INNOVATION SITUATION QUESTIONNAIRE : POST OFFICE

T E A M C H A I R N O B Y L

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FMEA - CONCEPT 1

Process Step	Potential Failure Mode	Potential Failure Effect	Potential Causes	SEV	OCC	RPN	Action Recommended
Camera based scanning of address on mail	FOV insufficient to capture entire address.	Address unable to be captured, scanning halted.	Larger envelope sizes with addresses out of FOV of camera.	7	4	28	Mechanism to adjust FOV of camera. Camera with wider FOV to be utilised.
	Illumination insufficient to capture legible address.	Lot of image noise, leading to illegibility of address.	Camera ISO sensitivity not sufficient for the task.	6	3	18	Provide illumination to the envelope by incorporating a light fixture in the device.
OCR by computer	Illegible address	Address unable to be detected. scanning halted.	Low contrast of text, illegible handwriting, orientation of envelope	6	5	30	Enhance software preprocessing to improve text contrast.
	Processor malfunction		Failure of computer, faulty connection to computer	9	2	18	Ensure reliable connections; use a higher-quality processor.

FMEA - CONCEPT 1

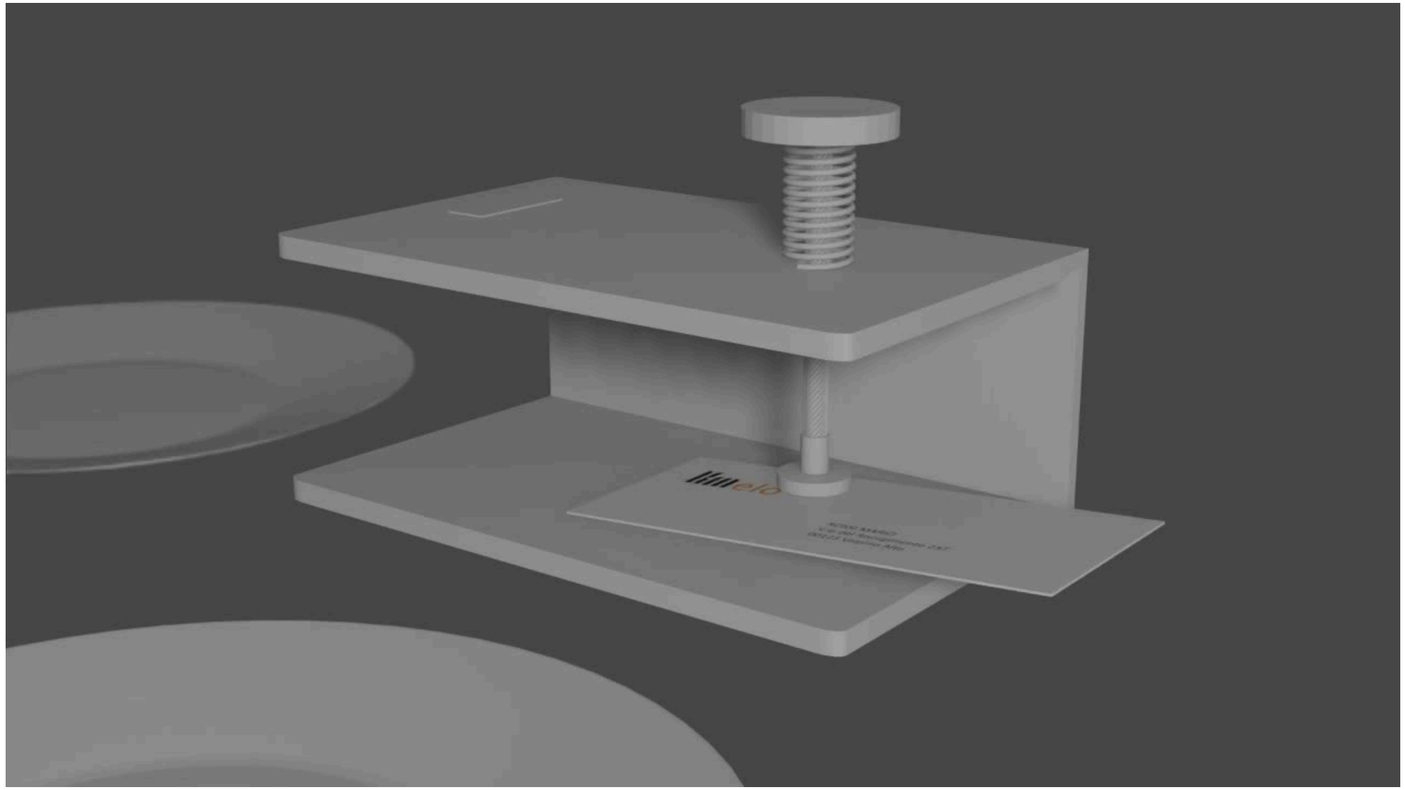
Process Step	Potential Failure Mode	Potential Failure Effect	Potential Causes	SEV	OCC	RPN	Action Recommended
Display of colour code based on destination	LED displays wrong destination colour code.	Unreliable sorting of mail	Improper training of AI model. Hardware malfunction	7	4	28	Improve AI training; test against edge case.
Manual stamping for authentication	Mechanical failure	Unable to authenticate	Wear and Tear of mechanical components	6	2	12	Regular maintenance.
	Illegible mark of authentication	No legible proof of authentication	Insufficient force applied, insufficient ink level.	2	3	6	Monitor ink and pressure.
Manual matching of mail to destination compartments	Mail is sorted to wrong compartment	Erroneous sorting of mail	Human error-fatigue, distractions	7	3	21	Introduce alerts for incorrect sorting.

