

Product Design & Development

Project II: Design and Develop a Coin Sorter

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Design and Develop a Coin Sorter

PROGRESS DESCRIPTION

- Define the customer needs
- Specify technical specifications
- Configure Product Concept

Design and Develop a Coin Sorter

- Define the customer needs
 - Scope of the effort
 - Gather raw data from customers
 - Interpret raw data in term of customer needs
 - Organize the needs into a hierarchy
 - Establish the relative importance of the needs
 - Reflect on the Results and the Process

Design and Develop a Coin Sorter

- **Scope of the effort**

- Description of the product

- A coin sorter

- Key business goal

- Product introduced in 3 months

- 40 % gross margin

- 35% market share

- Target market

- Shop owner

Design and Develop a Coin Sorter

- **Scope of the effort (cont.)**

Assumption: House holders, Shopkeppers..

Stakeholders

User

Sales force

Service center

Legal department

- Production

Police

Design and Develop a Coin Sorter

- **Gather raw data from customers**
 - Choosing customer
 - Questionnaire for customer needs
 - Customer interviewing and surveying
 - Collect the customer answers

Table 1 – Group of customers

	Lead users	Users
Accountant	2	4
Shop owner	2	6
Bank officer	3	3

Table 2- Form of Questionnaire

N ^o	Topic	1	2	3	4	5
1	Every people can learn to use coin sorter in one two minutes	1	2	3	4	5
2	I can accept coin mixing after sorting	1	2	3	4	5
3	Price of coin sorter is important	1	2	3	4	5
4	I don't like too noisy while sorting coin	1	2	3	4	5
5	Coin sorter should use less energy	1	2	3	4	5
6	Money should not over flow out of machine	1	2	3	4	5
7	I want coin sorter to be easily open	1	2	3	4	5
8	Coin sorter can break down regularly	1	2	3	4	5
9	I like a nice coin sorter	1	2	3	4	5
10	I prefer a compact coin sorter	1	2	3	4	5
11	I want a coin sorter safety in use	1	2	3	4	5
12	I want to see coins inside the machine	1	2	3	4	5
13	Time to sort is small	1	2	3	4	5
14	After sorting I want to know how much money is	1	2	3	4	5
15	I like big amount of money to be sorted each time	1	2	3	4	5
16	Coin sorter can distinguish between fake and real money	1	2	3	4	5
17	I want a coin sorter last long	1	2	3	4	5
18	I want to sort many kind of money	1	2	3	4	5
19	Coin sorter need to be brought everywhere	1	2	3	4	5

Table 3- Results of raw customer needs data

N ^o	Topic	Score
1	Every people can learn to use coin sorter in one two minutes	82
2	I can accept coin mixing after sorting	65
3	Price of coin sorter is important	67
4	I don't like too noisy while sorting coin	45
5	Coin sorter should use less energy	76
6	Money should not over flow out of machine	56
7	I want coin sorter to be easily open	67
8	Coin sorter can break down regularly	60
9	I like a nice coin sorter	57
10	I prefer a compact coin sorter	52
11	I want a coin sorter safety in use	76
12	I want to see coins inside the machine	56
13	Time to sort is small	79
14	After sorting I want to know how much money is	68
15	I like big amount of money to be sorted each time	67
16	Coin sorter can distinguish between fake and real money	78
17	I want a coin sorter last long	63
18	I want to sort many kinds of money	70
19	Coin sorter need to be brought everywhere	49

- **Interpret raw data in term of customer needs**

Easy to use

Accurate

Cheap

Low noise

Low energy

consumption

Coin over flow

resistance

Easy to maintain

Reliable

Aesthetic

Compact

Compact

Safe

Coin seeing ability

High productivity

Money display

High capacity

Fake coin

distinguishable

Durable

Large range of coin

Light

Organize the needs into a hierarchy:

I. Appearance

- **Aesthetic**
- **Compact**

II. Ergonomic

- **High productivity**
- **High capacity**
- **Large range of coin**
- **Coin seeing ability**
- **Coin over flow resistance**
- **Money display**
- **Fake coin distinguishable**

Organize the needs into a hierarchy (Cont.)

III. Economic

- Low price
- Low energy consumption

IV. Quality

- Easy to use
- Accurate
- Low noise
- Durable
- Easy to maintain
- Reliable
- Safe
- Light

Establish the relative importance of the needs

	Needs	Important of needs
Appearance	Aesthetic	3
	Compact	2
Ergonomic	High productivity	5
	High capacity	4
	Large range of coin	4
	Coin seeing ability	3
	Coin over flow resistance	3
	Money display	4
	Fake coin distinguishable	5
Economic	Low price	4
	Low energy consumption	5
Quality	Easy to use	5
	Accurate	4
	Low noise	5
	Easy to maintain	4
	Reliable	5
	Safe	5
	Durable	3
	Light	2

ESTABLISHING TARGET SPECIFICATIONS

- Relationship between customer needs and Product Specification
- Competitive Benchmarking Information
- Set the Marginal and Acceptable Target Values for Metrics

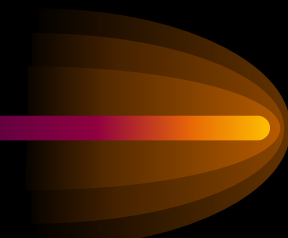
List of Customer Needs - Metrics

		Metric	Motor Power	Dimension(L*W*H)	Weight	Overflow tray	Life time	Power consumption	Speed sorting	No. of slotting in sorting kit	No. of coinable kits	Present of LEDfor displaying	Noise lever	Price	Tolerance	Volume of primary tray	The coin-out tray cover is transparent	Well- design	Time disassemble and assemble	Maintain cycle time	Maximum diameter of sorter coin	Minimum diameter of sorter coin	Ability adjusting vibration frequency
Customer Needs																							
Appearance	Aesthetic																						
	Compact																						
Eegonomic	High productivity																						
	High capacity																						
	Range of coin																						
	Coin seeing ability																						
	Coin over flow resistance																						
	Amount of Money display																						
Economic	Fake coin distinguishability																						
	Low price																						
Quality	Low energy consuntion																						
	Easy to use																						
	High Accuracy																						
	Low noise																						
	Reliable																						
	Safe																						
	Durable																						
	Light																						
Easy to maintance																							

Needs Benchmarking

Customer Needs		MoneySafeKit Co.	VietHome Co.	Importance
Appearance	Aesthetic	*****	*****	3
	Compact	***	**	2
Ergonomic	High productivity	***	***	5
	High capacity	*****	***	4
	Range of coin	***	***	4
	Coin seeing ability	*****	***	3
	Coin over flow resistance	***	***	3
	Amount of Money display	***	*****	4
	Fake coin distinguishable	**	***	5
Economic	Low price	**	***	5
	Low energy consumption	***	**	4
Quality	Easy to use	***	**	5
	High Accuracy	*****	***	5
	Low noise	***	**	4
	Reliable	***	***	5
	Safe	***	***	4
	Durable	**	**	5
	Light	***	**	3
	Easy to maintenance	***	**	2

Metric Benchmarking



Metric	Motor Power	Dimension(L*W*H)	Weight	Overflow tray	Life time	Power consumption	Speed sorting	No. of slotting tray in sorting kit	No. of coin holder kits	Presence of LED for displaying	Noise level	Price	Tolerance	Volume of primary tray	The coin-out tray cover is transparent	Well- design	Time disassemble and assemble	Maintain cycle time	Maximum diameter of sorter coin	Minimum diameter of sorter coin	Ability adjusting vibration frequency
Competitors																					
MoneySafeKit Co.	25	200x140x195	2	1	20	20	45	8	≥5	0	65	40	6H0	650	1	7H0	42	8	28	14	0
Family bank. Co	25	205x135x200	2,2	0	22	22	40	10	≥5	1	68	35	5H0	680	1	7H0	44	7	28	15	0
Measure	W	mm	Kg	binary	s	w	coin/s	q.ty	q.ty	binary	dB	\$US	score	cm3	binary	0-10/ score	s	month	mm	mm	binary

