

# **How Accuracy Impacts the Economic Benefit of Cable Diagnostic Programs**

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# Acknowledgements

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- Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of Energy.

# Outline

- Motivation
- Economics Model
- Effects of Accuracy on the Economics Model
- Illustrative example
- Conclusions

# Motivation

- The goal of proactive maintenance is to prevent future service failures
  - Wholesale Replacement
  - Targeted Maintenance
- A Targeted Maintenance program uses diagnostic test(s) to identify the “weak” circuits.
- Program carries upfront costs that must be offset by program benefits.
- The economics of diagnostics are difficult to model and even more difficult to quantify. Must be used to quantify the benefits.

# Components of Economics Model

- **Selection**

Data compilation and analysis needed for selecting the target population.

- **Diagnostic Testing**

Actual performance of the testing on the target population

- **Maintenance**

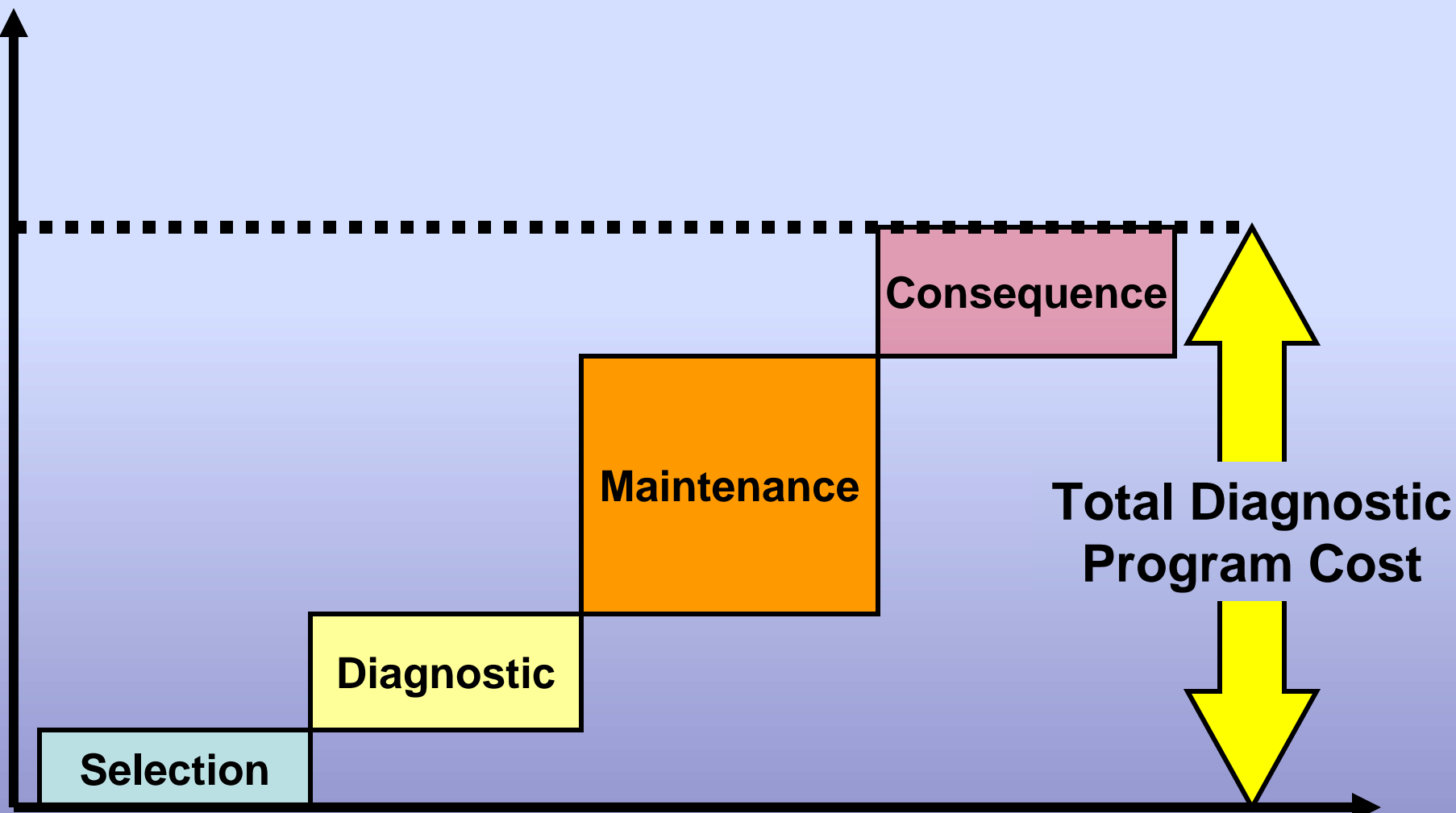
Actions taken on circuits based on results of diagnostic test

- **Consequence**

Service failures occurring in target population during diagnostic horizon.

