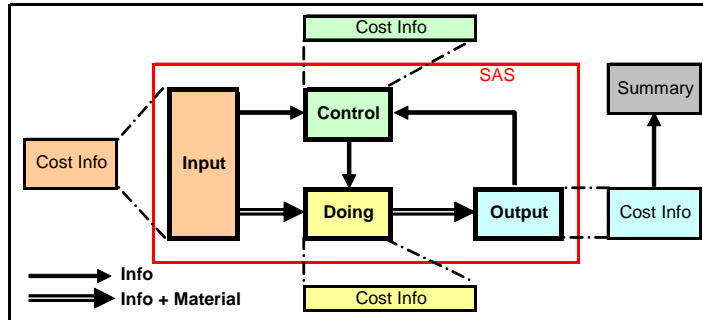
Cost driver is the main factor that contributes to the cost. In manufacturing, the objective is “To produce required amount of defect-free product within required customer lead-time and at the right cost”. Four main aspects are covered in this objective, which are “Quantity, Quality, Time and Cost”. Among them the aspects of Quantity, Quality and Time are relatively independent from each other, but tightly correlated with Cost. Further more, the extra cost in Input will contribute to increase in the cost of Output, no matter how much you reduce the cost in the production, such as a high fuel cost. Therefore “Extra Input Cost, Quantity, Quality and Time” (EQQT) are defined the cost drivers in this paper.

- Extra input cost presents how much extra money is paid for Input required to perform the job.
- Quantity presents how many resources and how much of each resource including the amount of effort used to perform the activity.
- Quality presents how good the resources in terms of consistency and how well the efforts are performed in terms of consistency.
- Time presents how long the time is spent to perform the job.

Waste is defined as “Any unplanned loss” in this paper. It is a relative definition since the baseline “Planned” can be defined in any way. While defining “Unplanned loss”, some unavoidable losses have to be defined as “Planned loss” such as the part arriving late or inevitable rework because mistakes are made in upstream activities. When measuring the cost of an activity, the first question is “What should be measured”? Usually, different people measure the different aspects for the same item / issue and come up with the different results. In order to reduce this type of subjectivity involved in costing process, a set of standard cost information is developed and attached to each activity element in SAS, which leads to a new module named as “Function Based Standard Activity Structure (FBSAS) for Costing as shown in Figure 2.

Figure 2

Function Based Structure (FBSAS) for Costing



**Standard Cost Information Attached to “Input”:** Cost information attached to Input includes headings such as: Input items, Cost per item, Unit cost, Quantity, Planned, Waste and % Waste, as shown in Figure 3.

Figure 3

Standard Cost Information Attached to “Input”

Cost of Input						
Input Items	Cost / Item	Unit Cost	Quantity	Planned	Waste	% Waste
<b>Material (\$/piece)</b>						
Material						
<b>Total (Material)</b>						
<b>Actor (\$/piece or hour)</b>						
Contract						
Tied Cost						
Labor						
Machine						
Fixture						
Space						
<b>Energy</b>						
Water						
Electricity						
High Pressure Air						
<b>Total (Actor)</b>						

Input items have two groups “Material” and “Actor”, which are shown by “Material (\$/piece)” and “Actor (\$/piece or hour)” respectively. They are basically adopted from OBC (Deo & Strong 2002; 2003).

- Material (\$/piece) includes the raw material, semi-finished part and finished part, etc. For the purpose of costing, the material cost is usually added to the top of “Cost of Doing”.
- Actor (\$/piece or hour) includes contract, tied cost, labor, machine, fixture, space and energy.

The above Input items are measured by Cost/Item, Unit cost, Quantity, Planned, Waste and % Waste. Planned is the cost as planned. Waste is the unplanned cost such as the unexpected damaged parts received from upstream. Percentage waste is the percentage of waste in total value, which is obtained either through analysis or from management decision. The Waste column in this table provides a user a place to consider waste from Up-stream activity, which is not mentioned in OBC.

**Standard Cost Information Attached to “Control”:** Cost information attached to Control includes headings such as: Control item, Cost per item, Unit cost, Quantity, Planned, Waste and % Waste, as shown in Figure 4.

**Figure 4**  
**Standard Cost Information Attached to “Control”**

Cost of Control						
Control Items	Cost / Item	Unit Cost	Quantity	Planned	Waste	%Waste
<b>Control (\$/piece or hour)</b>						
Penalty						
Organizing Cost						
<b>Total (Control)</b>						

Control items contain Management related issues such as “Penalty” and “Organizing” which are shown by “Control (\$/piece or hour)”. Penalty is also adopted from OBC.