The Ideal and Marginal Values of the Metrics

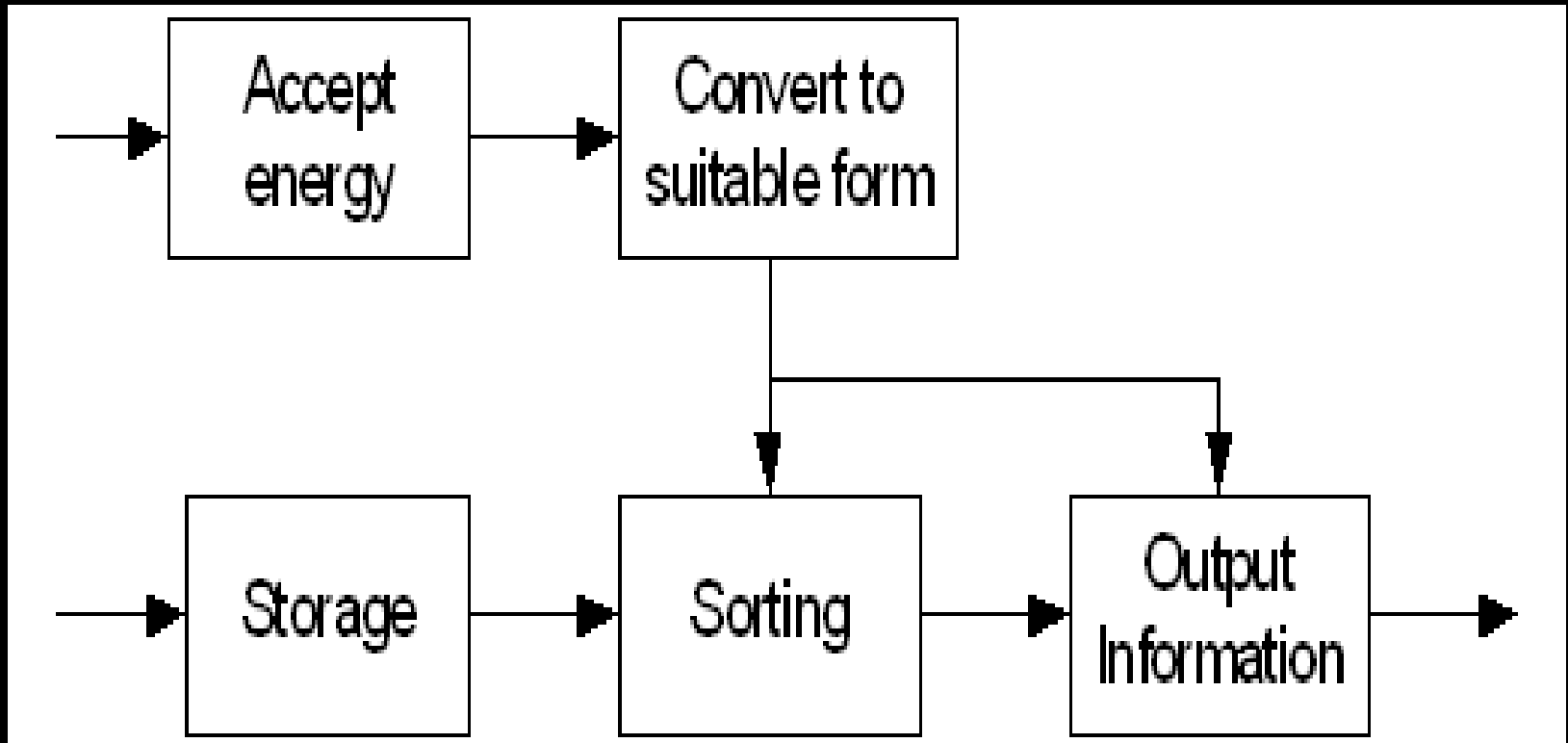
Metric	Motor Power	Dimension(L*W*H)	Weight	Overflowtray	Life time	Power consumption	Speed sorting	No. of slotting tray in sorting kit	No. of coin holder kits	Presence of LED for displaying	Noise level	Price	Tolerance	Volume of primary tray	The coin-out tray cover is transparent	Well- design	Time disassemble and assemble	Maintain cycle time	Maximum diameter of sorter coin	Minimum diameter of sorter coin	Ability adjusting vibration frequency
Marginal Value	28	180x160x200	1,8	1	20	20	45	10	25	0	50	28	7/10	650	1	7/10	25	9	28	12	0
Ideal Value	22	180x125x175	1,2	1	22	15	70	15	7	1	45	20	10/10	900	1	10/10	10	24	30	10	1
Measure	W	mm	Kg	binary	year	w/batch	coin/s	q.ty	q.ty	binary	dB	\$US	score	cm3	binary	0-10/score	s	month	mm	mm	binary
Importance of Metric	3	4	5	4	5	3	4	4	3	4	3	5	4	3	3	5	3	4	2	2	3

Generate Concept



- Clarify the problem.
- Search externally
- Search internally
- Explore systematically

Clarify the problem



Search Externally



- The motor for sorting should be not high capacity for compact and less power consumption.
- The sieve can be made from mica for accurate in classifying and lighting.
- The motor is DC motor for easy adjusting the sorting speed. The containing tube is made from paper for cheap and easy use.
- It is better to have a LED for the total counting value.
- The cover is made from phenomenal material for aesthetic and visual aid.

Search internally



Storing and accepting energy

- Home electrical supplier Network
- Battery.
- Electrical generator machine

Sorting

- Sliding surface base on weight
- Sort out base on size
- Slotting Sort base on weight and size.(using motor for shaping)
- Pattern recognize base on texture, color (using sensor, camera)

