Optimization of Maintenance and Renovation Project Selection Via Risk-Based Analysis at the IWK

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PROJECT DEFINITION

- The Redevelopment, Space & Leasing (RDSL) team oversee facility renovation and complex maintenance projects.
- Projects for the coming year are chosen at beginning of the fiscal year with a set budget. Project selection is limited based on available resources. This is a challenge, as numerous possible projects could be selected.
- The client finds often, at project budget allocation time, the most relevant projects at the time get selected. This makes project selection less informed in terms of risk analysis and budget optimization.

PROJECT SCOPE/OBJECTIVES

Inclusions

- Identifying facilities-based potential failure points in mechanical, electrical, and various other structures/systems.
- Proposing solutions for each of the identified issues.
- Solving small problems that can be immediately addressed throughout the project.
- Developing a model that is user friendly to assist in future budget allocation.

Exclusions

- Problems stemming from the lack of space in the facility.
- Assessment of clinical processes.

Objectives

- Optimize allocation and spending of maintenance and renovation budget by conducting a thorough Failure Modes and Effects Analysis (FMEA) that captures as many problems as possible and prioritizes based on Risk Profile Number (RPN) analysis.
- Create model/tool that will assist in budget allocation and project planning.
- Refine FMEA documentation and respective process.
- Redesign budget allocation process and develop SOPs.
- Address maintenance and renovation issues as they are encountered.

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METHODS & ANALYSIS (FMEA)

- A practical and repeatable process for identifying and analyzing facility failure points was required. Furthermore, this process needed to result in a quantifiable and semi-objective assessment of facility failure points.
- FMEA discussions were conducted to score, and rank identified failure effects.
- Interviews with IWK staff were completed in the following departments to gather a list of infrastructural improvements:
  - Redevelopment, Space & Leasing
  - Housekeeping & Environmental Services
  - Occupation Health
  - Fire Safety
  - Maintenance

Criteria for FMEA Analysis

In what ways can the step go wrong?	What is the impact on the customer if the failure more is not prevented or corrected?	How severe is the effect on the customer?	What causes the step to go wrong (i.e. how could the failure mode occur)?	How frequently is the cause likely to occur?	What controls exist that either prevent or detect the failure?	How probable is detection of the failure mode or its cause?	Risk Priority Number: Calculated as SEV x OCC x DET	What are the actions for reducing the occurrence of the cause or for improving its detection? (Provide actions on all high RPNs and on severity ratings or 9 or 10)
Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurance	Current Process Controls	Detection	RPN	Action Recommended

SOLUTIONS

Project Selection Tool – Excel application for optimizing project selection according to changes in RPN and available budget. The following is the mathematical formulation for the tool (resource scheduling component not included in tool):

Parameters for Sets

n: number of individual failure modes

v: number of combined individual failure modes that can me mitigated together

m_i: number of mitigation levels (projects) for failure mode i

T: number of planning periods in a year

K: number of types of resources to be considered in project planning

Indices

i: index of failure modes (FM), $i \in \boldsymbol{I} \cup \boldsymbol{Q} = \{1, \dots, n\} \cup \{n+1, \dots, n+v\}$

q: index of combined FM, $q \in \boldsymbol{Q} = \{n+1, \dots, n+v\}$

j: index of individual FM combined in FM q, $j \in \boldsymbol{I_q}$

l: index of mitigation levels (projects), $l \in \boldsymbol{L_i} = \{1, \dots, m_i\}$

t: index of planning periods, $t \in \boldsymbol{T} = \{1, \dots, T\}$

k: index of resource types, $k \in \boldsymbol{K} = \{1, \dots, K\}$

Other Parameters

c_{il}: cost of project l to address FM i

d_{il}: duration of project l to address FM i (in same time unit as T)

r_{ilk}: demand of resource k for project l to address FM i

ΔRPN_{il}: reduction in RPN of FM i if project l is performed

S_i: severity of FM i

W_{il}: severity weighted reduction in RPN for FM i if project l is performed ($W_{il} = S_i \times \Delta RPN_{il}$)

R_k: total available capacity for resource k

B: total annual improvement budget

Decision Variables

$$x_{ilt} = \begin{cases} 1, & \text{if project } l \text{ is selected to start in period } t \text{ to address FM } i \\ 0, & \text{otherwise} \end{cases}$$

DISCRETE-TIME FORMULATION

Objective Function

$$Maximize \sum_{i \in \boldsymbol{I}} \sum_{l \in \boldsymbol{L_i}} \sum_{t \in \boldsymbol{T}} W_{il} x_{ilt} \leq 1$$

Constraints

- Up to one project (mitigation level) can be selected per failure mode:

$$\sum_{l \in \boldsymbol{L_i}} \sum_{t \in \boldsymbol{T}} x_{ilt} \leq 1, \forall i \in \boldsymbol{I} \cup \boldsymbol{Q}$$

- Total cost of all selected projects cannot exceed the available budget:

$$\sum_{i \in \boldsymbol{I}} \sum_{l \in \boldsymbol{L_i}} \sum_{t \in \boldsymbol{T}} c_{il} x_{ilt} \leq B$$

- Projects must finish before the end of the fiscal year (i.e, project i cannot start if it will end after T):

$$\sum_{b=t-d_{il}+1}^{T} x_{ilb} = 0, \forall i \in \boldsymbol{I} \cup \boldsymbol{Q}, \forall l \in \boldsymbol{L_i}$$

- Resource capacity must be satisfied in all time periods:

$$\sum_{i \in \boldsymbol{I}} \sum_{l \in \boldsymbol{L_i}} \sum_{b=t-d_{il}+1}^{t} r_{ilk} x_{ib} \leq R_k, \forall k \in \boldsymbol{K}, \forall t \in \boldsymbol{T}$$

- A selected FM can be mitigated only once as an individual FM or as part of a combined FM:

$$x_{qlt} + x_{jlt} \leq 1, \forall q \in \boldsymbol{Q}, \forall j \in \boldsymbol{I_q}, \forall l \in \boldsymbol{L_i}, \forall t \in \boldsymbol{T}$$

- Domain constraints

$$x_{ilt} \in \{0, 1\}, \forall i \in \boldsymbol{I} \cup \boldsymbol{Q}, \forall l \in \boldsymbol{L_i}, \forall t \in \boldsymbol{T}$$

RESULTS

1. The team delivered a list of **19 potential improvement projects** that were scored and ranked according to the failure modes they would each address.
2. An **improved project selection** process was developed and presented to the client including **standard work documentation**, **data collection tools**, and a **project selection tool**.
3. **Major progress** was made on the **top priority selected project** including meetings and evaluations.