Incorporating Crash Severity to Improve Highway Safety Project Prioritization

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Background

Safety Project Prioritization

The Highway Safety Manual Approach

Safety Performance Functions → Empirical Bayes method → Excess of the expected crashes (EEC*)
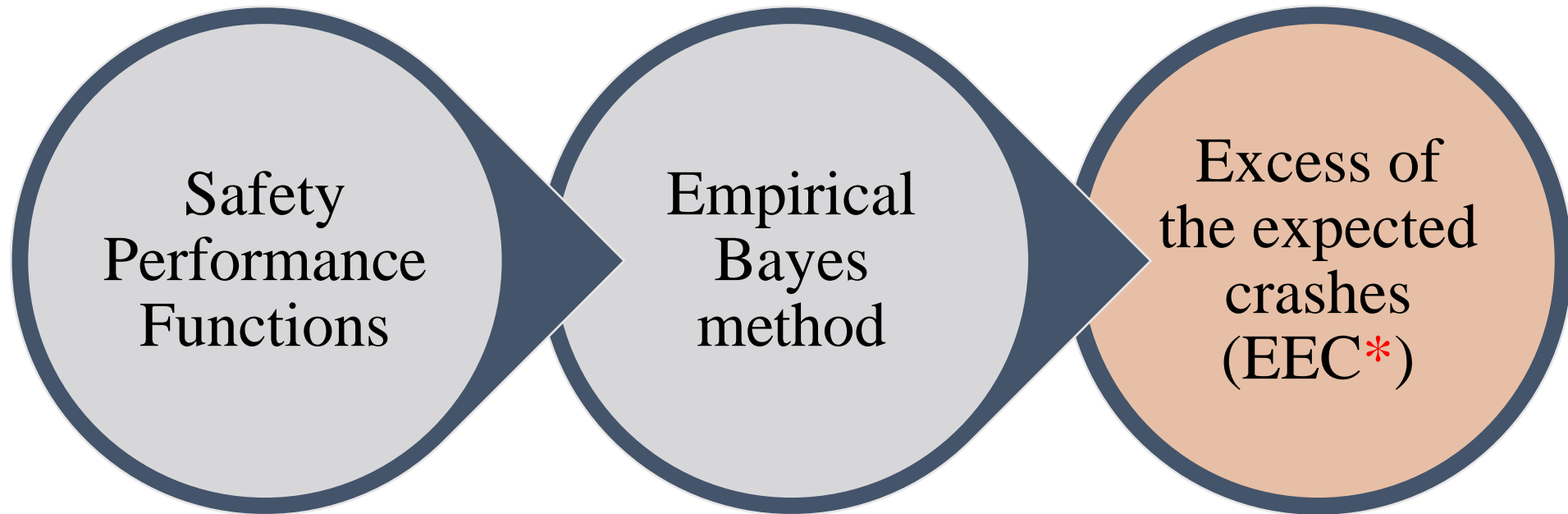
Project Prioritization Criteria

* In Kentucky, PSI is referred to as "EEC"

Safety Performance Functions (SPF)

- Negative Binomial Regression

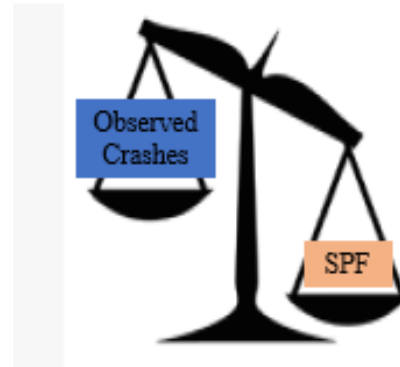$$SPF\ predicted\ crashes\ (N_{SPF}) = e^{\alpha} * Length * AADT^{\beta}$$

Here,
  AADT = Average Annual Daily Traffic
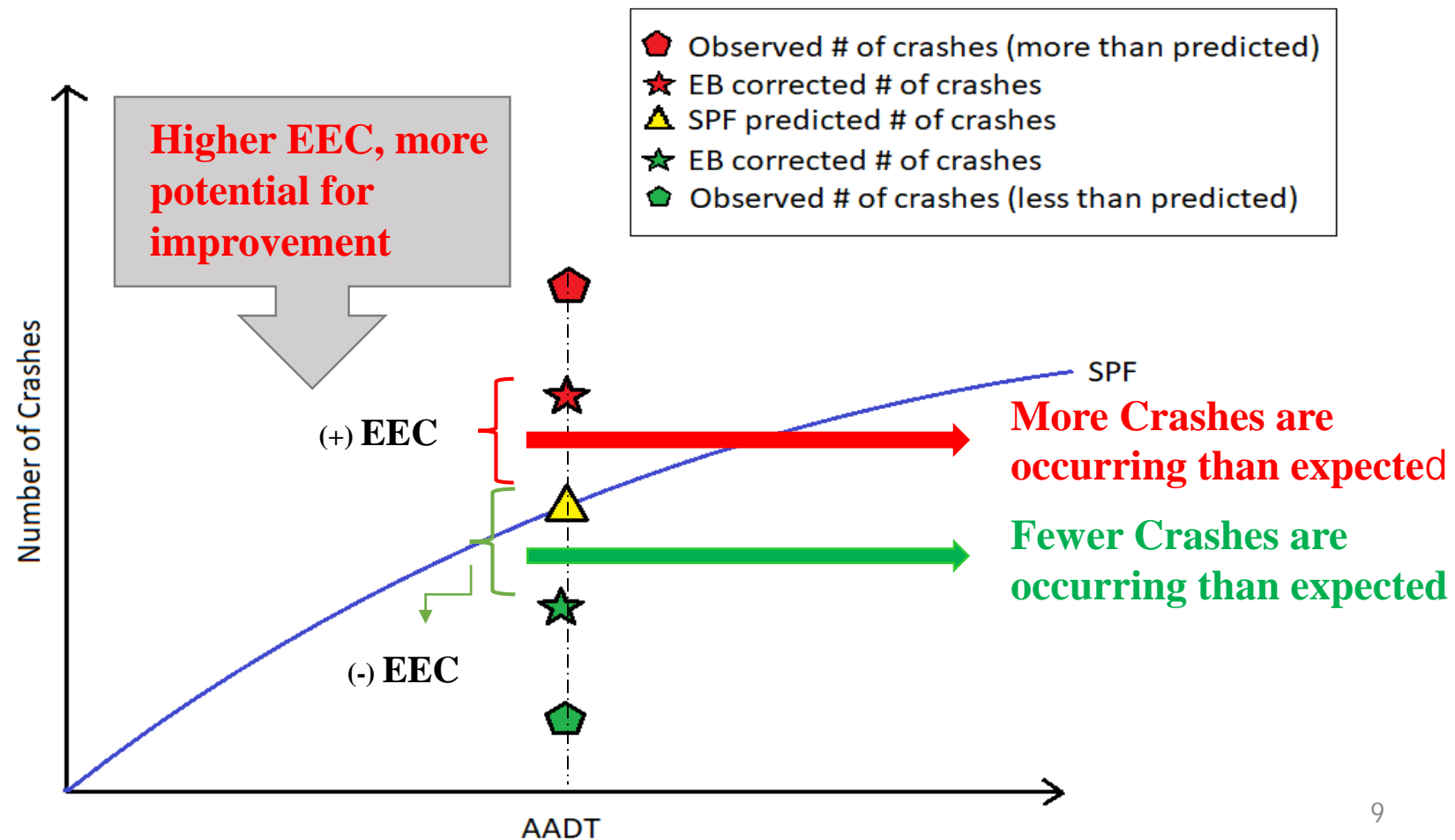 α, β = Regression parameters