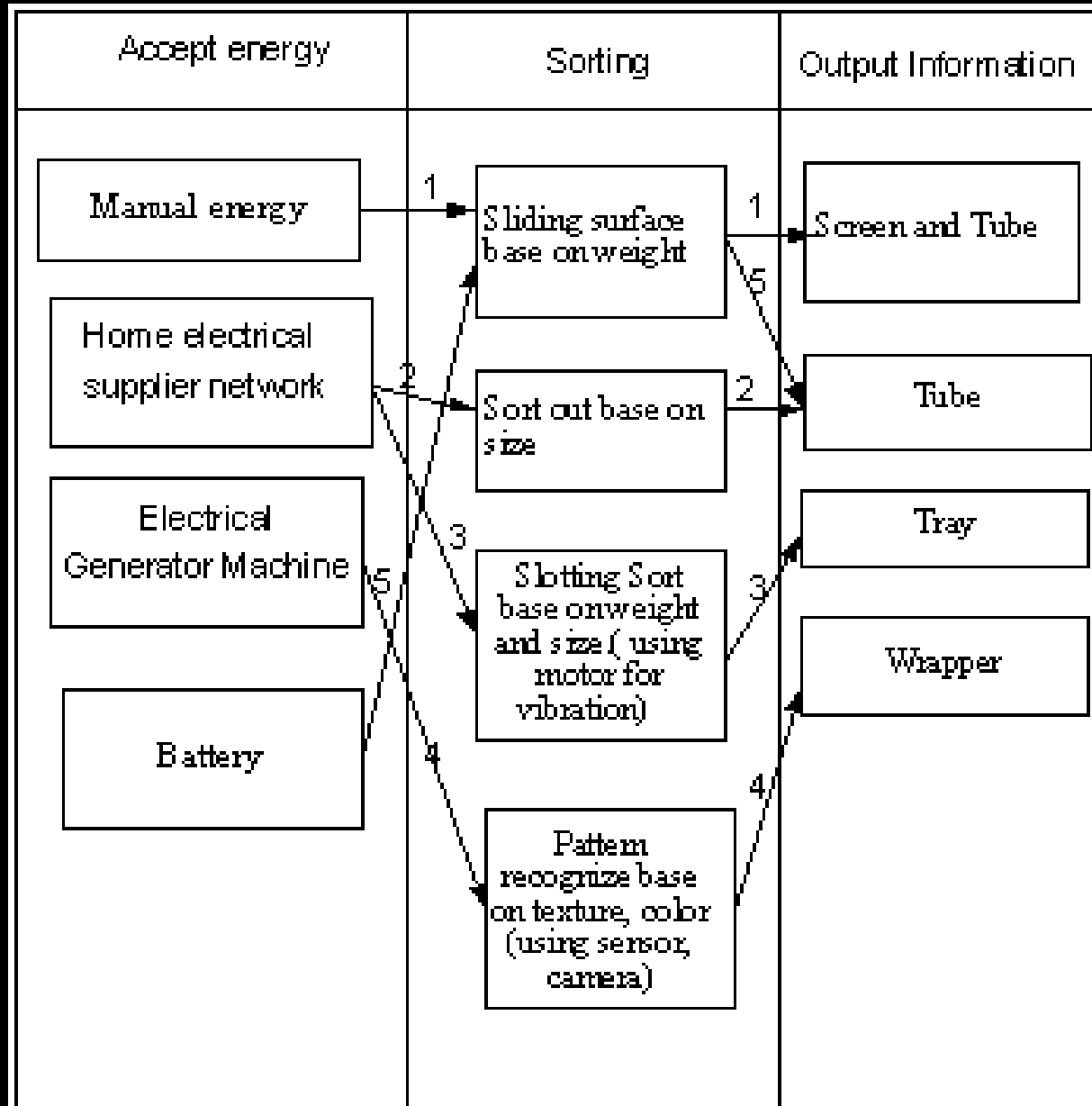
Output Information

- Screen and Tube
- Tube
- Tray
- Wrapper

Explore systematically

Accept energy	Sorting	Output Information
Home electrical supplier network	Sliding surface base on weight	Screen and Tube
Battery	Sort out base on size	Tube
Electrical Generator Machine	Slotting Sort base on weight and size (using motor for vibration)	Tray
Manual energy	Pattern recognize base on texture, color (using sensor, camera)	Wrapper

Explore Systematically





Select Concept

We present a two-stage select concept methodology

- *The first stage is concept screening
- *The second stage is concept scoring

Selection Criteria	Concepts					Remark
	1	2	3	4(ref)	5	
Aesthetic	+	+	+	-	-	'+' for 'better than' '-' for 'worse than' '0' for 'same as'
Compact	0	+	-	-	-	
High productivity	-	-	+	+	+	
High capacity	-	-	+	+	+	
Range of coin	-	0	+	+	+	
Coin seeing ability	+	+	0	0	0	
Coin over flow resistance	-	0	-	+	+	
Amount of Money display	+	-	-	0	-	
Fake coin distinguishable	-	0	0	+	0	
Low price	+	+	0	-	-	
Low energy consumption	+	-	0	-	-	
Easy to use	+	+	+	0	0	
High Accuracy	0	0	+	+	+	
Low noise	+	-	0	0	0	
Reliable	0	+	0	-	-	
Safe	0	-	0	0	0	
Durable	-	+	+	0	0	
Light	+	0	-	0	0	
Easy to maintain	0	+	+	0	0	
Sum +'s	8	8	8	6	5	
Sum 0's	5	5	7	8	8	
Sum -'s	6	6	4	5	6	
Net Score	2	2	4	1	-1	
Rank	2	2	1	3	4	
Continue?	Yes	Yes	Yes	No	No	

Selection Criteria	Weight (%)	Concepts					
		1		2(ref)		3	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Aesthetic	4	2	0.08	3	0.12	4	0.16
Compact	3	2	0.06	3	0.09	2	0.06
High productivity	7	2	0.14	3	0.21	3	0.21
High capacity	5	3	0.15	3	0.15	3	0.15
Range of coin	5	3	0.15	3	0.15	2	0.10
Coin seeing ability	4	4	0.16	3	0.12	3	0.12
Coin over flow resistance	4	2	0.08	3	0.12	2	0.08
Amount of Money display	5	3	0.15	3	0.15	4	0.20
Fake coin distinguishable	7	3	0.21	3	0.21	4	0.28
Low price	7	4	0.28	3	0.21	5	0.35
Low energy consumption	5	3	0.15	3	0.15	4	0.20
Easy to use	7	4	0.28	3	0.21	5	0.35
High Accuracy	6	3	0.18	3	0.18	4	0.24
Low noise	5	3	0.15	3	0.15	3	0.15
Reliable	7	3	0.21	3	0.21	4	0.28
Safe	5	4	0.20	3	0.15	5	0.25
Durable	7	3	0.21	3	0.21	5	0.35
Light	4	2	0.08	3	0.12	4	0.16
Easy to maintain	3	3	0.09	3	0.09	5	0.15
Total Score		3.01		3		3.84	
Rank		3		2		1	
Continue?		No		No		Develop	

Refine Specifications



After developing the Models for predicting the Values of the Metrics, creating a Cost Model of the Product, refining Specs and making some Trade-off, the Development Team has shortlisted the Product Refined Specifications

List of Refined Specifications

Metric	Motor Power	Dimension(L*W*H)	Weight	Overflow tray	Life time	Power consumption	Speed sorting	No. of slotting tray in sorting kit	No. of coin holder kits	Presence of LED for displaying	Noise level	Price	Tolerance	Volume of primary tray	The coin-out tray cover is transparent	Well- design	Time disassemble and assemble	Maintain cycle time	Maximum diameter of sorter coin	Minimum diameter of sorter coin	Ability adjusting vibration frequency
Target Measure	25	180x125x175	1,3	1	15	10	50	12	≥6	1	50	23,5	8/10	≥850	1	9/10	<12	18	30	10	1
Measure	W	mm	Kg	binary	year	w/bat ch	coin/s	q.ty	q.ty	binary	dB	\$US	score	cm3	binary	0-10/ score	s	month	mm	mm	binary