FMEA - CONCEPT 2

Process Step	Potential Failure Mode	Potential Failure Effect	Potential Causes	SEV	OCC	RPN	Action Recommended
Loading stack of letters to tray	Letters are not oriented facing down	Address side of envelope not available to be scanned	Human error in loading correctly	7	3	21	Add guide system, or automated flipping mechanism with sensors
Digital image scanner based scanning of address on mail	improper orientation of envelope on scanning bed	Address illegibilty	Envelope may be displaced from scanning bed due to irregularities in the form/shape of envelope. Improper loading.	8	3	24	Clamp or suction mechanism, alignment rails
OCR by computer	Illegible address	Address unable to be detected. scanning halted.	Low contrast of text, illegible handwriting, orientation of envelope	6	5	30	Enhance software preprocessing to improve text contrast.
	Processor malfunction		Failure of computer, faulty connection to computer	9	2	18	Ensure reliable connections; use a higher-quality processor.
Validating address by comparison with database	False positives, False negatives in validation	Erroneous sorting	Robustness of address database may be insufficient. AI may not be trained sufficiently.	5	2	10	Dynamic database, Regular updation, user feedback

FMEA - CONCEPT 2

Process Step	Potential Failure Mode	Potential Failure Effect	Potential Causes	SEV	OCC	RPN	Action Recommended
Choice of sorting compartment based on destination	Incorrect choice of compartment	Erroneous sorting	Improper training of AI model.	7	4	28	Improve AI training; test against edge case.
	Inadequate number of choices for sorting mail	Inadequate sorting	Space constraints	8	4	32	Introduce more trays.
Orientation of sorting head to correct sorting compartment	Electro-mechanical failure	Erroneous sorting	Servo motor failure, faulty electrical wiring	8	2	16	Regular maintanence, fault detection mechanism
	Calibration of hardware	Mismatched orientation of intended compartment and actual compartment	Sorter gets shifted around without recalibration, accidental shifting.	8	3	24	Periodic calibration, real-time position feedback
Printing of authentication seal on mail	Illegibility of print	No legible proof of authentication	Printerhead malfunction, Printer ink not sufficient.	7	2	14	Add a low-ink detection mechanism; ensure the printer is well-calibrated and serviced periodically to avoid feed issues.
Ejecting the letter out to compartment	Electro-mechanical faliure	Mail gets jammed in the ejector.	Faulty mechanical components, roller, motor. Mail too thick to be rolled out.	8	2	16	Ensure chute is designed with adequate tolerances; implement sensors to detect and clear jams automatically.



CONCEPT 1

OCR Based colour coding and stamping assistant

INNOVATION SITUATION QUESTIONNAIRE

EXISTING SYSTEM

S T U D Y

Q. Name of the system?

A. Mail Dispatch Management System

Q. Structure of system

A. Mail, camera, color code display, mechanical stamping tool, computing device (external)

EXISTING SYSTEM & ENVIRONMENT

S T U D Y

Q. Function of system

A. Primary useful function (PUF): Reliable sorting and authentication of mail

Q. Purpose of performing PUF

A. For fast and accurate dispatch of mail to destination

EXISTING SYSTEM & ENVIRONMENT

S T U D Y

Q. System Functioning- Dynamic state

1. Manual loading of letter into scanner tray
2. Scanning of address on mail through camera
3. OCR by computer
4. Sorting function by computer
5. LED Display to show destination tray’s colour code
6. Letter gets stamped
7. Letter transferred to tray with matching colour code

EXISTING SYSTEM & ENVIRONMENT

S T U D Y

Q. Interaction with supersystem, other systems?

- Interaction with mail - Mail is fed into the device, scanned and marked with a visible mark, then sorted to correct compartment by postal worker
- Placed on a table, connected to a computer
- Plugged to an electrical power source
- Postal worker interacts with machine by feeding and removing mail

EXISTING SYSTEM & ENVIRONMENT

STUDY

Q. Natural system surrounding it?

- Clean, dry, well-lit environment,
- Minimal noise during working of device
- Color code display lights up the adjacent area
- No audible noise between the sealing device and the envelope while stamping
- Normal ambient temperature and pressure