Empirical Bayes (EB) Estimate

- Accounts for the regression-to-the-mean bias.

- **EB Expected Crashes** $=$
$weight * SPF\ predicted\ crashes\ + (1 - weight) * observed\ on\ that\ site$

$$weight = \frac{1}{1 + \dfrac{N_{SPF}/Length}{\theta}}$$

Excess Expected Crashes (EEC)

$$EEC = EB\ estimate - SPF\ predicted\ crashes$$

Observed # of crashes (more than predicted)
EB corrected # of crashes
SPF predicted # of crashes
EB corrected # of crashes
Observed # of crashes (less than predicted)

Higher EEC, more potential for improvement

(+) EEC

(-) EEC

Number of Crashes

AADT

SPF

More Crashes are occurring than expected

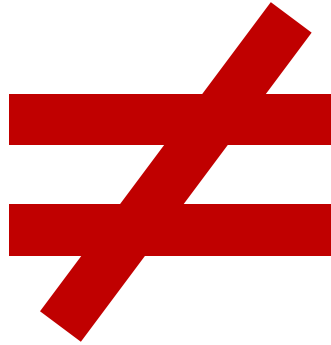Fewer Crashes are occurring than expected

Motivation of the research

Problem Statement 1: Equal weight on all crashes

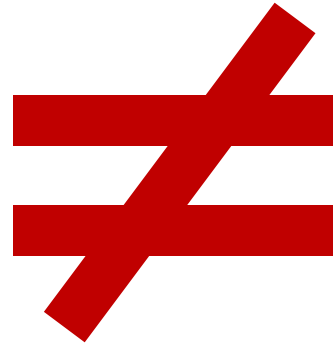**EEC = 20**

Fatal = 20%
PDO = 80%

≠

EEC = 20

Fatal = 50%
PDO = 50%

Problem Statement 2: *Does not reflect magnitude of the projected crashes*

EEC = EB crashes – SPF crashes

EEC = 20

EB crashes = 80
SPF crashes = 60

$\neq$

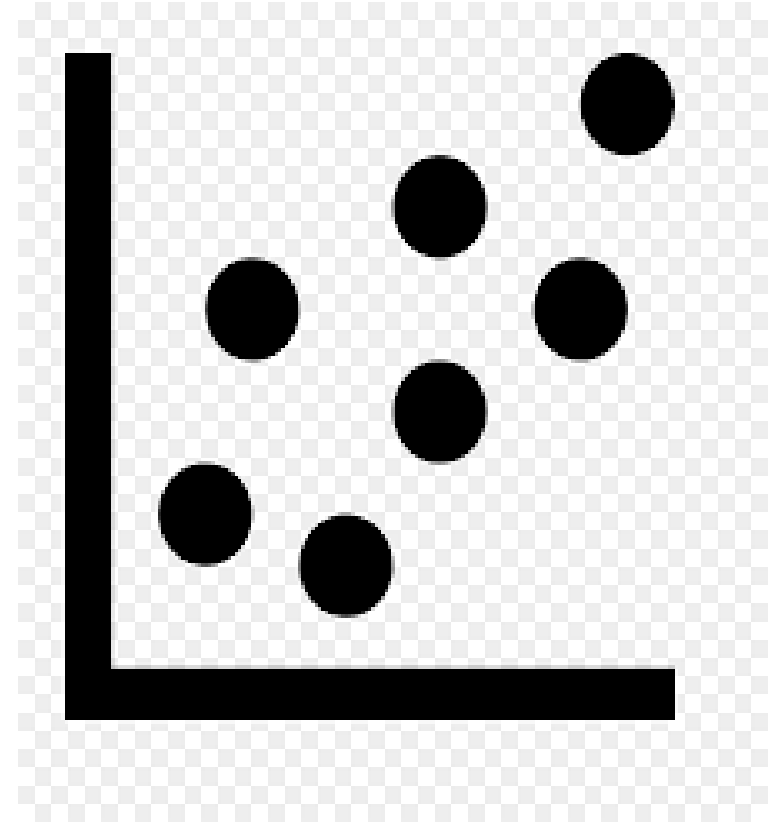**EEC = 20**

EB crashes = 30
SPF crashes = 10

Goal of the research

The study aims to improve project prioritization process by:

- ➢ Integrating crash severity
- ➢ Using both EB estimate and EEC
- ➢ Proposing a goal-driven EEC

Data

Data Source

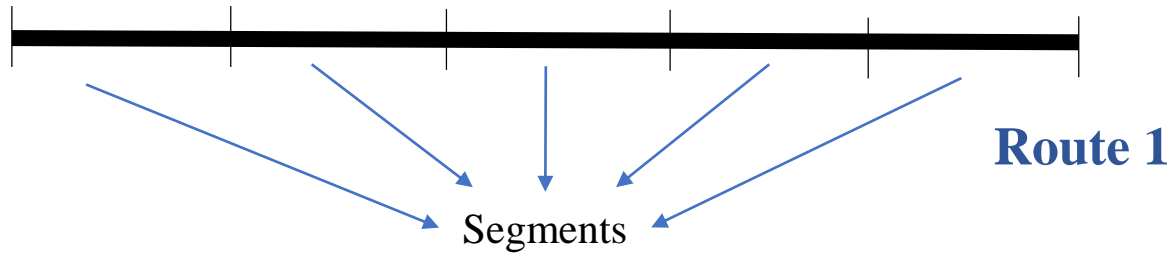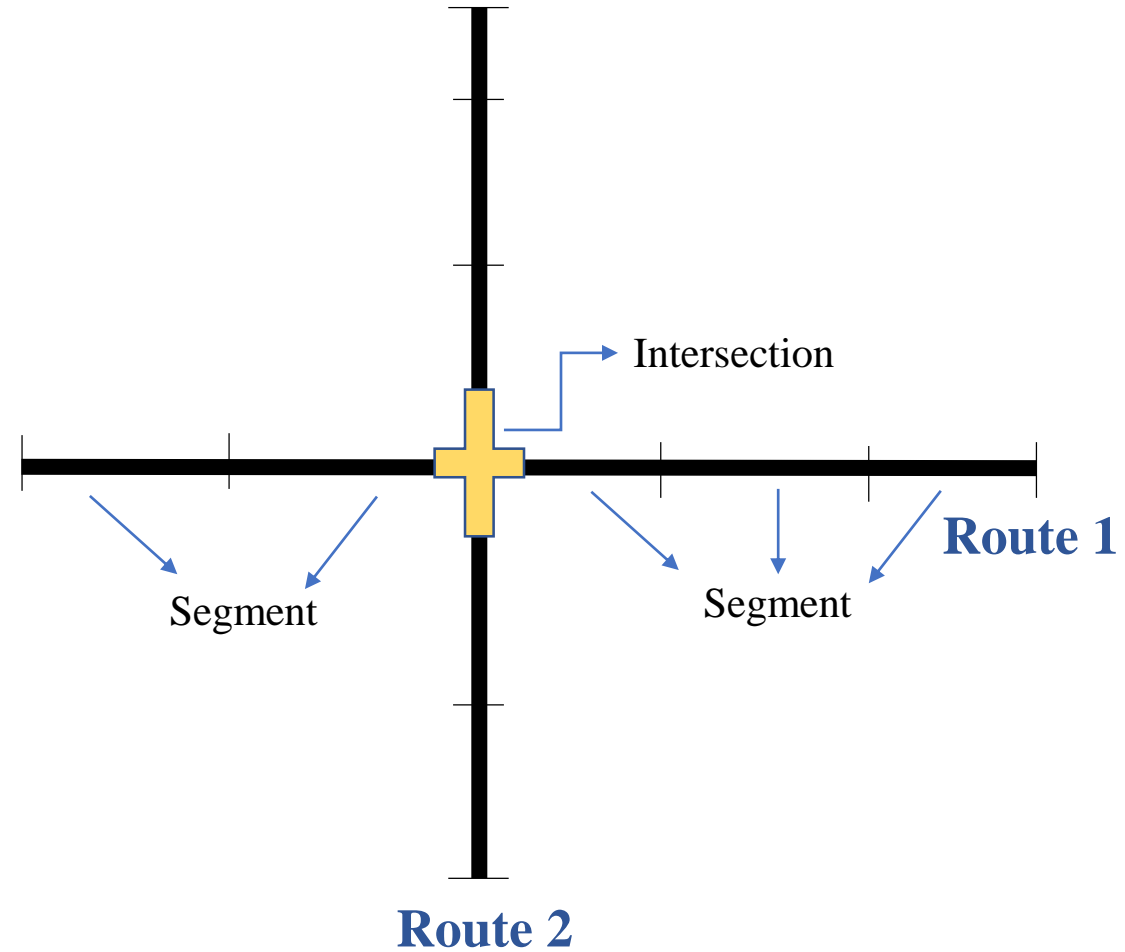|	
Roadway Data	Highway Information System (HIS)
Intersection Data	Kentucky Transportation Center (KTC)
Crash Data (2013-2017)	Kentucky State Police (KSP)