PROTOTYPE DESIGN AND DEVELOPMENT

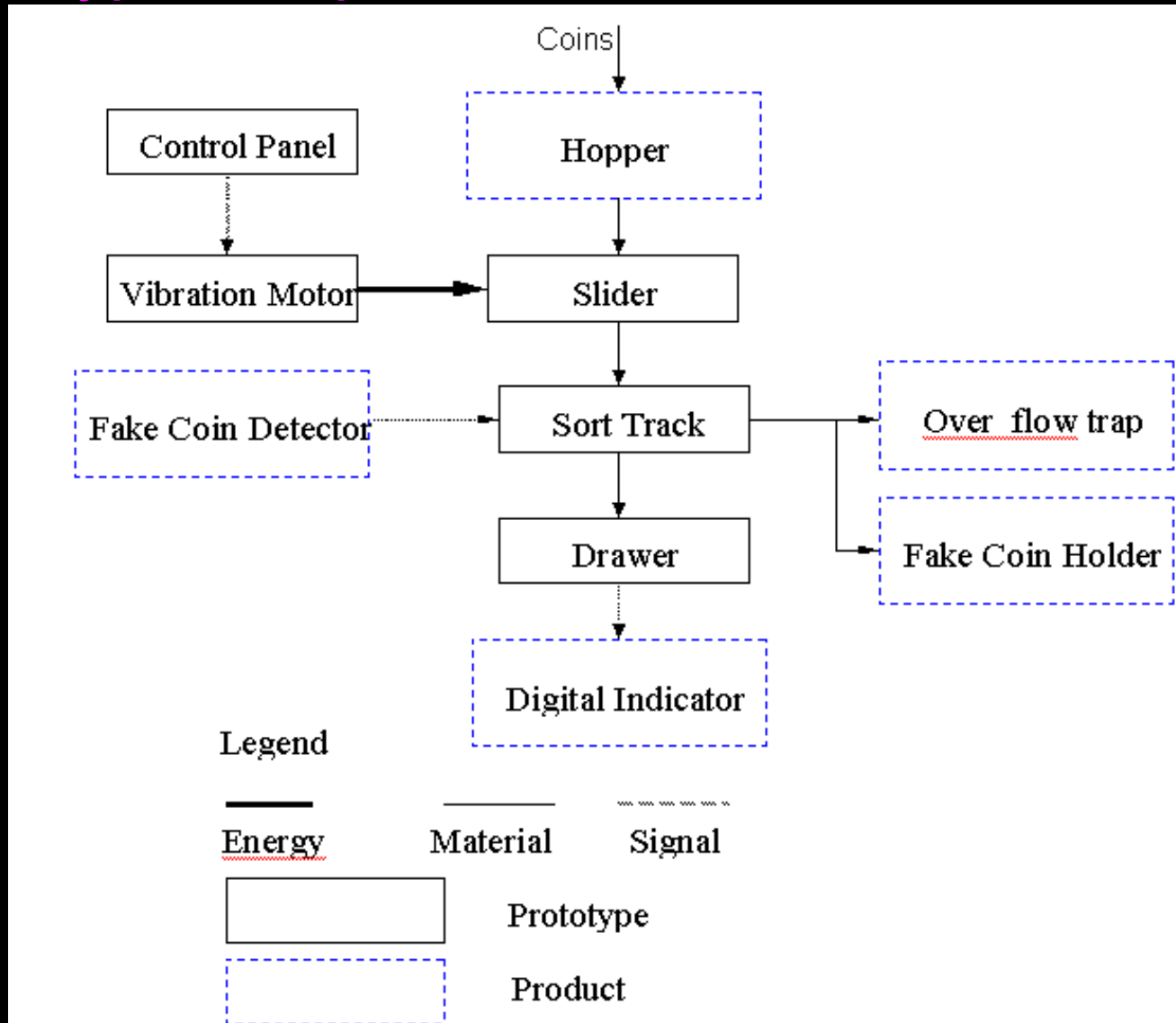
PROTOTYPE ARCHITECTURE

Requirements for prototype architecture:

- Easy and fast to make
- Reasonable price
- Flexible, adjustable: the sliding angle, the vibration amplitude and frequency can be changed easily in a wide range to facilitate the experiment process
- The coins are ready for use in the coin-holding tubes after sorting
- Comprehensive and close to the final product as much as possible
- Try to apply modular architecture
- Good manufacturability and easy to assemble when upgrading to the final product
- Use the standardized components and details as much as possible.

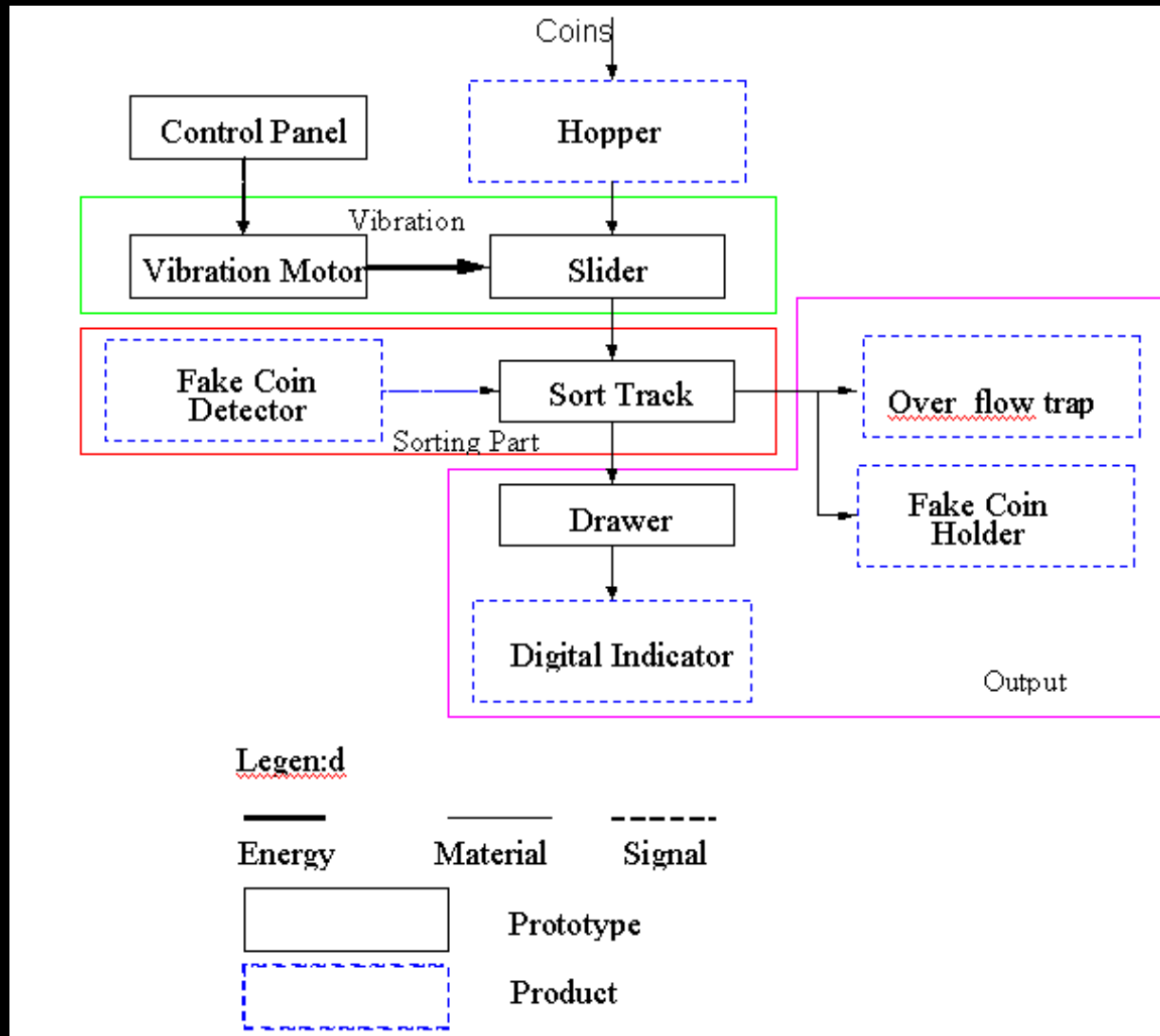
PROTOTYPE ARCHITECTURE (CON'T)