UNDERSTANDING THE DRAWBACKS

S T U D Y

Problem to be resolved

- Inability to capture the address of the mail to be sorted

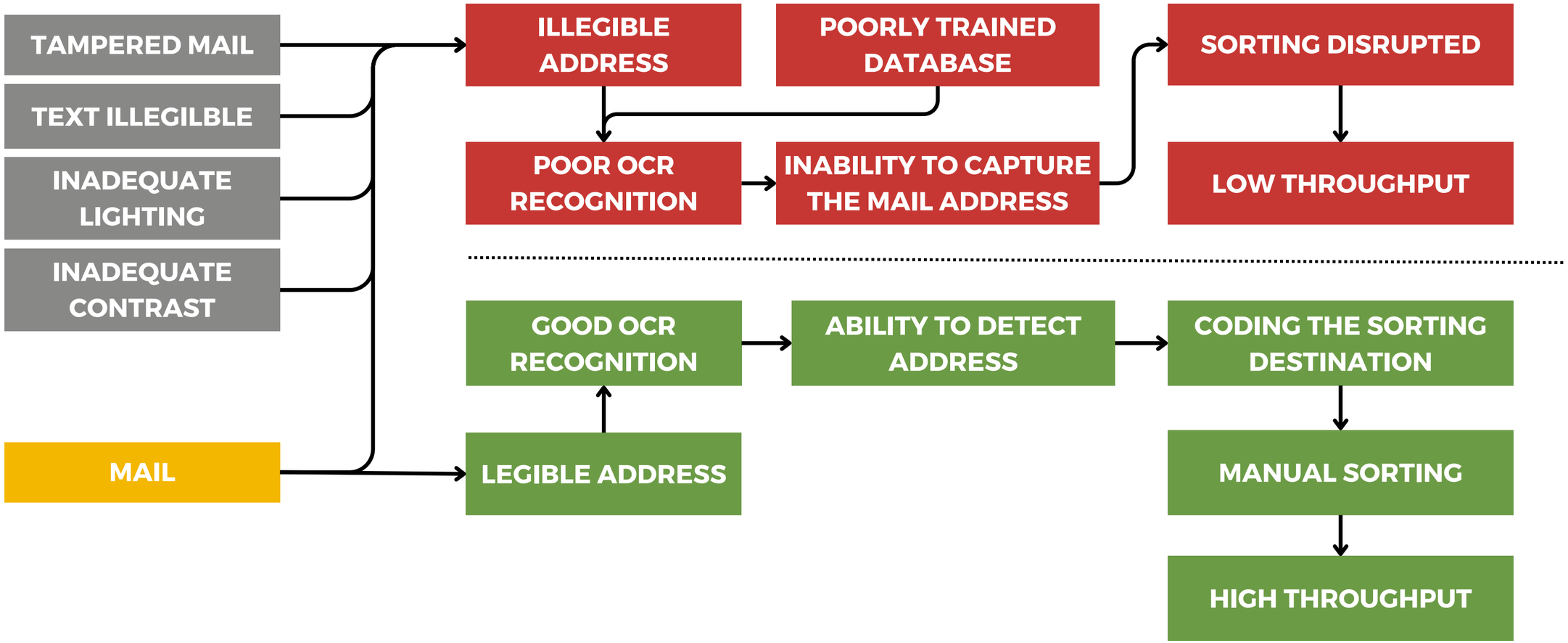
Mechanism causing the problem

- Camera based scanning of address on mail - Insufficient FOV to capture entire address

- OCR by computer - low contrast of text, illegible or complex handwriting, misorientation of envelope

INFORMATION ABOUT THE PROBLEM SITUATION

CAUSE-EFFECT ANALYSIS



INFORMATION ABOUT THE PROBLEM SITUATION

H I S T O R Y

Q. Undesired consequences of unresolved problem

A.

- Failure of OCR leads to halting of entire sorting process.
- Inaccurate OCR results leads to unreliable sorting which will result in backtrack of mails, thus lengthening the entire mail dispatch process.

INFORMATION ABOUT THE PROBLEM SITUATION

H I S T O R Y

Q. History of problem

A.

- Testing OCR algorithm for handwritten address on envelope -> some were illegible/complex, lighting conditions-> lead to failure of OCR model to capture the address on mail accurately

INFORMATION ABOUT THE PROBLEM SITUATION

SYSTEM CHANGES

Q. Decisions that changed the system to one with problem

A.

- Decision to use camera and OCR for scanning of written address
- Decision to automate the process of scanning and sorting of mail

INFORMATION ABOUT THE PROBLEM SITUATION

PREVIOUS/FAILED ATTEMPTS

Q. Attempts to eliminate/reduce/prevent problem

A.

In other systems with similar problem:

- Scanning at a higher resolution helps but takes longer
- An image should be not skewed, but deskewing is time consuming
- Add brightness and contrast adjustments in post production before processing the image

IDEAL VISION OF SOLUTION

The ideal solution would be a sorting system capable of accurately interpreting a **wide range of addresses** as effectively as a postal worker, but **with greater speed**. It should efficiently direct mail to the correct destination while incorporating a mechanism for effortless stamping.

RESOURCES AVAILABLE

S T U D Y

Materials available

- Paper
- Ink
- Inkwell
- Stamp
- Human resource
- Information scanner
- Table
- Collection bag
- Computer system
- Artificial lighting
- Stamping tool
- Camera

Sources of Energy available

- Chemical Energy between Ink and Paper
- Energy use by man to work
- Mechanical displacement of stamping tool
- Electric energy used by the device
- Electromagnetic radiations
- Impact force
  - Important consideration for successful imprint
- Friction
- Light Energy due to color code display

System/Environmental attributes

- The Ink has a tendency to dry on its own
  - The property can be leveraged to assess when it is okay to stack papers over one another
- The parcels/letters are already labelled.
- Time in hand to complete the tasks: 10PM-3PM
- A space of two work tables
  - Usually the reason of mixup or letter losses

CHANGING THE SYSTEM

STUDY

Q. Allowable changes

A.

- Material or mechanism of the seal
- Size of the system (within certain limits)
- Level of automation
- Changing software/algorithms
- Camera, OCR system can be changed
- No. of sorting compartments
- Layout of system components
- Mechanism of interaction with system

CHANGING THE SYSTEM

S T U D Y

Q. Limitations, what can’t be changed?

A.