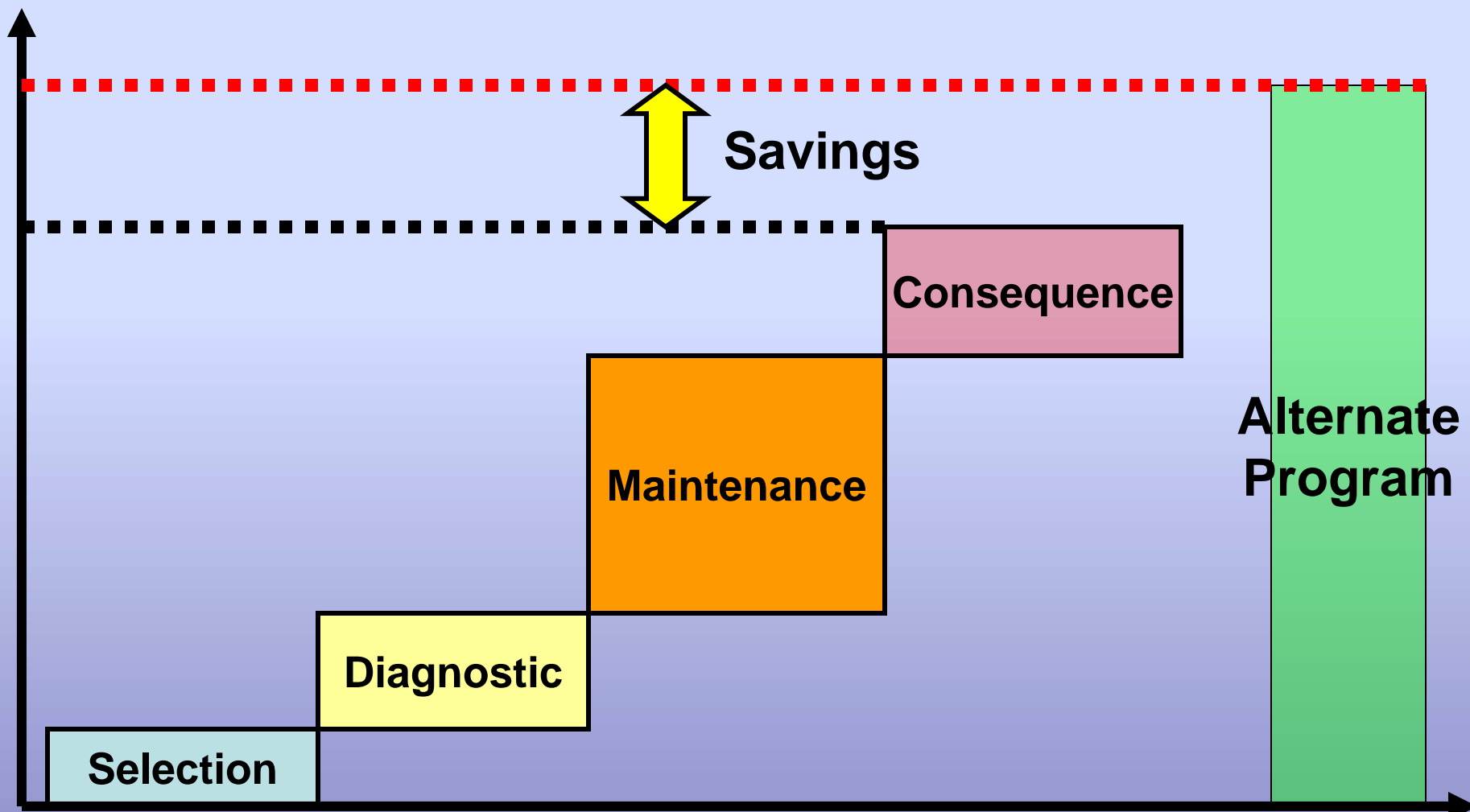
# Diagnostic Program Costs

Cost [\$]