Prototype and product scheme



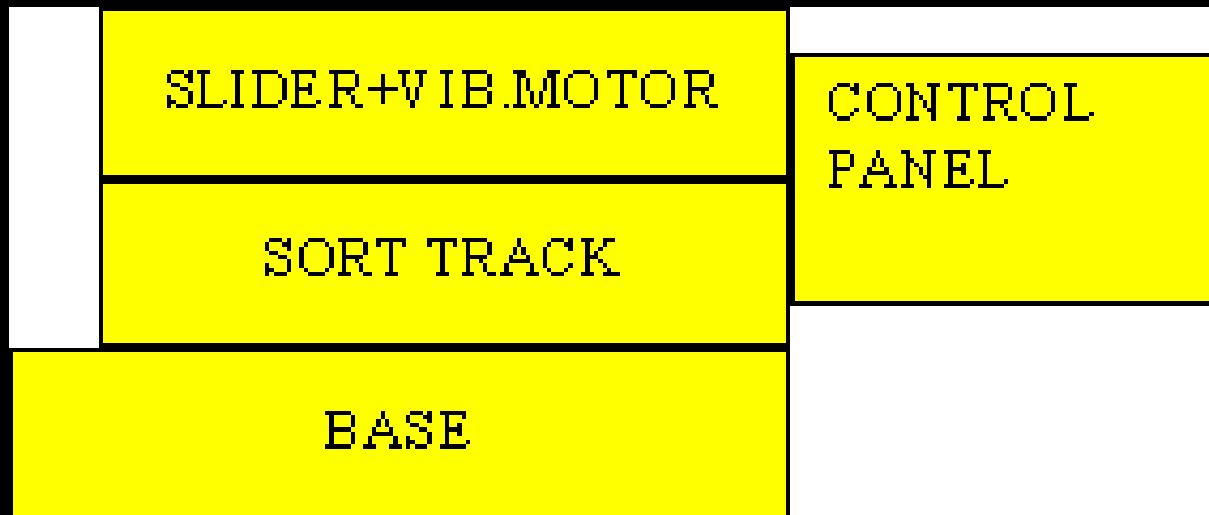
PROTOTYPE ARCHITECTURE (CON'T)

Cluster the elements of the scheme



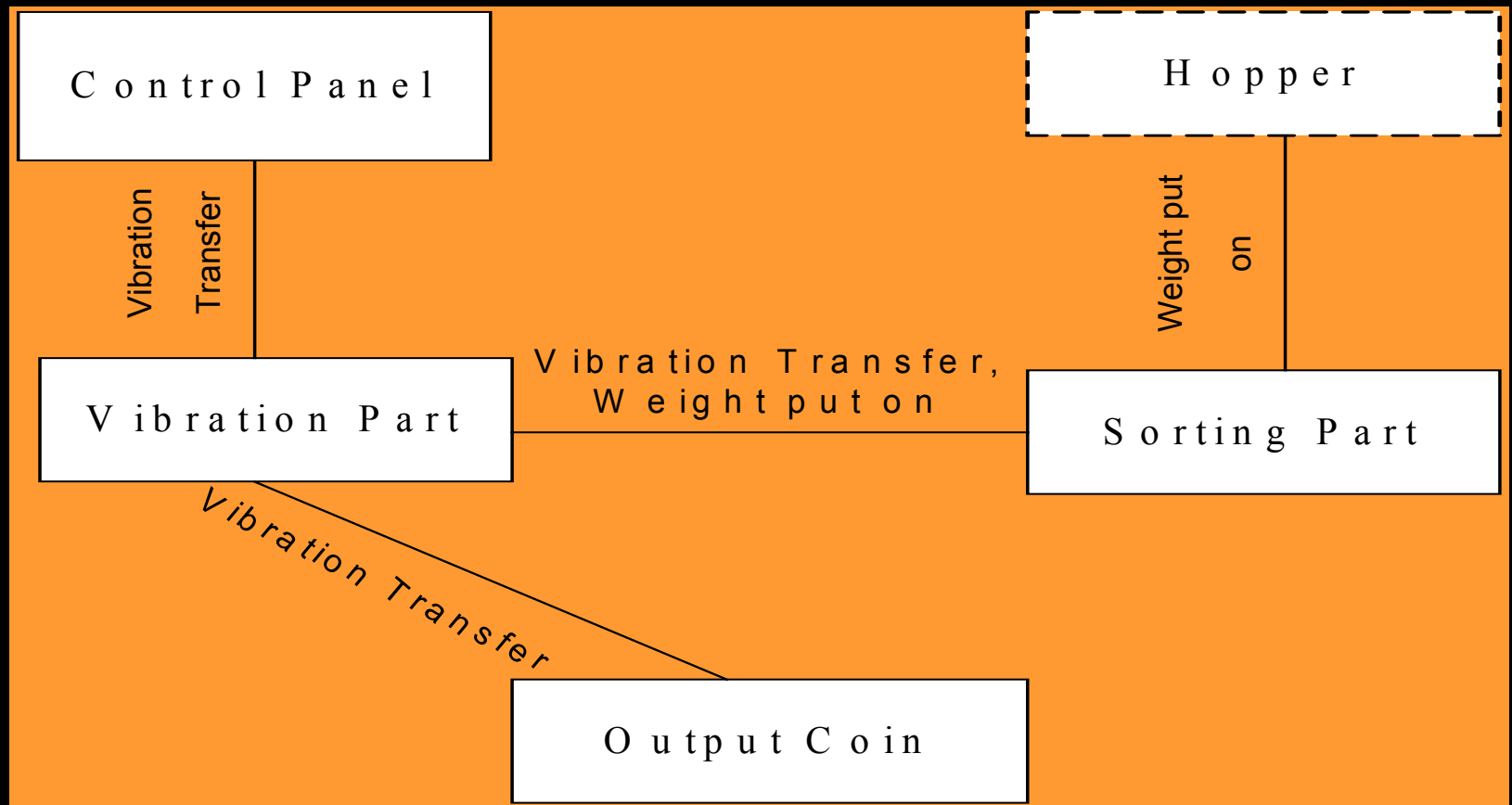
PROTOTYPE ARCHITECTURE (CON'T)

Rough geometric layout



PROTOTYPE ARCHITECTURE (CON'T)

- Identify the Fundamental and Incidental Interactions



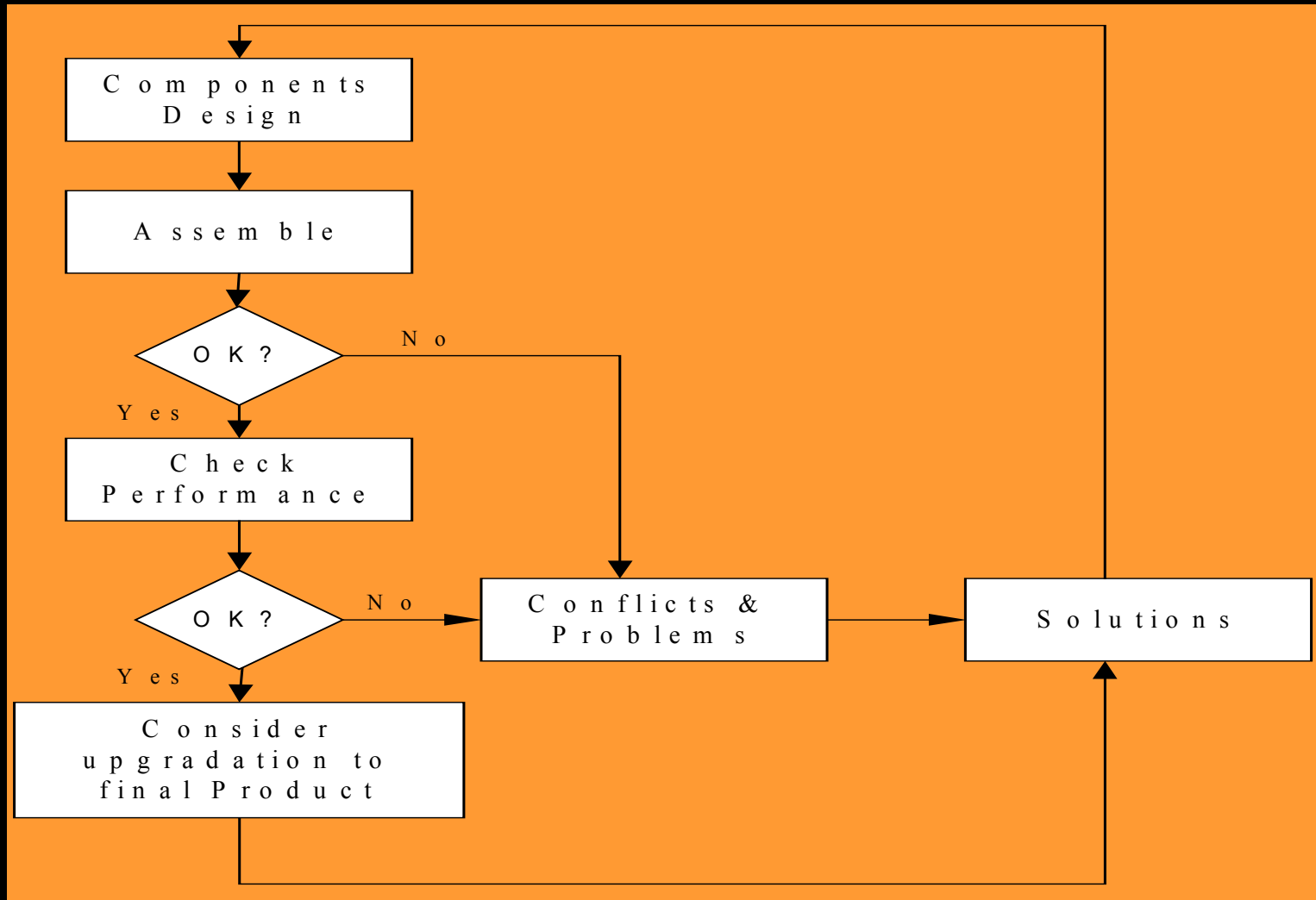
PROTOTYPE ARCHITECTURE (CON'T)