- Penalty is the payment for customer’s dissatisfaction related to timing, quality and quantity.
- Organizing is the effort to manage, guide or regulate “Doing”, such as meeting, planning and supervising.

The above Control items are measured by the same way as in Input. It also provides a user a place to consider waste created by Control effort, which is not mentioned in OBC.

**Standard Cost Information Attached to “Doing”:** Cost information attached to Doing includes headings such as: Settings, Doing item, Cost per item, Unit cost, Time, Planned and Waste, as shown in Figure 5.

**Figure 5**  
**Standard Cost Information Attached to “Doing”**

Number of Setups					
Batch Size					
Same Labor for Run and Setup?					
Cost of Doing					
Doing Item	Cost / Item	Unit Cost	Time (h)	Planned	Waste
Setup					
Busy					
Idle					
Run					
Busy					
Idle					
Waste from Actor/Control					
Setup (Busy)					
Run (Busy)					
<b>Cost of Doing</b>					

Settings set “Number of setups”, “Batch size” and “Whether using “Same labor for run and setup”. Doing item has three groups “Setup”, “Run” and “Waste from actor/control”.

- Setup is the effort to make the machine, sometimes operator, ready to do the job, which includes collecting, removing the last fixture used, installing next fixture and changing tools.
- Run is the effort to transform the material from one stage to another, such as drilling, cutting and welding.
- Waste from actor/control is the waste created by Actor and Control such as the extra wage paid for drilling work.

The above Doing item is measured by Cost/Item, Unit cost, Time, Planned and Waste. Time is the time spent for “Doing”, which is further separated into “Busy and Idle”. Planned represents the Value added through Doing. Waste represents the Waste from Actor (Input), Control and Doing.

**Standard Cost Information Attached to “Output”**: Cost information attached to Output includes headings such as: Output item, Cost (Planned and Waste) as shown in

Figure 6.

**Figure 6**  
**Standard Cost Information Attached to “Output”**

Cost of Output per Part			
Output Item	Cost	Planned	Waste
<b>Total Cost</b>			
Material (\$/piece)			
Actor (\$/piece)			
Control (\$/piece)			
<b>Cost of Doing</b>			

Output item is basically cost information that is “Total cost”, which is contributed by Material (\$/piece), Actor (\$/piece), Control (\$/piece) and Cost of Doing. They are also shown in Planned and Waste cost.

**“Summary” of Cost Information:** As a summary, many views can be created to correspond with different cost concerns. The summary created in this paper is focusing on waste since it is the main concern in the paper, as shown in

Figure 7. The table shows “Total cost” that is contributed by “Value added” and “Value loss”.

- Value added is the planned costs to perform the activity.
- Value loss is the waste from Material, Actor, Control, Doing and Output. The waste from Output is further narrowed down to Over throughput, Damaged (Repairable), Damaged (Non-repairable) and Obsolete. Over throughput is the Output more than planned; Damaged (Repairable) is the damaged Output but repairable; Damaged (Non-repairable) is the damaged output without repairable; Obsolete is the Out of date” style or degraded specs. This loss provides a direction where improvement should be started.

**Figure 7**

**“Summary” of Cost Information**

Summary (per Part )			
Output Item	Cost	Planned	Waste
<b>Total Cost</b>			
<b>Value Added</b>			
<b>Value Loss</b>			
Material (Waste, \$/piece)			
Actor (Waste, \$/piece)			
Control (Waste, \$/piece)			
Waste in Cost of Doing			
Waste in Output			
Over throughput			
Damaged (Repairable)			
Damaged (Non-repairable)			
Obsolete			

The above standard cost information can be refined to fit any specific industry to emphasize its specific concern.