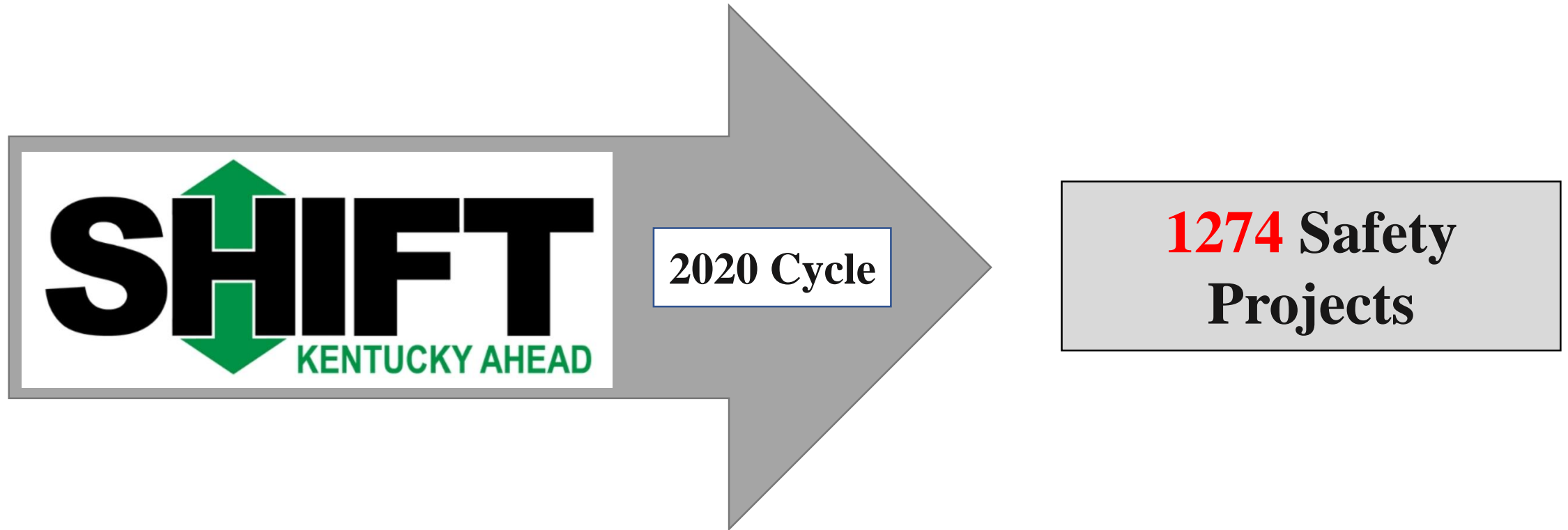# Project Prioritization

Definition of a project

Route 1

Segments

Route 1

Intersection

Segment

Segment

Route 1

Route 2

Example 2

Example 1

Example projects

SHIFT
KENTUCKY AHEAD

2020 Cycle

1274 Safety Projects

Proposed Improvements

Combination of EEC_{KAB} and EEC_{CO}

Combination of EB_{total} and EEC_{total}

EEC_{alt}

Initial Method

Ranking Criteria

$$EEC_{total\ (KABCO)}$$

SHIFT
KENTUCKY AHEAD

2020 Cycle

Improvement 1: *Combination of EEC for KAB and CO*
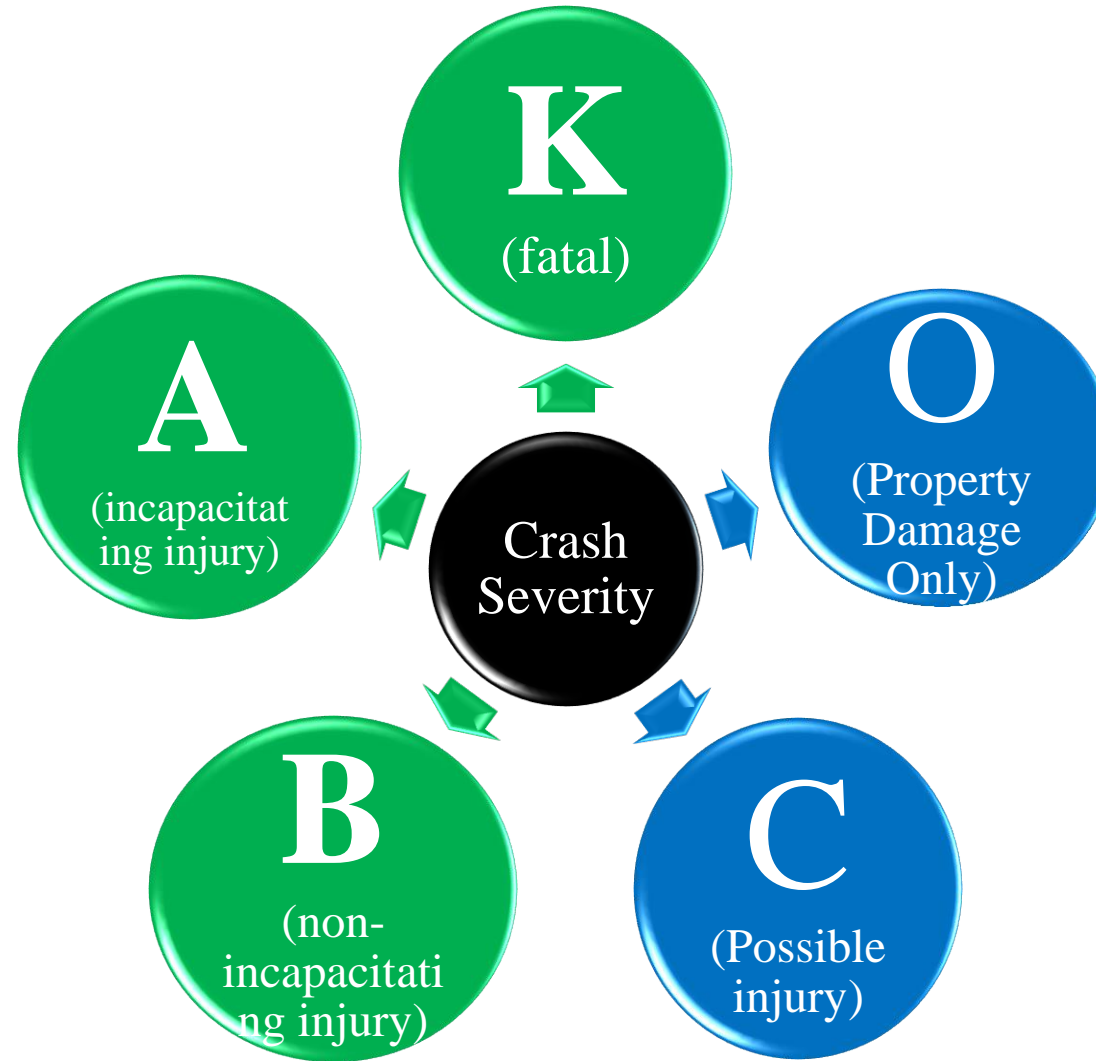
Improvement 1: Combining KAB and CO for EEC