Modular or Integral Architecture?

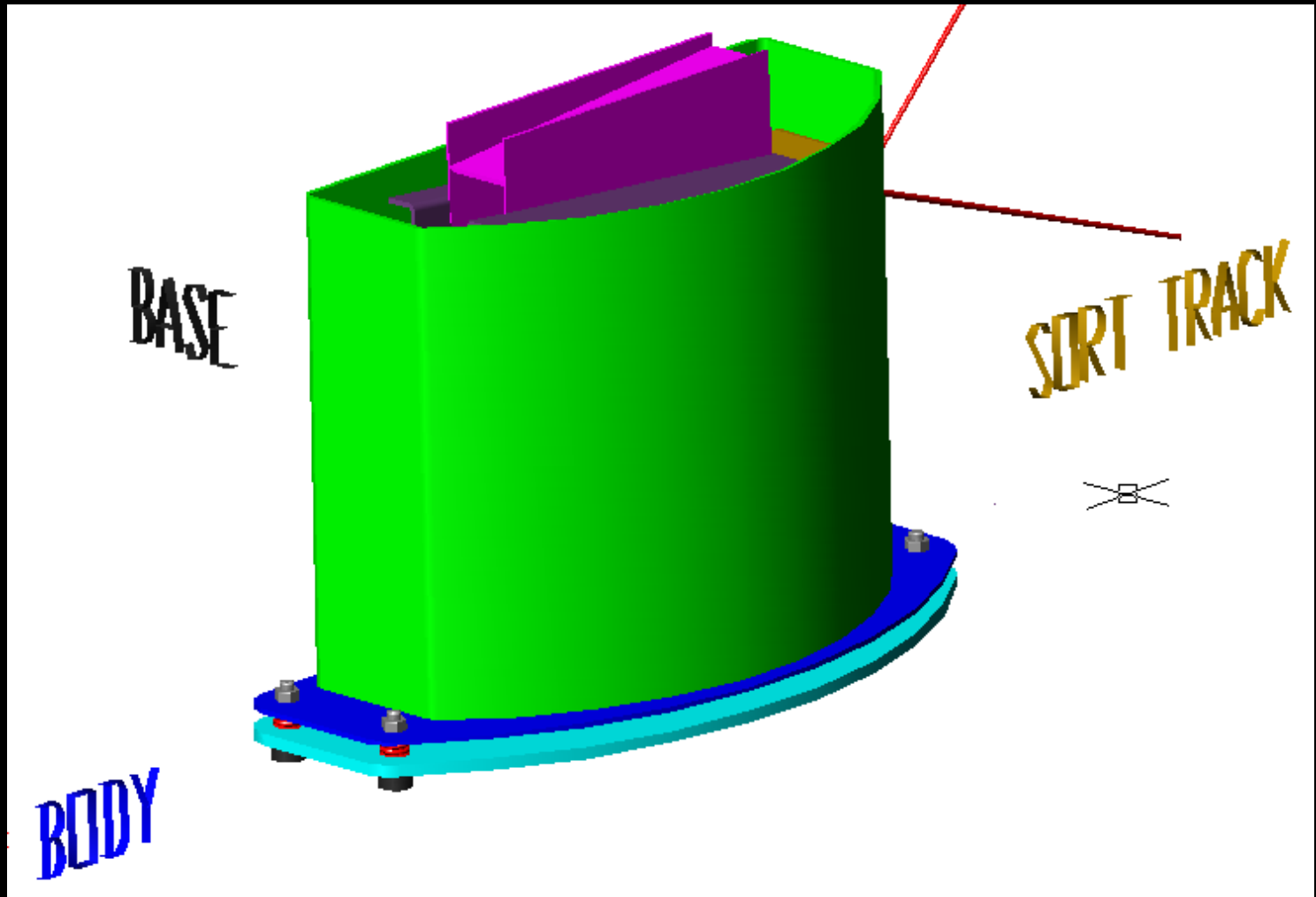
- *The Modular Architecture clearly has many advantages:*
 - + *Ease the design process*
 - + *The structure of each chunk can be simpler*
 - + *The prototype (and then the product) is easy to manipulate, improve and troubleshoot; increase the manufacturability and the ease of assemble.*
- *Apply the Modular Architecture for the coin sorter*

PROTOTYPE DESIGN AND DEVELOPMENT

- Design procedure:

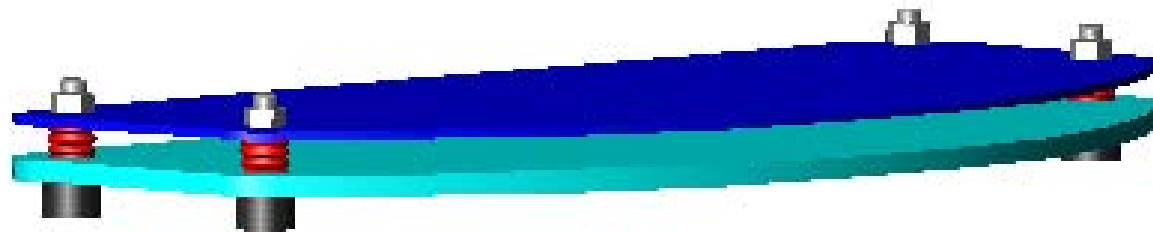


Coin Sorter Prototype

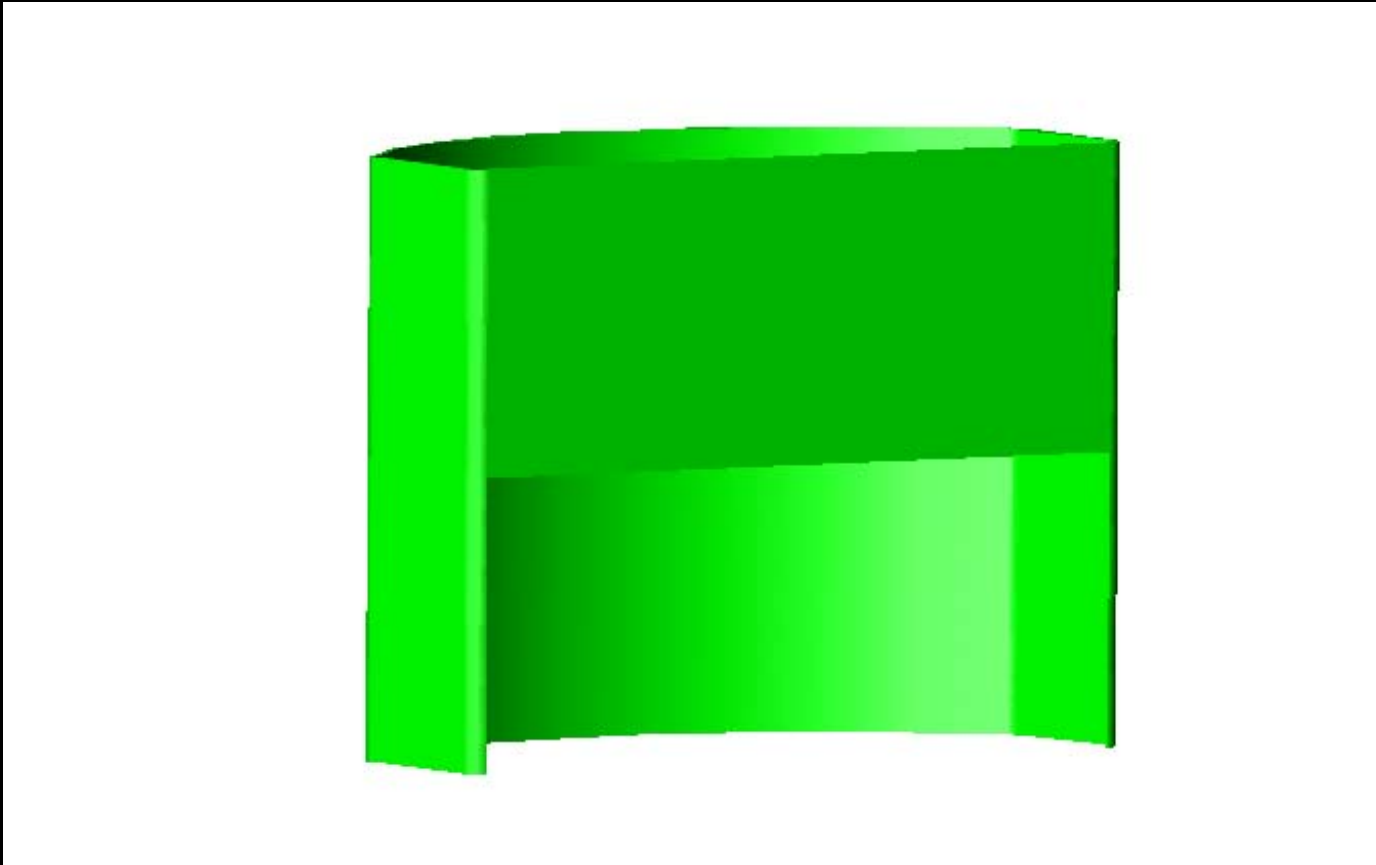


Base Component

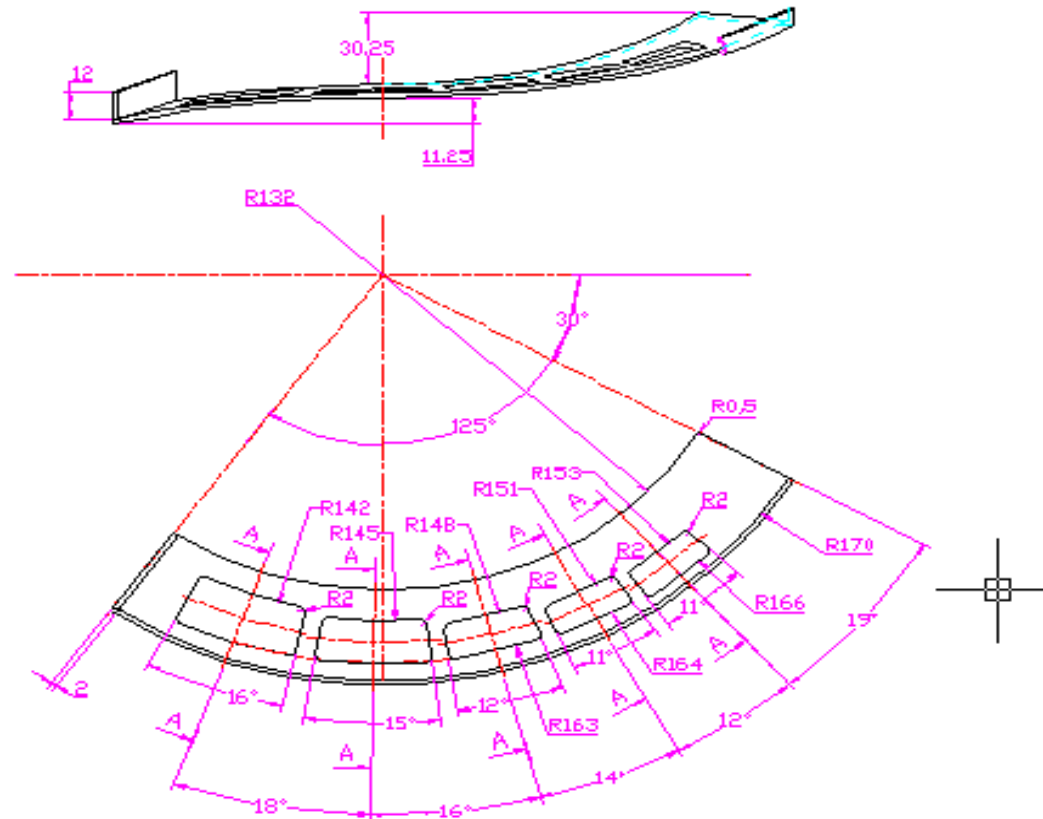
BASE



Body Component

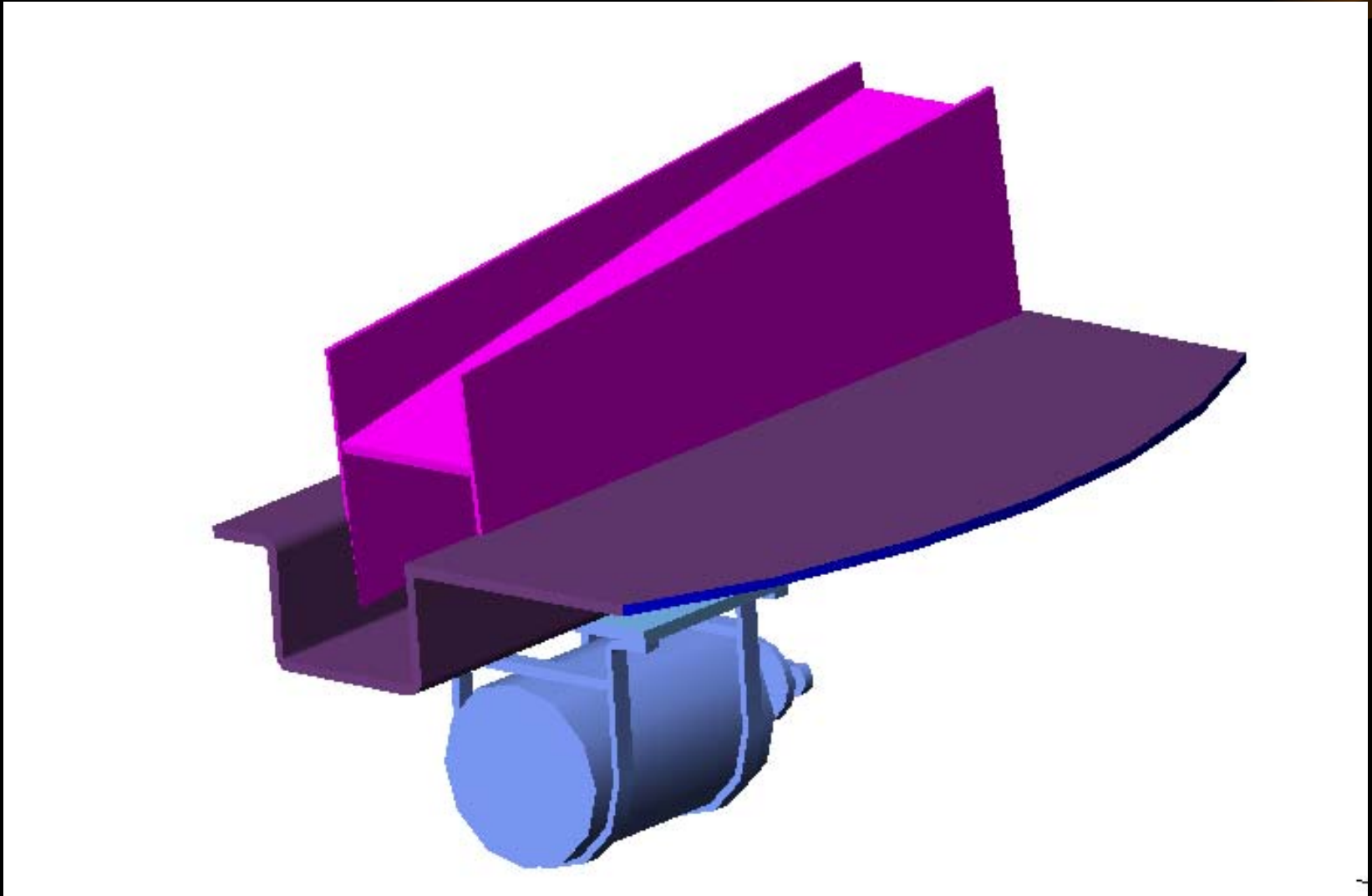


The sort track



Note: a and b are calculated from top projection

The slider and vibration



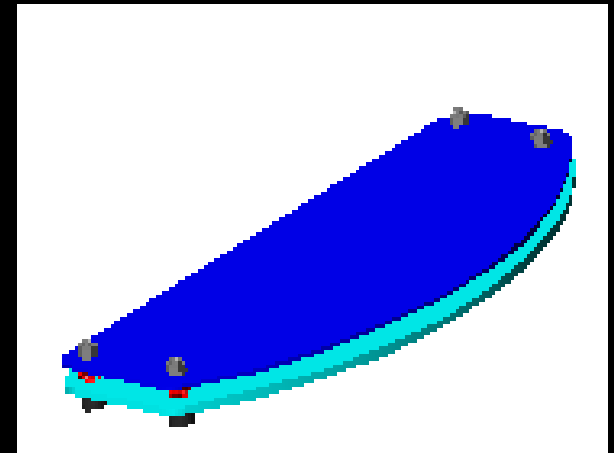
Problem – Solution - adjustment

BASE

- Noisy
- Difficult to take coin
- Spring too hard or soft

Solution

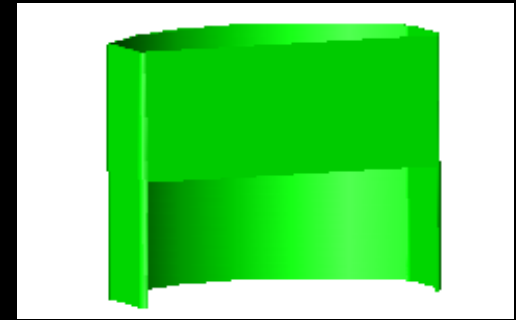
- Change thickness, gap
- Spring alternative
- Base architecture



Problem – Solution - adjustment

BODY

- Vibration absorption
- Bad vision
- Manufacturing difficulty



Solution

- Spring adjustment
- Material changing

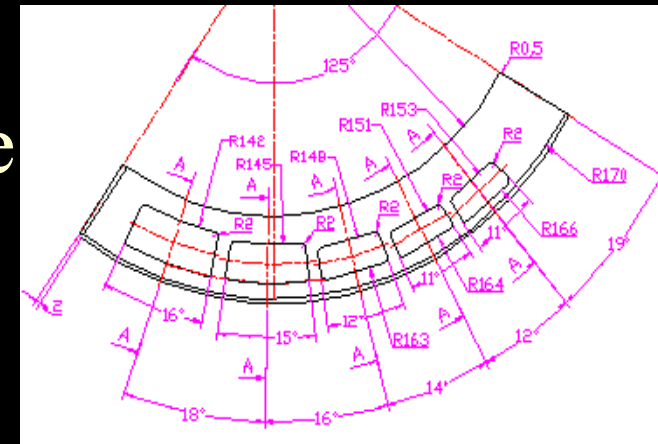