- Mail has to be sorted by destination.
- Mail must be authenticated for delivery to take place.
- Mail has to be delivered on the date of authentication at the last node (Sub-Post Office)
- Date and location must be authenticated.
- Solution cannot occupy too much space.

CRITERIA FOR SOLUTION SELECTION

SUCCESS CRITERIA

Desired Technological Characteristics	Desired economic characteristics
• High accuracy and reliability in stamping, sorting, and authentication. • High level of integration and minimal interference between components. • Scalability and durability for long-term use and increased mail volume.	• Cost-effective design to keep the system affordable for customers to purchase. • Low operational and maintenance costs for long-term use.

Expected Degree of Novelty
• Improvements for refining existing processes. • Balance between cost-effective upgrades and competitive innovation.

RESOLVING CONTRADICTIONS

USING PRINCIPLES OF TRIZ

UF: OCR has good accuracy in reading the address in standard format

HF: Throughput get reduced

16. Partial or excess actions

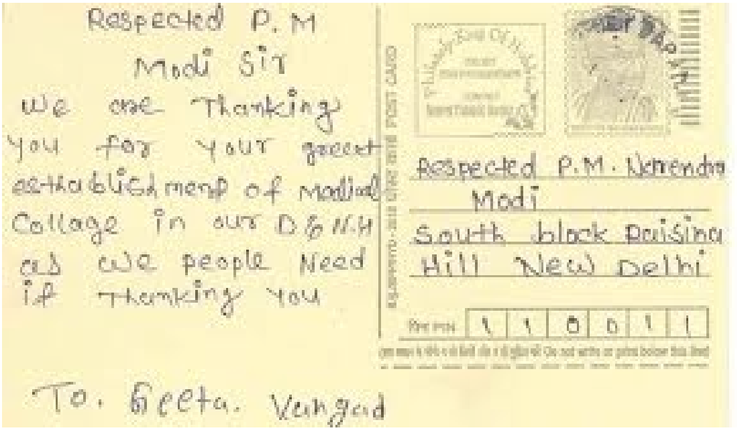
Instead of scanning entire address **just scan pincode** - more accuracy as well as faster processing.

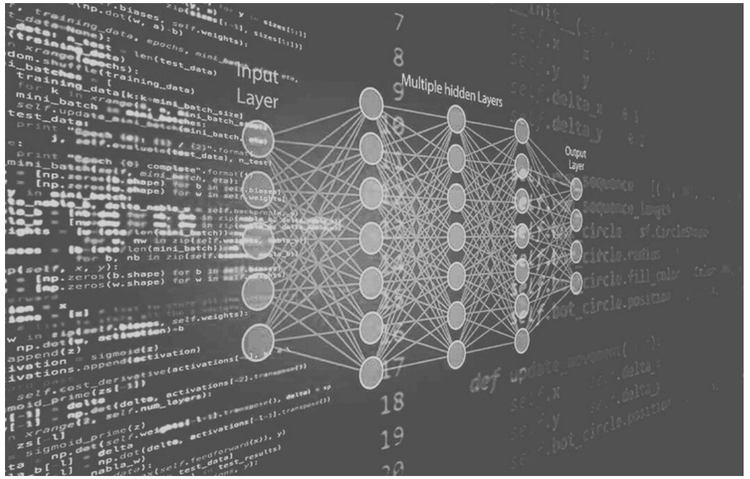
10. Preliminary Action

Pre-process the letters to remove noise and ensure clear visibility of the address - speeds up the text recognition

3. Local Quality

Use specialized OCR : Need to train the ML model for texts of postal letter, for high-accuracy for complex text data.