Ranking Criteria

$$R_1 = a * EEC_{KAB} + b * EEC_{CO}$$

KENTUCKY	Weighted average cost	%
KAB	$652,612	**89%**
CO	$81,187	**11%**
Total	$733,799	100%

a = 0.89, b = 0.11

Improvement 1 : *Combining KAB and CO for EEC*

Rank by improvement 1

Rank by initial method
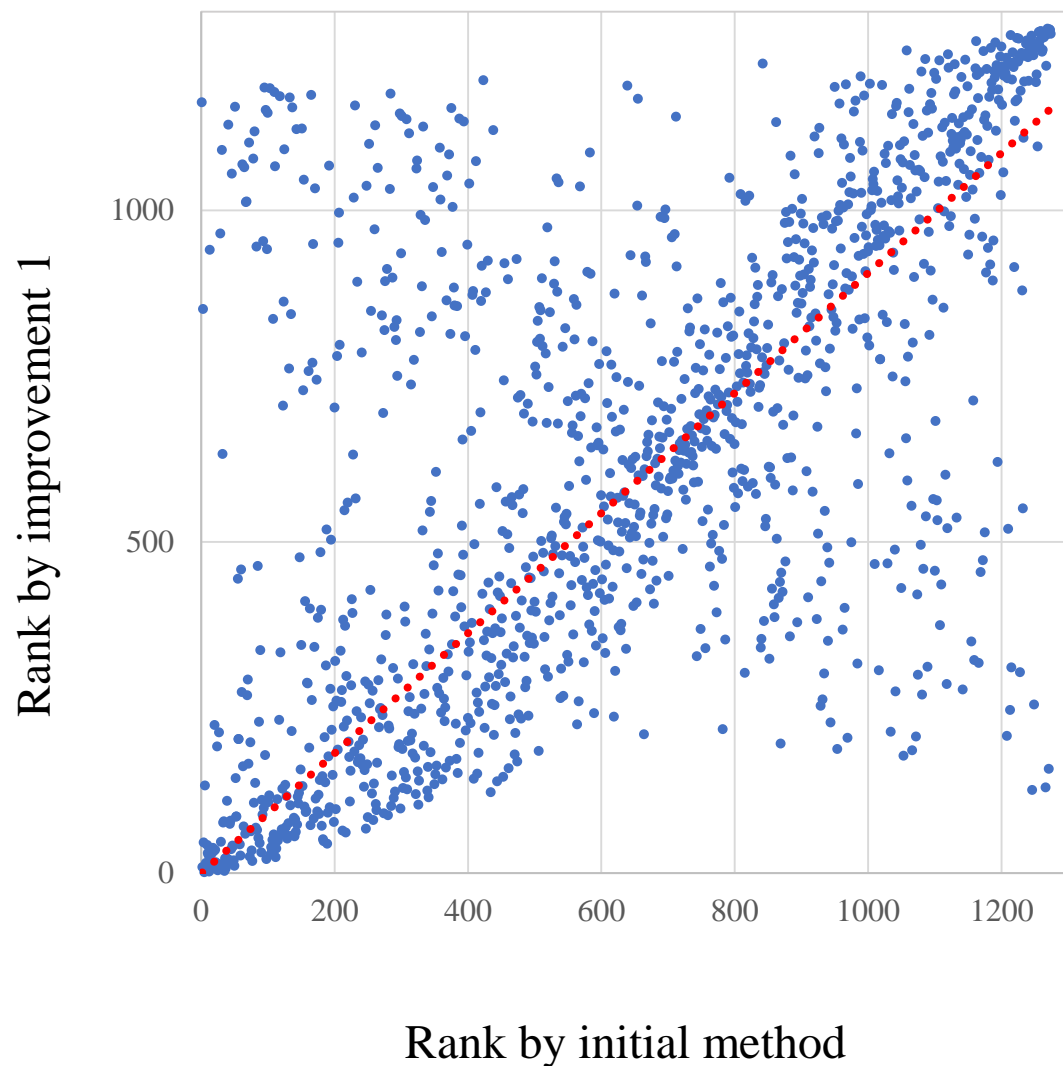
Differences in ranking between improvement 1 and initial method