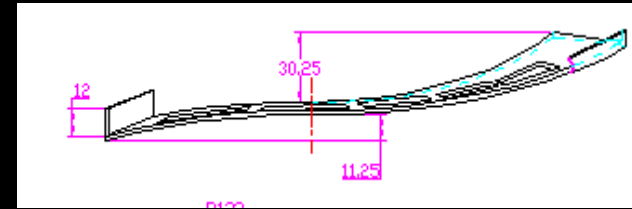
Problem – Solution - adjustment

SORT TRACK

- Noisy
- Inaccuracy and low capacity

Solution

- Latitude angle: 27 degree
- Bending radius: $R = 170$
- Tilt angle: 4°
- Centrifugal mass: ≥ 88 gr
- Motor r.p.m $\geq 80\%$ max r.p.m



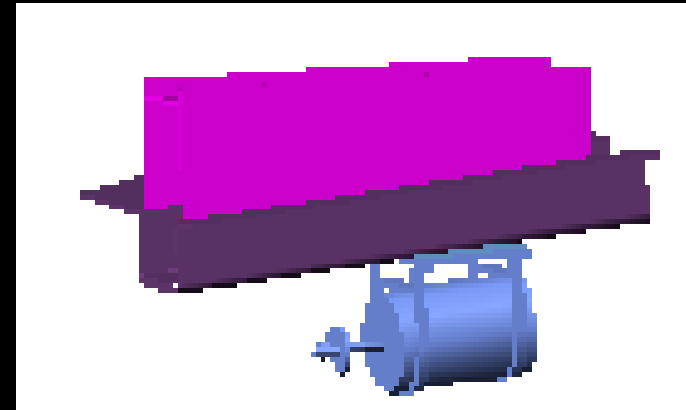
Problem – Solution - adjustment

SIDER AND VIBRATION MOTOR

- Noisy
- Coin get stuck or go too fast

Solution

- Tilt angle: $4^{\circ} - 8^{\circ}$
- Centrifugal mass adjustment
- Motor r.p.m $\geq 80\%$ max r.p.m



Prototype EVALUATION



- Reliable and stable
- 90% accuracy
- The noise is high
- The prototype can be more compact
- Rigid structure

Prototype upgrade



- Sort track
- Hopper
- Drawer
- The base
- The Slider
- The Control panel
- The DC vibration motor



THANK YOU !