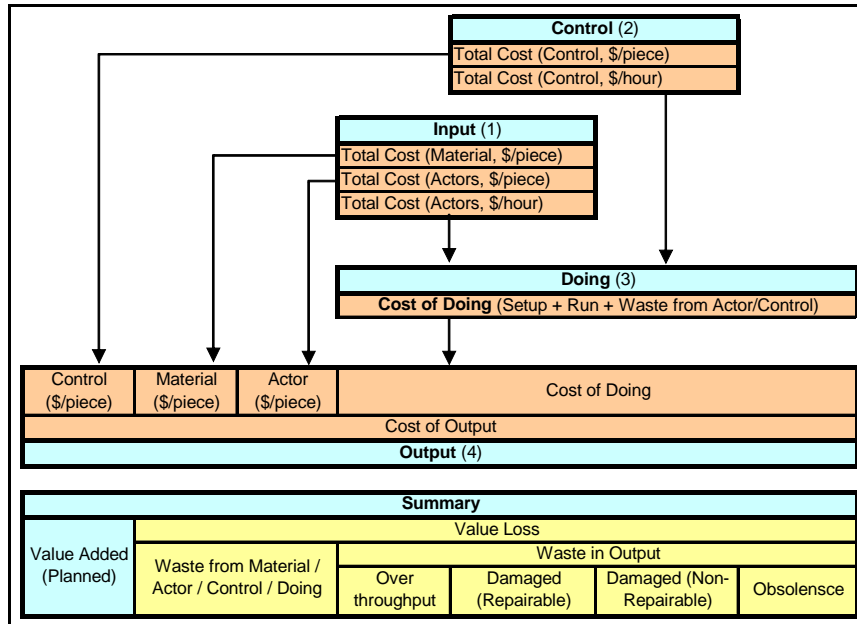
**Standard Costing Flow**

The standard costing flow shows how the cost of individual activity element interact each other, which is shown in Figure 8

Figure 8. From the

Figure 8, the “**Cost of Output**” is basically contributed by Piece work based cost (from Input and Control) and Time based cost (from Doing). This “Cost of Output” is also presented by another view (Summary), which shows “Value added” and “Value loss” since the loss is a main concern in this paper.

**Figure 8**  
**Standard Costing Flow**



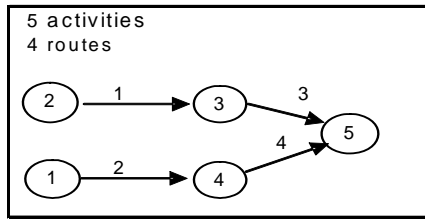
### Application of FBSAS for Costing

A contribution to the costing from this paper is to separate the costing process from the activity analysis process to reduce the complexity and confusions when mixing those two processes together. The correct way to use FBSAS for Costing is 1) Build the concerned production flowchart, which is an activity analysis process; and 2) Plug FBSAS module into each activity included in the production flowchart to obtain the cost statement.

#### Build the concerned production flow chart

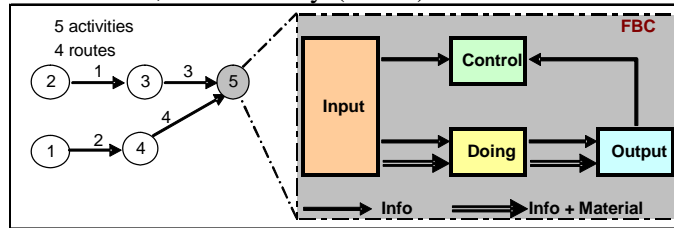
It is a production process analysis for understanding the production. Let us assume a process has 5 activities, as shown in Figure 9. Each activity is presented by a numbered circle. The travel between activities is presented by the numbered arrows. Activity 5 is the final assembly activity that joins the activities 3 and 4.

**Figure 9**  
**A Process with 5 Activities**



**Plug FBSAS module into each activity included in the production flowchart**

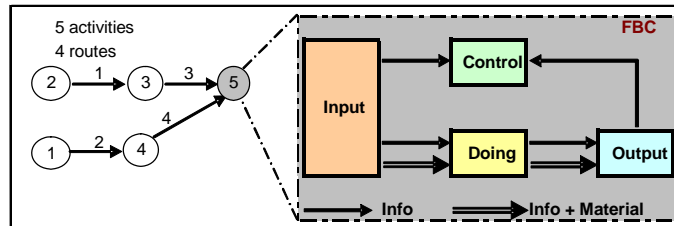
Once the production flow is clear, each activity (1 to 5) in the flow is substituted by the FBSC



module, for example,

Figure 10 shows that activity 5 is replaced by the FBSAS module. The cost information of the Output in the preceding operation is the cost information of Input in the next operation. In this way, it can clearly show each intermediate cost and final cost.

**Figure 10**  
**Activity 5 Replaced by FBSAS for Costing**



**Example of Using FBSAS for Costing**

A process with two activities: “Press a part” and “Store and deliver the part to the customer”, as shown in 11, is used to illustrate how FBSAS for costing can be used.



Cost Information in “Control” is shown in table 2.