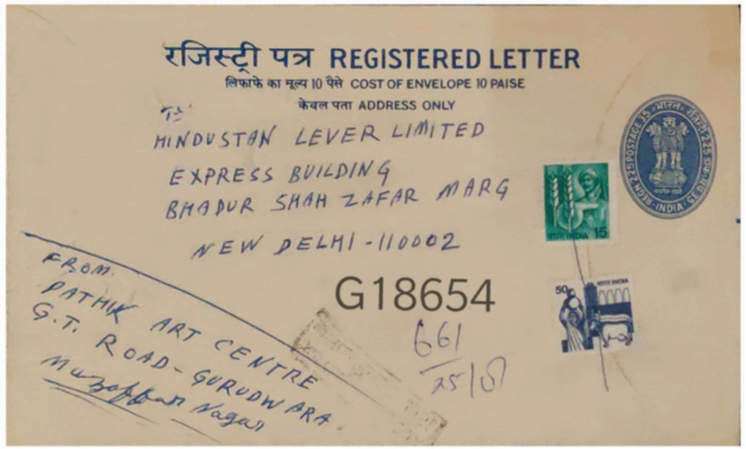
RESOLVING CONTRADICTIONS

USING PRINCIPLES OF TRIZ

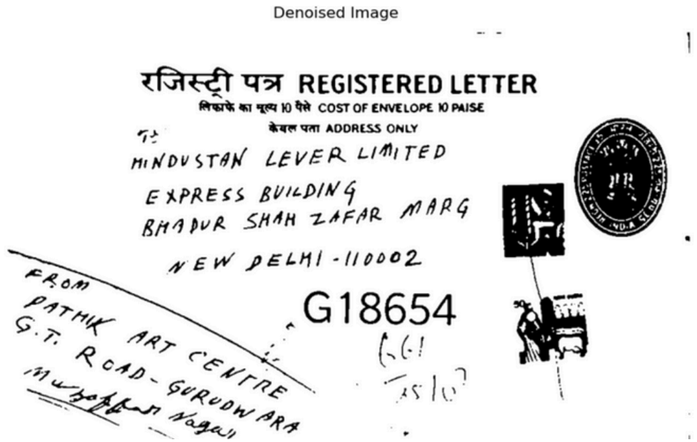
Partial action and Preliminary action

- just scan pincode
- Improved pre-processing

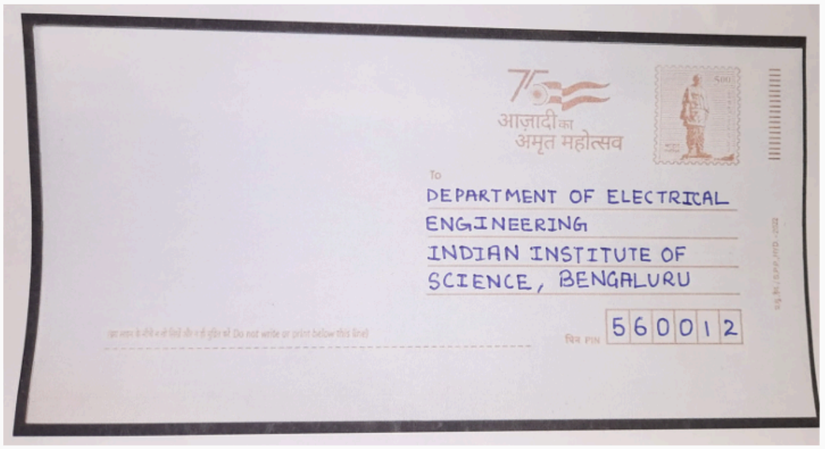
Original Image



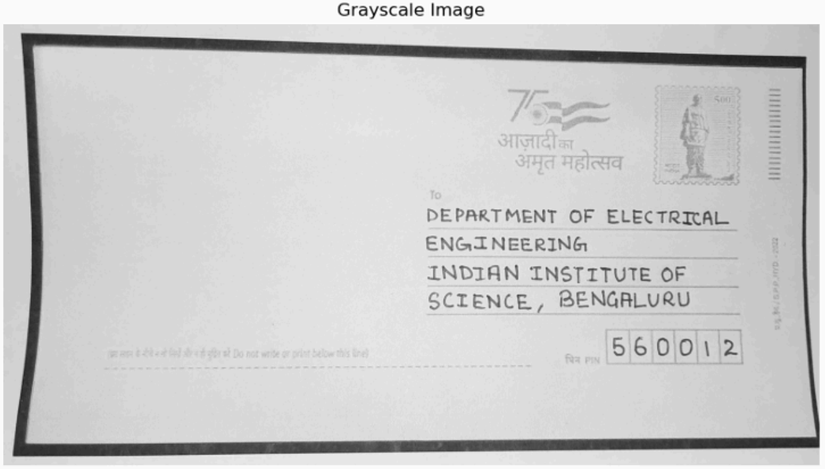
Denoised Image

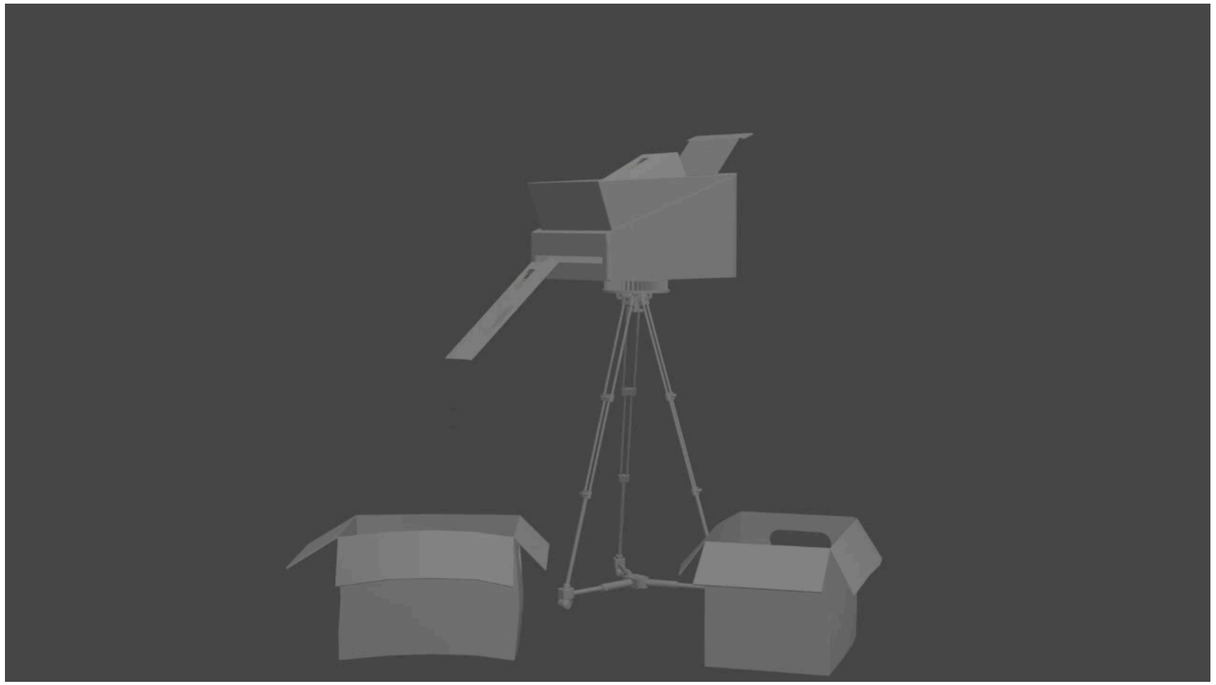


Original Image



Grayscale Image





CONCEPT 2

Automated Scanning and Sorting Assistant

EXISTING SYSTEM

S T U D Y

Q. Name of the system?

A. Mail Dispatch Management System

Q. Structure of system

A. Mail, scanning tray, scanning device, stamping device, LED display, computing device(external)

EXISTING SYSTEM & ENVIRONMENT

S T U D Y

Q. Function of system

A. Primary useful function (PUF): Reliable sorting and authentication of mail

Q. Purpose of performing PUF

A. For fast and accurate dispatch of mail to destination

EXISTING SYSTEM & ENVIRONMENT

S T U D Y

Q. System Functioning- Dynamic state

A.

1. Manual loading of stack of letters to collector tray on sorting head
2. Digital image scanner based scanning of address on mail
3. OCR by computer