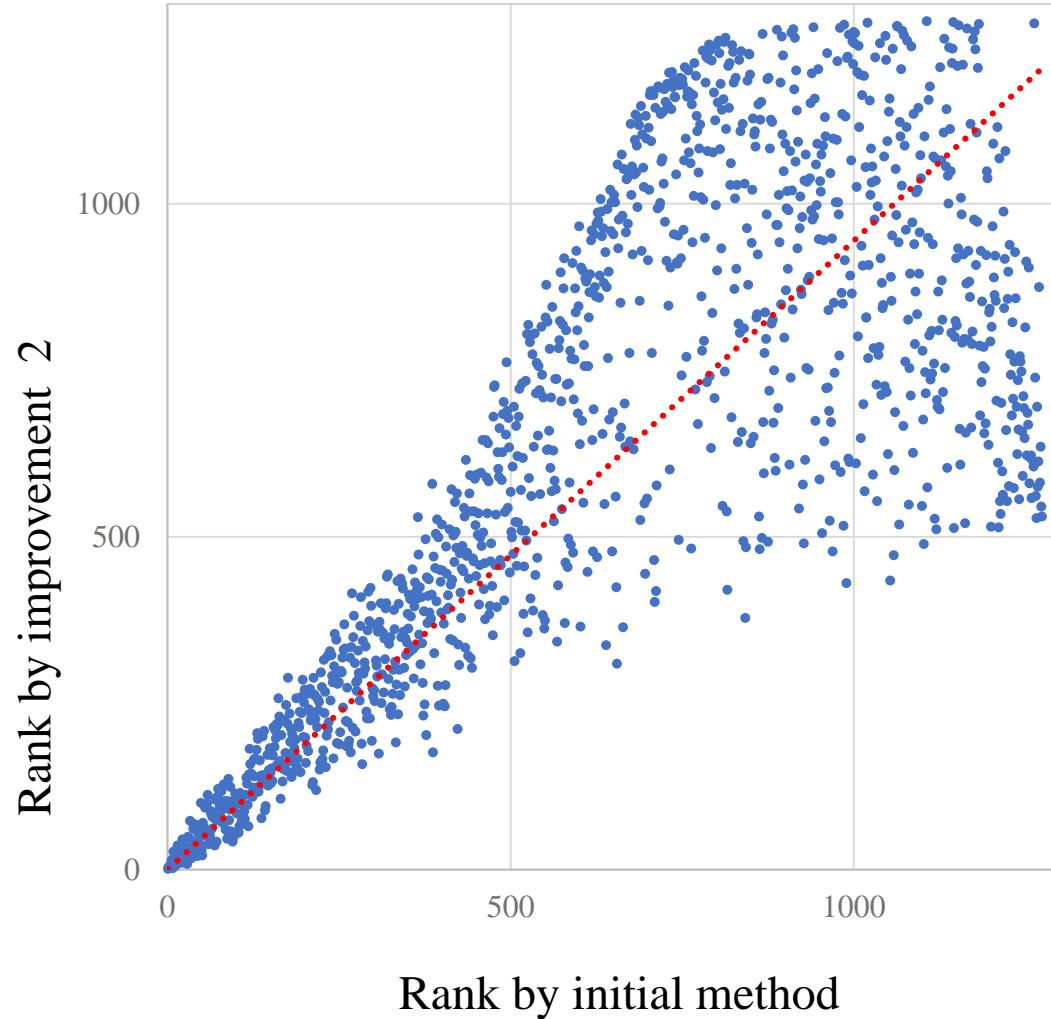| Ranking Difference	Number of projects	%
± 10 positions	95	7.5
± 20 positions	75	5.9
± 50 positions	178	14.0
± 100 positions	252	**19.8**
> 100 positions	674	**52.9**
Total	**1274**	**100**

73%

Improvement 2 : Combination of EB and EEC

Ranking Criteria

$$R_2 = m * EB_{total} + n * EEC_{total}$$

m = 0.50, n = 0.50

Improvement 2 : *Combination of EB and EEC*

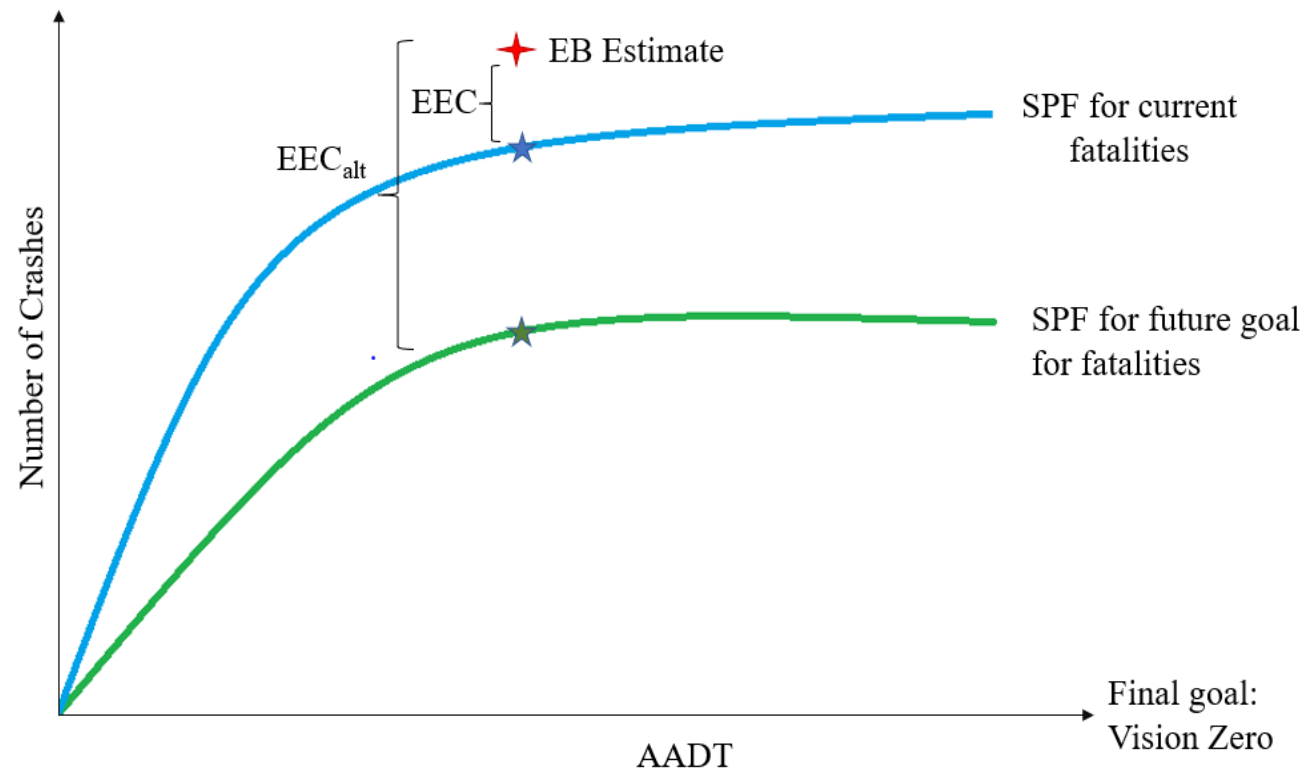Differences in ranking between improvement 2 and initial method