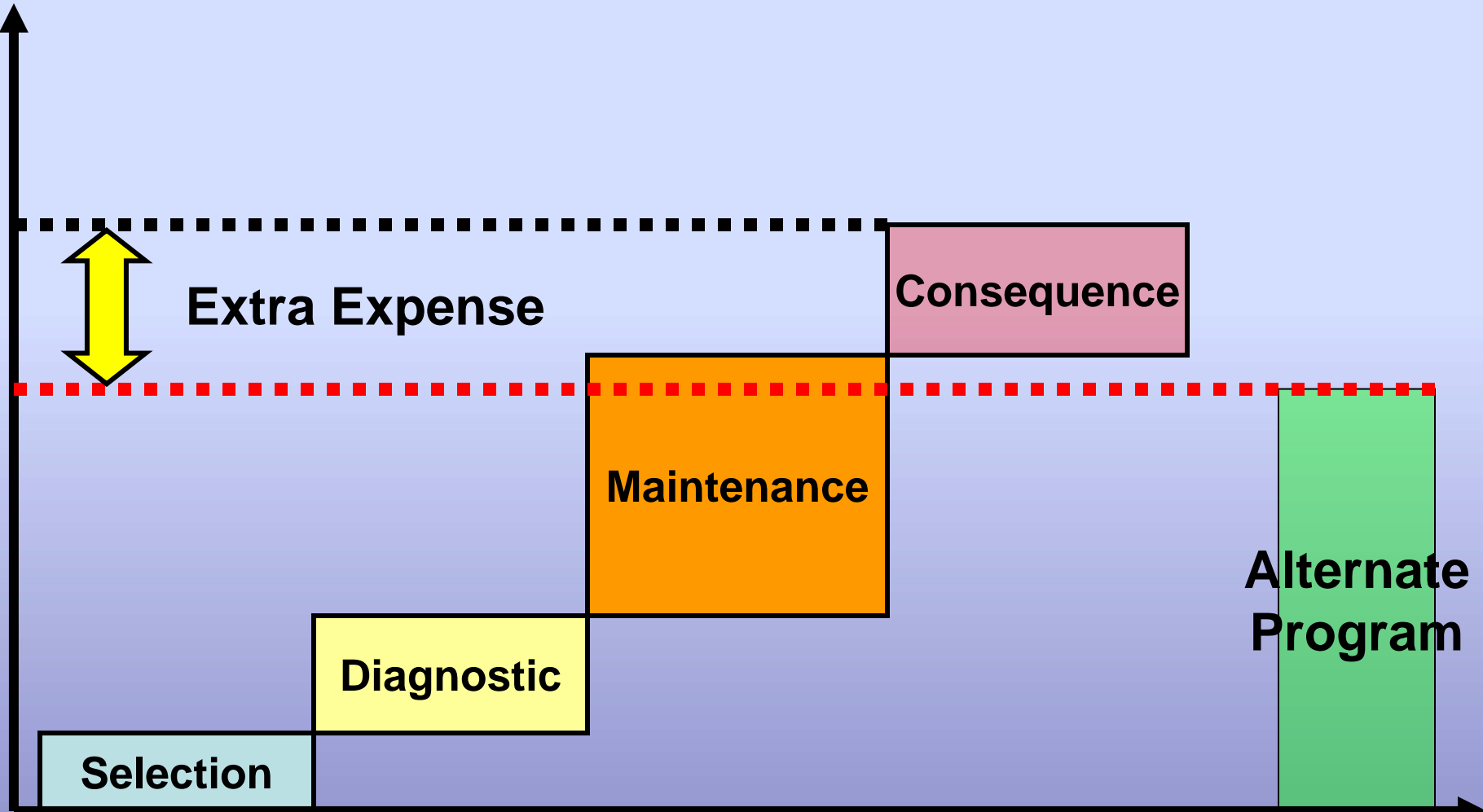
# Program Savings

Cost [\$]



# Program Additional Spending

Cost [\$]



# Where does accuracy have an impact?

Cost [\$]

**Accuracy Dependent Costs**

**Accuracy Independent Costs**

Consequence

Maintenance

Diagnostic

Selection

# Why does accuracy affect these costs?

- Maintenance cost is directly determined by diagnostic testing results
  - Maintenance can be misspent on “Good” circuits
  - “Bad” circuits may not receive maintenance
- Consequence cost is determined by inaccuracy of diagnostic test
  - “Bad” circuits diagnosed as “Good” will lead to service failures.