4. Validating address by comparison with database
5. Choice of sorting compartment based on destination
6. Orientation of sorting head to correct sorting compartment
7. Printing of authentication seal on mail
8. Ejecting the letter out to matching compartment
9. Mail worker collects the sorted mail

EXISTING SYSTEM & ENVIRONMENT

S T U D Y

Q. Interaction with supersystem, other systems?

A. Interaction with mail -

1. Mail is fed into the device, scanned and marked with a visible mark, rolled out into correct compartment.
2. Placed on a floor, connected to a computer
3. Plugged to an electrical power source
4. Postal worker interacts with machine by feeding and removing mail.

EXISTING SYSTEM & ENVIRONMENT

S T U D Y

Q. Natural system surrounding it?

- Clean, dry, well-lit environment,
- Space to access the device, and place the trays
- No audible noise between the sealing device and the envelope while stamping
- Normal ambient temperature and pressure

UNDERSTANDING THE DRAWBACKS

S T U D Y

Problem to be resolved

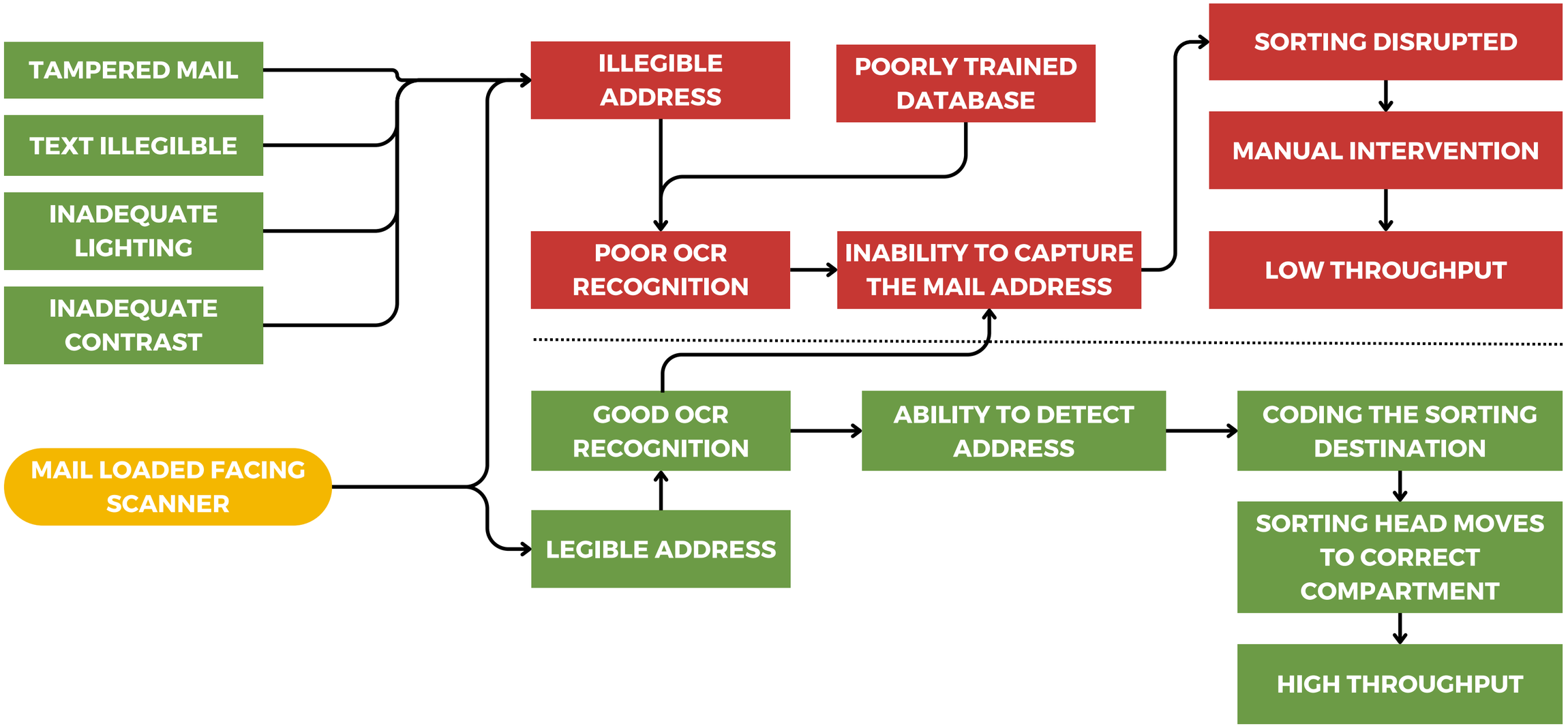
- PHF: Inadequate number of outputs for sorting mail.