Ranking Difference	Number of projects	%
± 10 positions	112	8.8
± 20 positions	77	6.0
± 50 positions	198	15.5
± 100 positions	206	**16.2**
> 100 positions	682	**53.5**
Total	**1274**	**100**

70%

Improvement 3: *Goal-driven EEC [EEC_{alt}]*

$$EEC_{alt} = EB_{total} - \left(\frac{SHSP\ fatalities\ goal}{Current\ fatal\ crashes} \right) * N_{SPF(Total)}$$

Improvement 3 : *Goal-driven EEC [EEC$_{alt}$]*

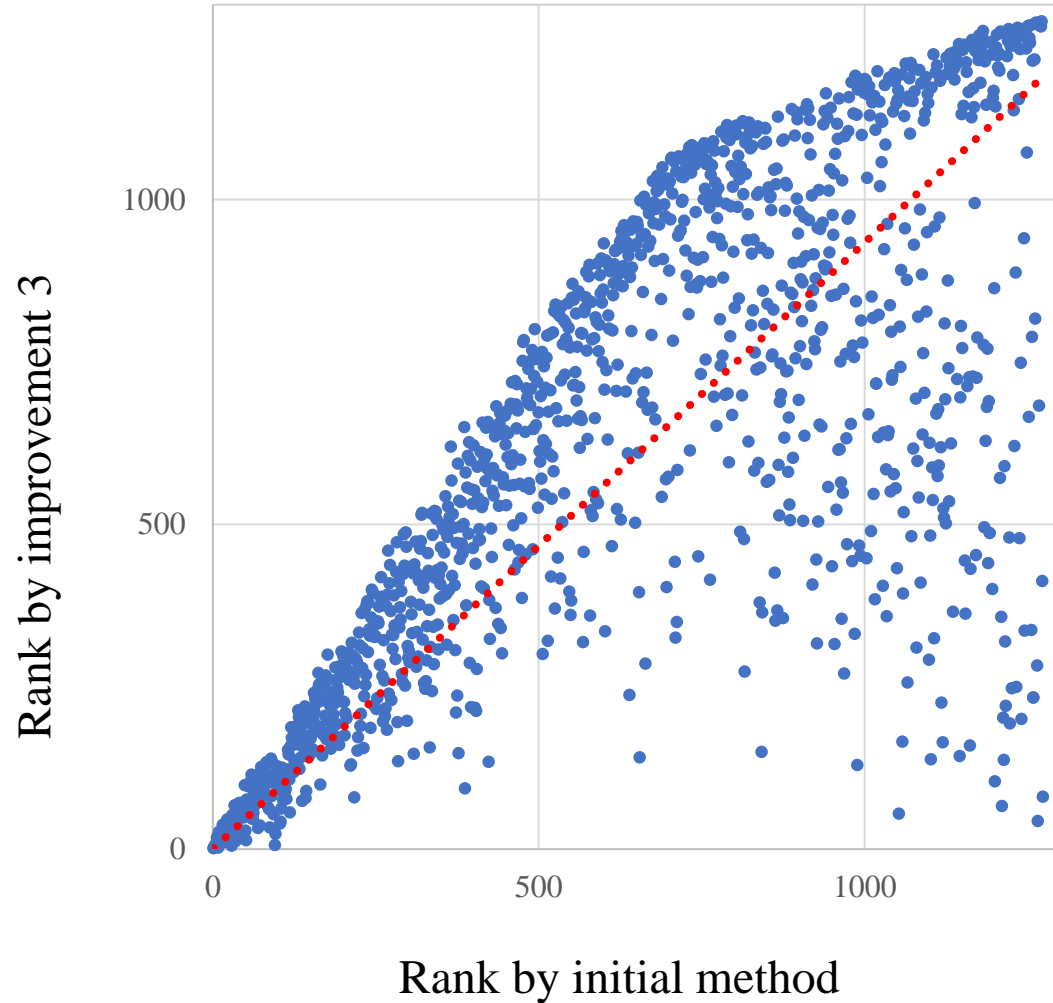Ranking Criteria

EEC$_{alt(total)}$

Acc. to the Kentucky 2020-2024 SHSP,
Fatalities per year = 750
Goal of fatalities = 500
So, **ratio = 2:3**

$$EEC_{alt(total)} = EB_{total} - \left(\frac{2}{3}\right) * N_{SPF(Total)}$$

Improvement 3 : Goal-driven EEC [EEC_alt]

Rank by improvement 3 / Rank by initial method

Differences in ranking between improvement 3 and initial method

Ranking Difference	Number of projects	%
± 10 positions	97	7.6
± 20 positions	66	5.2
± 50 positions	172	13.5
± 100 positions	218	**17.1**
> 100 positions	721	**56.6**
Total	**1274**	**100**

74%

Results

Improvements	Description	A significant difference in the ranking?*
1	Combination of EEC_{KAB} and EEC_{CO}	Yes
2	Combination of EB_{total} and EEC_{total}	Yes
3	$EEC_{alt\ (total)}$	Yes

Compared with the initial method (EEC_{total})