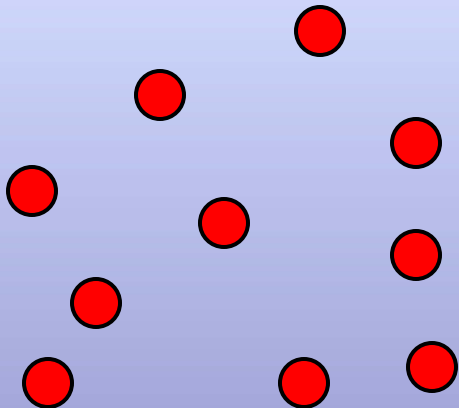
**Will use a two-level diagnostic as an illustration**

# Diagnostic Population

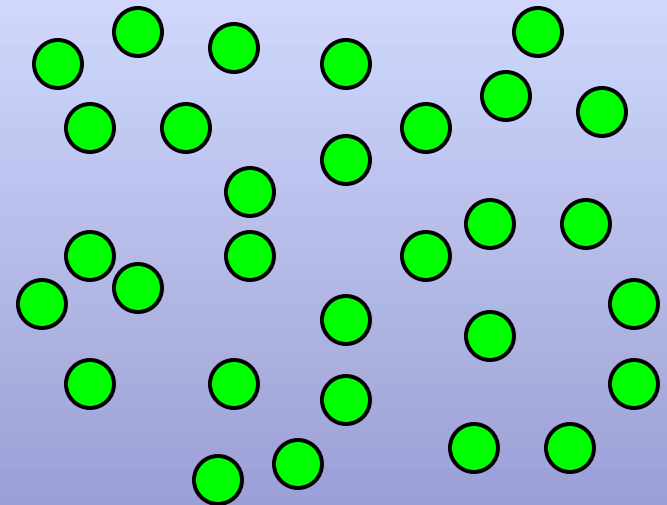
The target population contains both “Good” and “Bad” circuits

- “Good” – Will not fail within diagnostic horizon
- “Bad” – Will fail within diagnostic horizon

“Bad” Circuits



Target Population “Good” Circuits

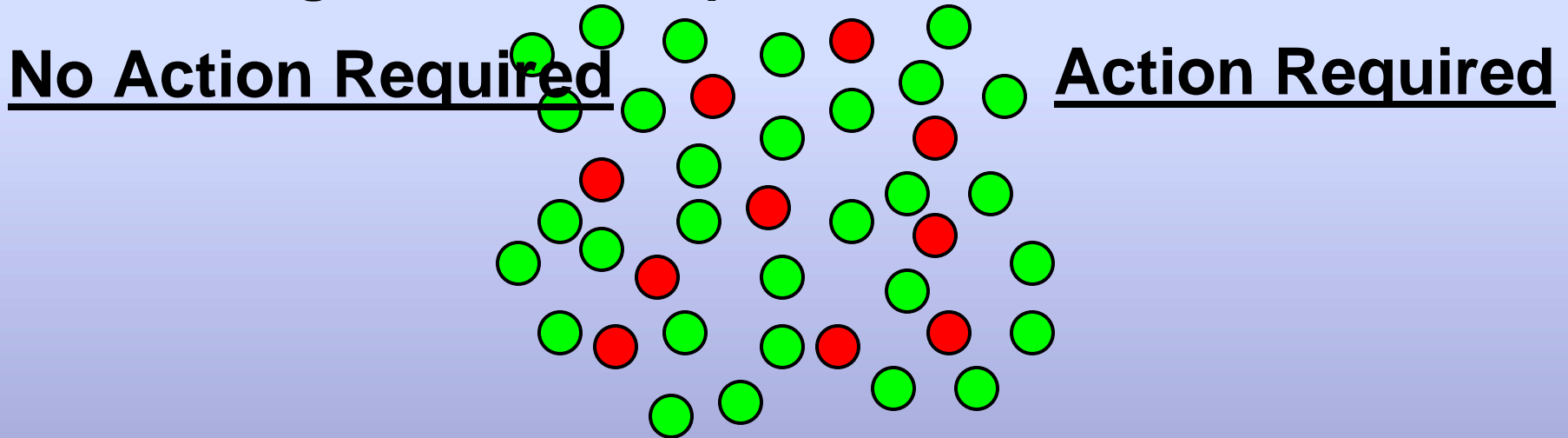


# Diagnostic Operation

Applying the diagnostic will separate the population into:

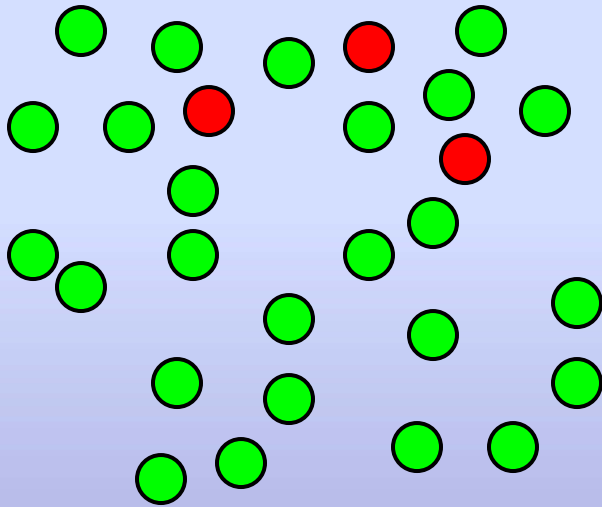
- No Action Required group
- Action Required group

**But all diagnostics are imperfect at some level**



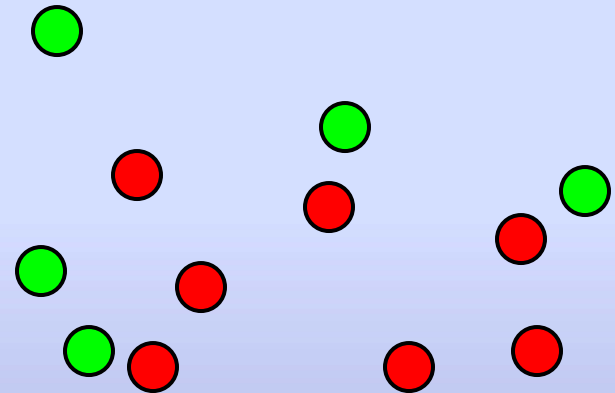
# Population Analysis – Correct Diagnosis

## No Action Required



Avoided Maintenance

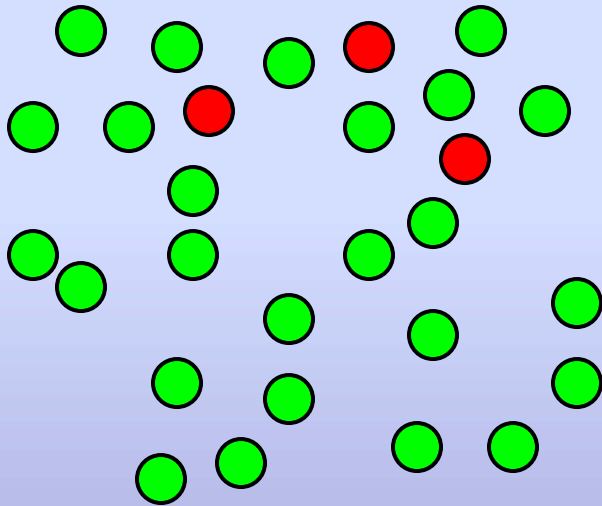
## Action Required



Avoided service failures

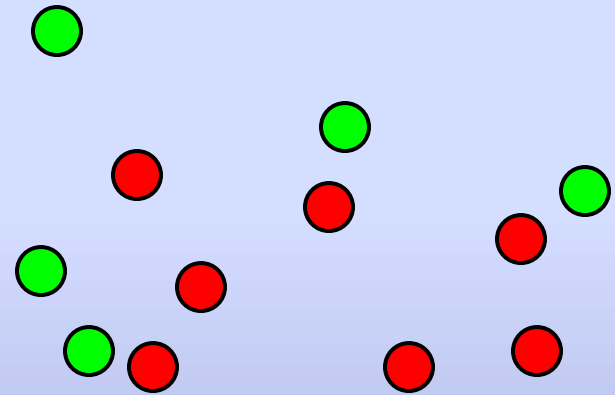
# Population Analysis – Incorrect Diagnosis

## No Action Required



Future service failures

## Action Required



Unneeded Maintenance  
Actions

# Accuracies by Diagnostic Condition

- Diagnostic was imperfect at separating “Good” from “Bad”
- “Action Required” and “No Action Required” each contain both “Good” and “Bad” circuits.