Mechanism causing the problem

- Lack of space->Need for compact system->Not enough trays in current state->inadequate sorting choices

INFORMATION ABOUT THE PROBLEM SITUATION

C A U S E - E F F E C T A N A L Y S I S



INFORMATION ABOUT THE PROBLEM SITUATION

H I S T O R Y

Q. Undesired consequences of unresolved problem

A.

- Slower sorting process due to sorting bandwidth (lesser sorting compartments)
- Higher frequency manual intervention required to reload mail.

INFORMATION ABOUT THE PROBLEM SITUATION

H I S T O R Y

Q. Evolution of problem

A.

- The system sorted mail up to eight categories at a time in one place, but to get a higher throughput rate we needed more bandwidth.
- Conventional methods were to increase the space to accommodate more trays, but it needs to be sorted.

INFORMATION ABOUT THE PROBLEM SITUATION

SYSTEM CHANGES

Q. Decisions that changed the system to one with problem

A.

- Decision to have increase the categories to sort the mail into.
- Decision to automate the process of scanning and sorting of mail.

IDEAL VISION OF SOLUTION

The solution is ideally a black box with an input tray and a number of output trays. The black box decides the number of sorting conditions based on the diversity of the mail that is input and sorts into the decided number of sorting trays, and the trays are collected to be put into bags.

RESOURCES AVAILABLE

S T U D Y

Materials available

- Paper
- Ink
- Inkwell
- Stamp
- Human resource
- Information scanner
- Table
- Collection bag
- Computer system
- Artificial lighting
- Automatic Stamping tool
- Scanner
- Printer
- Rotating head
- Rooler/Motor
- Display for color code

Sources of Energy available

- Chemical Energy between Ink and Paper
- Energy use by man to work
- Energy due to rotation of rotating head distributor
- Energy due to motion of roller
- Electric energy used by the device
- Electromagnetic radiations
- Impact force
  - Important consideration for successful imprint
- Friction

System/Environmental attributes

- The Ink has a tendency to dry on its own
  - The property can be leveraged to assess when it is okay to stack papers over one another
- Time in hand to complete the tasks: 10PM-3PM
- A space of two work tables
  - Usually the reason of mixup or letter losses

CHANGING THE SYSTEM

S T U D Y

Q. Allowable changes

A.

- Mechanism of printing seal
- Size of the system (within certain limits)
- Level of automation
- Changing software/algorithms
- Scanner, OCR system can be changed
- No. of sorting compartments
- Layout of system components
- Mechanism of interaction with system

CHANGING THE SYSTEM

STUDY

Q. Limitations, what can’t be changed?

A.

- Mail has to be sorted by destination.
- Mail must be authenticated for delivery to take place.
- Mail has to be delivered on the date of authentication at the last node (Sub-Post Office)
- Date and location must be authenticated.
- Solution cannot occupy space beyond existing post office solution (retrofitting)

CRITERIA FOR SOLUTION SELECTION

SUCCESS CRITERIA

Desired Technological Characteristics	Desired economic characteristics
• High accuracy and reliability in stamping, sorting, and authentication. • High level of integration and minimal interference between components. • Scalability and durability for long-term use and increased mail volume.	• Cost-effective design to keep the system affordable for customers to purchase. • Low operational and maintenance costs for long-term use.
Expected Degree of Novelty	
• Improvements for refining existing processes. • Balance between cost-effective upgrades and competitive innovation.	

RESOLVING CONTRADICTIONS

USING PRINCIPLES OF TRIZ

UF: Increasing number of trays for higher throughput

HF: Solution might not be compact

1. **Segmentation**
   - Break the radial structure into modular components that can be rearranged or stacked vertically. **Introduce tiers of trays** with vertical stacking while keeping the **radial structure** compact.

13. **Separation of Spaces:**
   - Divide the sorting area into zones based on usage frequency. Frequently used trays can remain at hand level, while less used ones are placed in less accessible zones.

25. **Self-Service:**
   - Implement rotating or carousel mechanisms so trays move to the operator, reducing the need for extra space to access them.