Final Ranking Metric
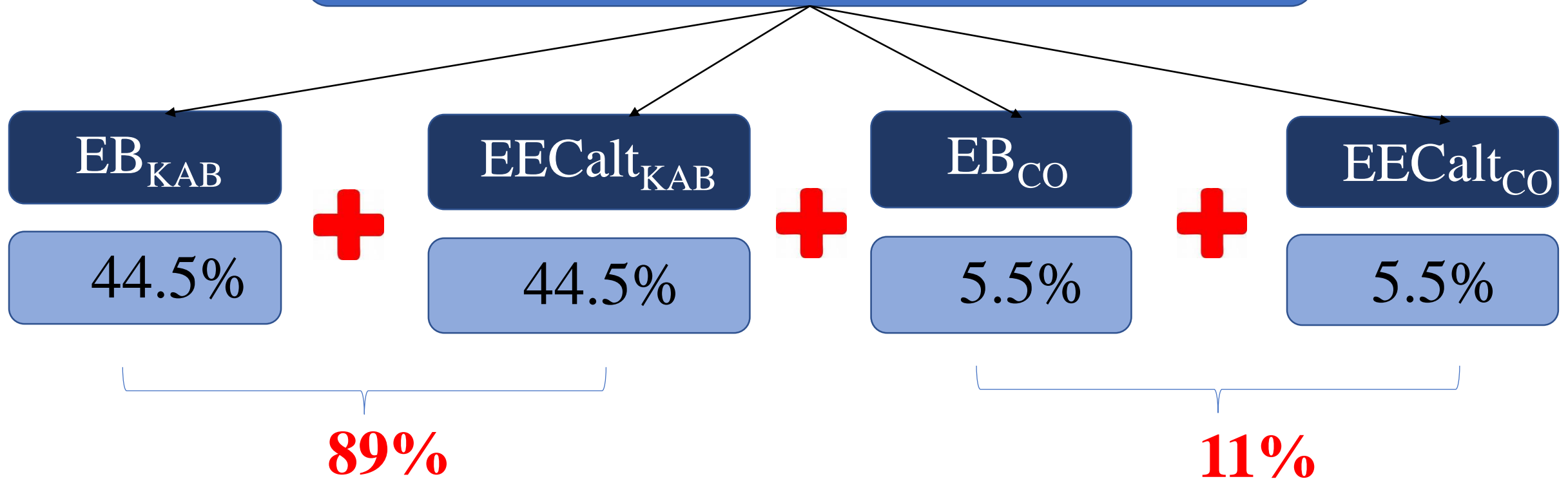
✓ **Combination of EEC$_{KAB}$ and EEC$_{CO}$**
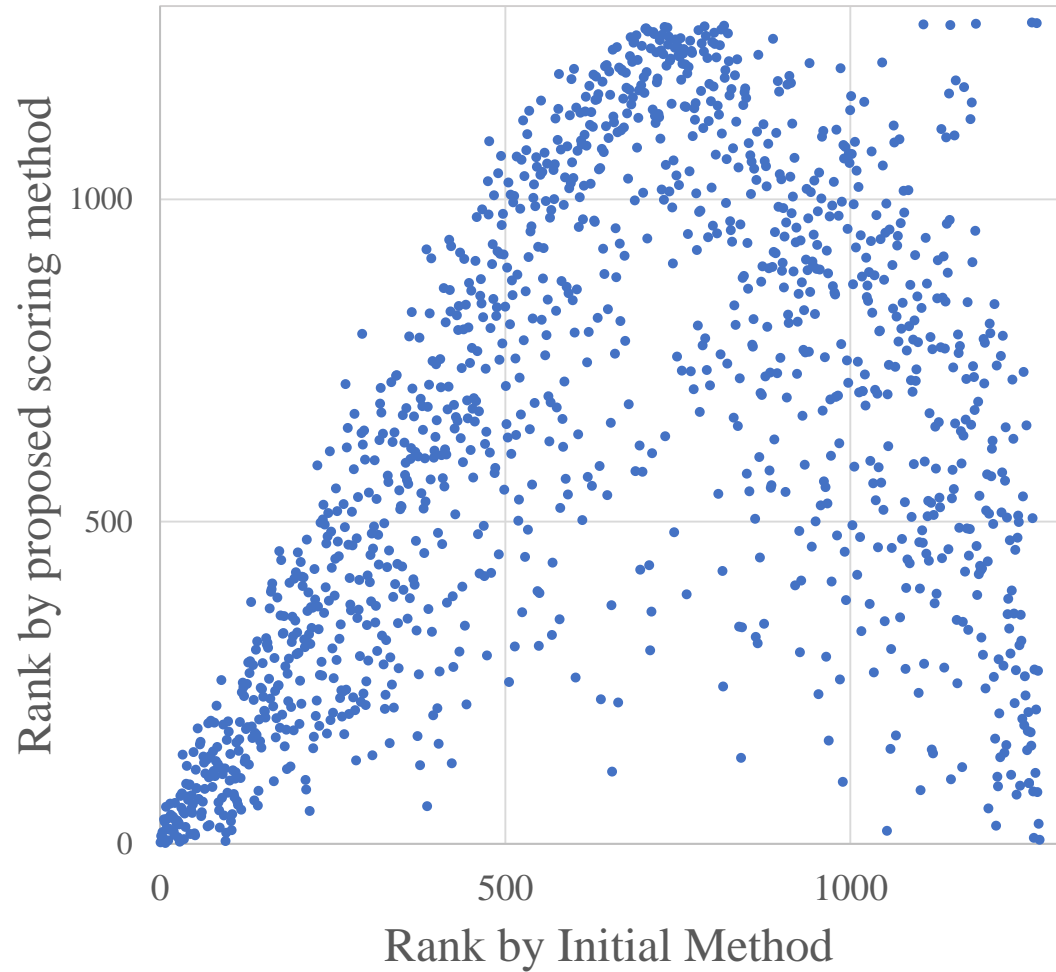
✓ **Combination of EB$_{total}$ and EEC$_{total}$**

✓ **EEC$_{alt\ (total)}$**

$$R = 0.445 * EB_{KAB} + 0.445 * EEC_{alt(KAB)} + 0.055 * EB_{CO} + 0.055 * EEC_{alt(CO)}$$

Comparison: Proposed Method vs Initial Method

Differences in ranking between proposed method and initial method

Ranking Difference	Number of projects	%
± 10 positions	51	4.0
± 20 positions	38	3.0
± 50 positions	127	10.0
± 100 positions	145	**11.3**
> 100 positions	913	**71.7**
Total	**1274**	**100**

83%

Questions?

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