**Table 2**  
**Cost Information Plugged into “Control” Table**

Cost of Control						
Control Items	Cost / Item	Unit Cost	Quantity	Planned	Waste	% Waste
<b>Control-1 (\$/piece)</b>				Cost per Piece		
Penalty	\$0.50	\$0.5	1.0	\$0.50		
Orgnizing Cost						
<b>Total (Control-1)</b>	<b>\$0.50</b>			<b>\$0.50</b>	<b>\$0.00</b>	

Cost Information in “Doing” is shown in table 3.

**Table 3**  
**Cost Information in “Doing” Table**

Number of Setup	1
Batch Size	5
Same Labor for Setup?	y

Time of Doing					
Doing Items	Hour / Item			Planned	Waste
Setup	0.05			0.05	0.00
Busy	0.05			0.05	
Idle	0.00				
Run	0.15			0.14	0.01
Busy	0.14			0.14	
Idle	0.01				0.01
<b>Time of Doing</b>	<b>0.20</b>			<b>0.19</b>	<b>0.01</b>

Cost of Doing					
Doing Items	Cost / Item	Unit Cost	Time (h)	Planned	Waste
Setup	\$1.52	\$30.42	0.05	\$1.52	\$0.00
Busy	\$1.52	\$30.42	0.05	\$1.52	
Idle	\$0.00	\$30.42	0.00		\$0.00
Run	\$4.56	\$30.42	0.15	\$4.26	\$0.30
Busy	\$4.26	\$30.42	0.14	\$4.26	
Idle	\$0.30	\$30.42	0.01		\$0.30
<b>Waste from A-2 / A-3 / C</b>	<b>\$0.46</b>		<b>0.19</b>		<b>\$0.46</b>
Setup (Busy)	\$0.12	\$2.40	0.05		\$0.12
Run (Busy)	\$0.34	\$2.40	0.14		\$0.34
<b>Cost of Doing</b>	<b>\$6.08</b>		<b>0.20</b>	<b>\$5.32</b>	<b>\$0.76</b>

Cost Information in “Output” is shown in table 4.

**Table 4.**

**Cost Information in “Output” Table**

Cost of Output per Part			
Output Items	Cost	Planned	Waste
<b>Total Cost</b>	<b>\$18.88</b>	<b>\$18.12</b>	<b>\$0.76</b>
<b>Material</b>	\$10.00	\$10.00	\$0.00
<b>Actor-1</b>	\$2.30	\$2.30	\$0.00
<b>Control-1</b>	\$0.50	\$0.50	\$0.00
<b>Cost of Doing</b>	\$6.08	\$5.32	\$0.76

Cost view by focusing on waste is shown in table 5, which focuses on: Value added and Waste.

**Table 5**

**Cost View by Focusing on Waste**

Allocation of Total Cost (per Part)				
Output Items	Cost	Planned	Waste	% Waste
<b>Total Cost</b>	<b>\$18.88</b>	<b>\$18.12</b>	<b>\$0.76</b>	
<b>Value Added</b>	<b>\$18.12</b>	<b>\$18.12</b>		
<b>Value Loss</b>	<b>\$0.76</b>		<b>\$0.76</b>	
Material (Waste)	\$0.00		\$0.00	
Actor-1 (Waste)	\$0.00		\$0.00	
Control-1 (Waste)	\$0.00		\$0.00	
Waste from A / C / D	\$0.76		\$0.76	
Waste in Output	\$0.00		\$0.00	
Over throughput				
Scrapped				
Damaged				
Obsolete				

**Conclusions**

FBSAS for Costing improves ABC and OBC by adding a standard activity structure, standard cost information and standard costing flow, and reduces the subjectivity involved in the costing procedure.

The information is described separately for each activity element. For example, the material and actor used are described in “Input”; the time and number of uses of actors are described in “Doing”; the efforts related to controlling and customer satisfaction are described in “Control”; and the creations after performing the activity, such as desired output, planned scrap and unplanned scrap, are described in “Output”. Waste is immediately shown by separating it from the legitimate costs in each activity element. The types of waste can easily be compared to help direct the short-term effort and determine where improvement could do the most good.

FBSAS for Costing could be assembled to simulate any manufacturing activity (e.g. step, operation and process). The tables and calculation structures can be adjusted to emphasize any concern without hurting the overall structure of FBSAS. The use of FBSAS is not limited to

manufacturing and it can be used in services such as banking, health care or government services. The separation of the costing process from the activity analysis process makes the costing clearer and simpler.

### **Acknowledgement**

The researches for this paper was partly funded by NRC (National Research Council), Aero-Recip (Canada) Ltd and Bristol Aerospace Limited.

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