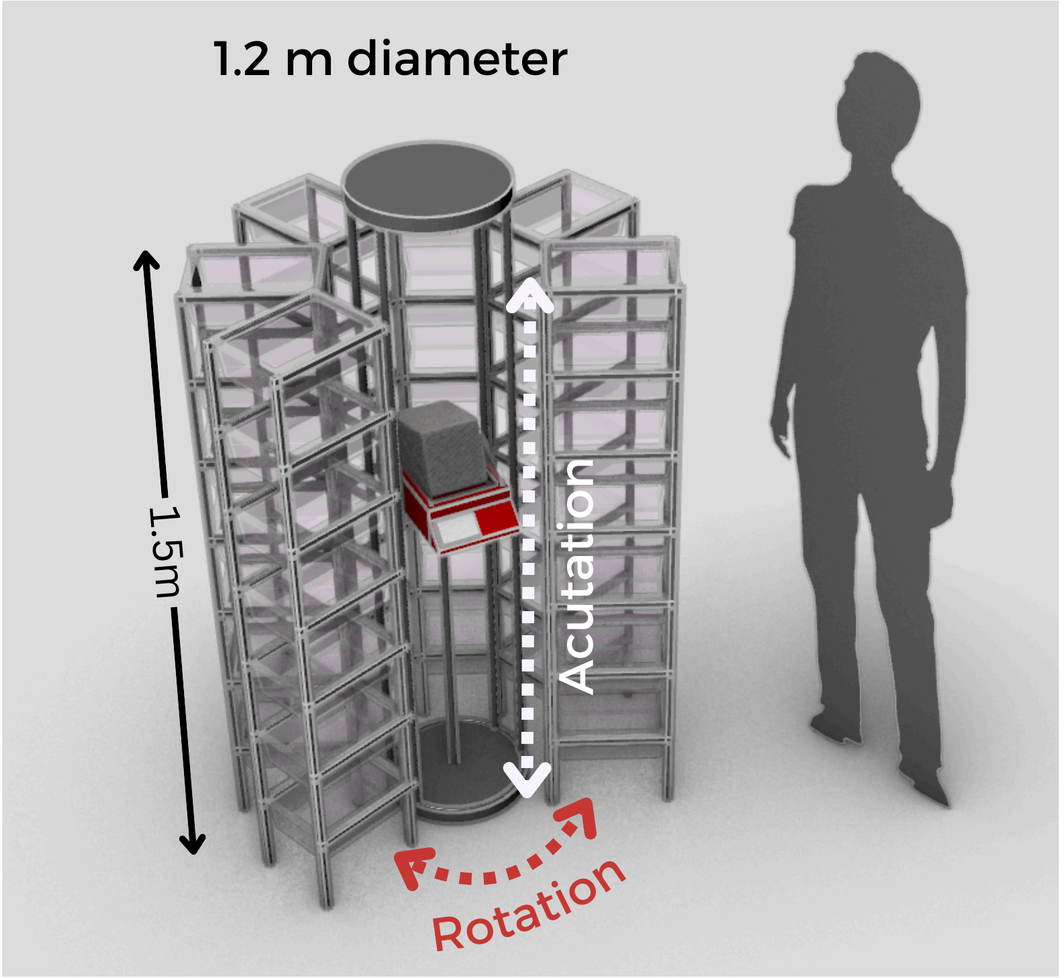
RESOLVING CONTRADICTIONS

USING PRINCIPLES OF TRIZ

Segmentation

- A multi-tiered, **rotating sorter** with **vertically adjustable levels** and subdivided trays.
- The operator loads mail into a **central feeder**, and the system rotates and dispenses sorted mail into trays by category. Dynamic partitions within trays allow sorting for subcategories.

  - Multiple levels of trays
  - Adjustable head height of the rotation
  - Compartmentalization
  - More frequent destinations stay low, less frequent high



EVALUATION AND SELECTION OF CONCEPTS

COMPARISON OF CONCEPTS

	C1 Size of system (cm^3)	C2 Throughput (mails/hr)	C3 Manual effort for stamping (J/hr)	C4 Sorting Accuracy (%)	C5 Ink efficiency (imprints/ml)
A1	20 x 15 x 15 = 4500	400	40	97	300
A2	Machine: 30 X 20 x 25 = 15000 System: 120 x 120 x 150 = 2160000	650	0	97	185
Target	15000	500	35	98	150

LEXICOGRAPHICAL RULE

ORDINAL METHOD

	C1 Size of system (cm^2)	C2 Throughput (mails/hr)	C3 Manual effort (J/hr)	C4 Sorting Accuracy (%)	C5 Ink efficiency (imprints/ml)
Rank	5	2	3	1	4
A1	1	2	2	1	1
A2	2	1	1	1	2

DATUM METHOD - PUGH MATRIX

ORDINAL METHOD

	C1	C2	C3	C4	C5	SUM OF +	SUM OF -	SUM OF S
A1	+	-	-	S	+	2	2	1
A2	-	+	+	S	-	2	2	1

WEIGHTED OBJECTIVES METHOD

CARDINAL METHOD

Sr. No.		K1	K2	K3	K4	K5	SUM	Weightage	ki
1	Size of system		0	0.5	0	0	0.5	0.05	5
2	Throughput	1		0	0	1	2	0.2	20
3	Manual effort	0.5	1		0	1	2.5	0.25	25
4	Sorting accuracy	1	1	1		1	4	0.4	40
5	Ink efficiency	1	0	0	0		1	0.1	10

WEIGHTED OBJECTIVES METHOD

CARDINAL METHOD

	C1 Size of system (cm^2)	C2 Throughput (mails/hr)	C3 Manual effort (J/hr)	C4 Sorting Accuracy (%)	C5 Ink efficiency (imprints/ml)
A1	4500	400	40	97	300
A2	15000	650	0	97	185

	C1 Size of system (cm^2)	C2 Throughput (mails/hr)	C3 Manual effort (J/hr)	C4 Sorting Accuracy (%)	C5 Ink efficiency (imprints/ml)	SUM
ki	5	20	25	40	10	
A1	9	3	4	4	9	375
A2	5	8	9	4	7	640

SELECTION OF CONCEPT

	Concept 1	Concept 2
Lexicographical	1	1
Datum	1	1
Weighted Objective	2	1

SELECTED DESIGN

CARDINAL METHOD