Group	Correct Diagnoses [#]	Incorrect Diagnoses [#]	Accuracy [%]
No Action Required	25	3	89 %
Action Required	7	5	58 %
Overall	32	8	80 %

**Condition-specific accuracies** – They depend on the overall accuracy and the composition of the target population.

# Accuracies by Diagnostic Condition

- Diagnostic was imperfect at separating “Good” from “Bad”
- “Action Required” and “No Action Required” each contain both “Good” and “Bad” circuits.

Group	Correct Diagnoses [#]	Incorrect Diagnoses [#]	Accuracy [%]
No Action Required	25	3	89 %
Action Required	7	5	58 %
Overall	32	8	80 %

Overall accuracy - Not the average of the “No Action Required” and “Action Required” accuracies

# Which accuracy should be used?

- Comparison of performance of diagnostic techniques

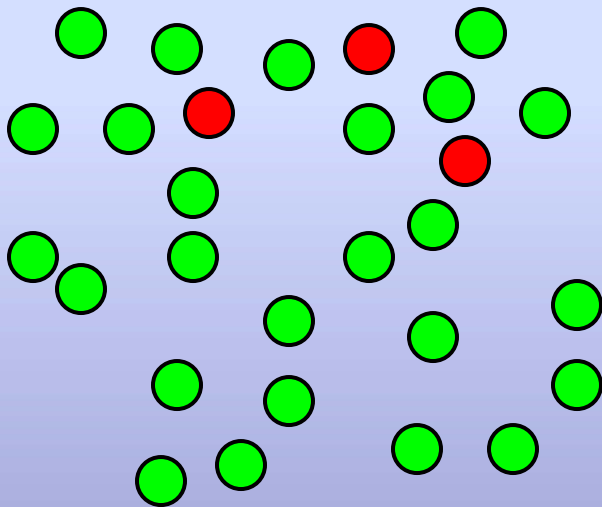
**Overall Accuracy**

- Calculation of economic benefits from diagnostic program

**Diagnostic  
Condition-Specific  
Accuracies**

# Performance of Diagnostic Program

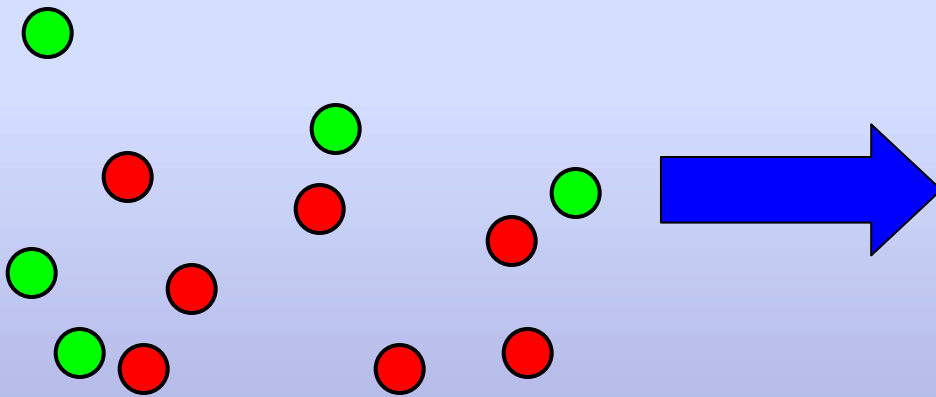
## No Action Required



- No action performed on **70%** of the target population
- **3** service failures

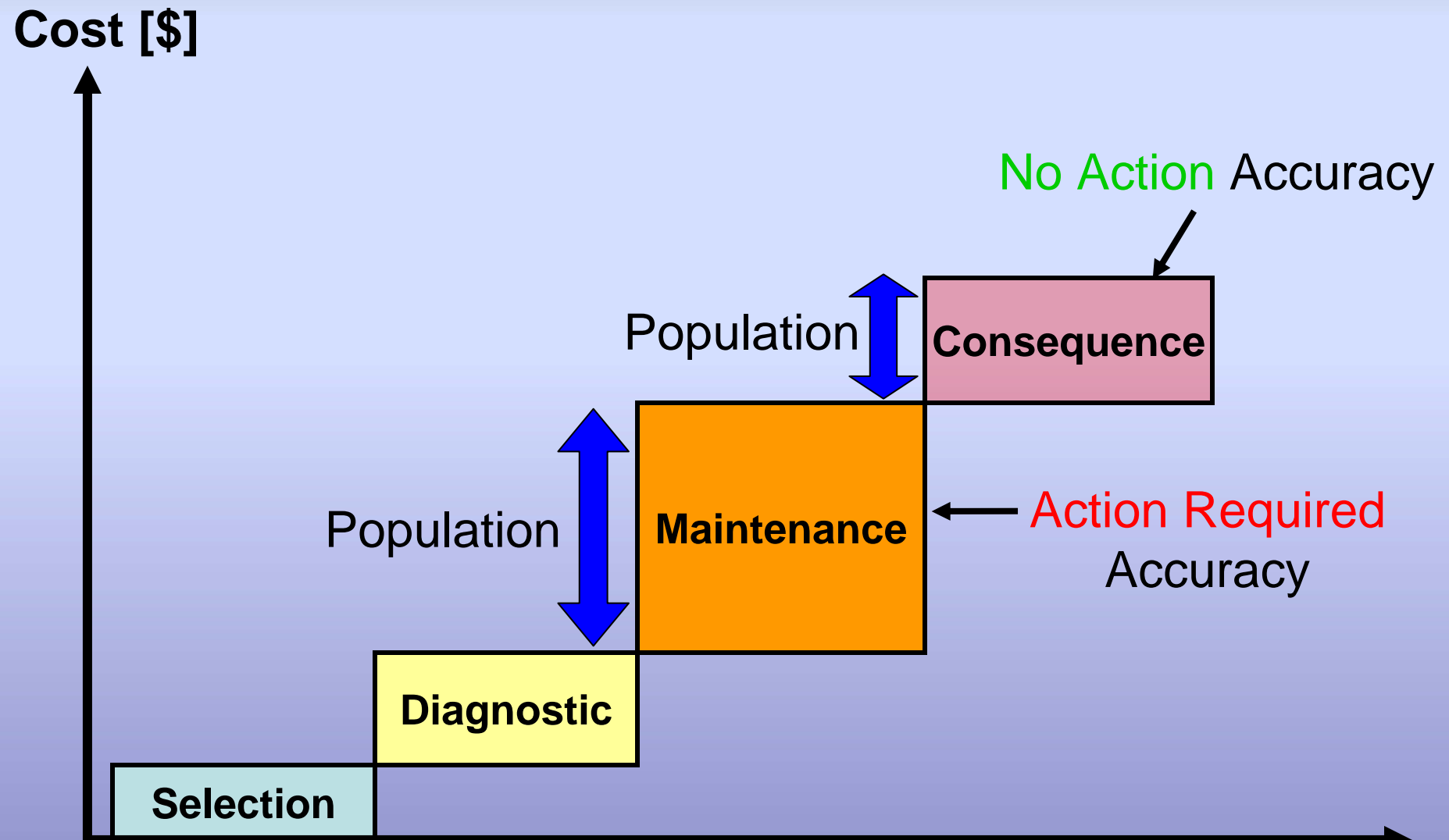
# Performance of Diagnostic Program

## Action Required



- Action performed on **30%** of the diagnostic population
- **7** service failures avoided
- Action was unnecessarily performed on “**Good**” circuits.

# Which accuracies impact the components?



# Comparison to Wholesale Replacement

	Diagnostic Program	Wholesale Replacement
Maintenance Actions	12	40
% of Population Receiving Maintenance	30%	100%
Service Failures	3	0
Avoided Failures	7	10
Avoided Failures per Maintenance Action	<b>0.583</b>	<b>0.250</b>

Efficiency of Diagnostic Program is much higher than for Wholesale Replacement

# Conclusions

- The economics of a diagnostic program depend heavily on the accuracy of the diagnostic.
- Overall accuracy can be used to compare diagnostics in general terms.
  - Target population independent
- Only diagnostic condition-specific accuracies can be used in economics calculations since the consequences are different for each condition.
  - Target population dependent