How Accuracy Impacts the Economic Benefit of Cable Diagnostic Programs

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Subcommittee C

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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

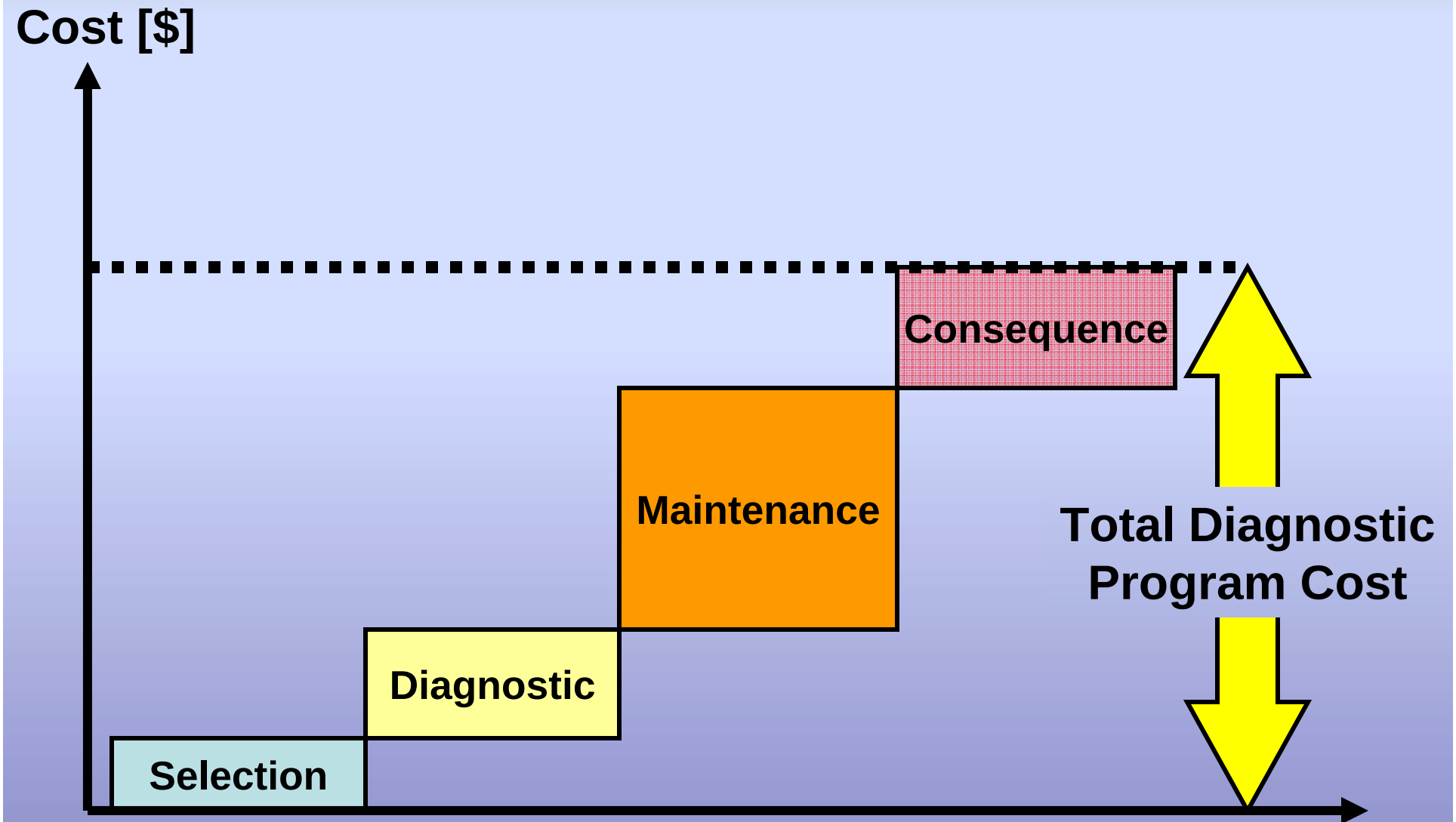
- **Maintenance**

  Actions taken on circuits based on results of diagnostic test

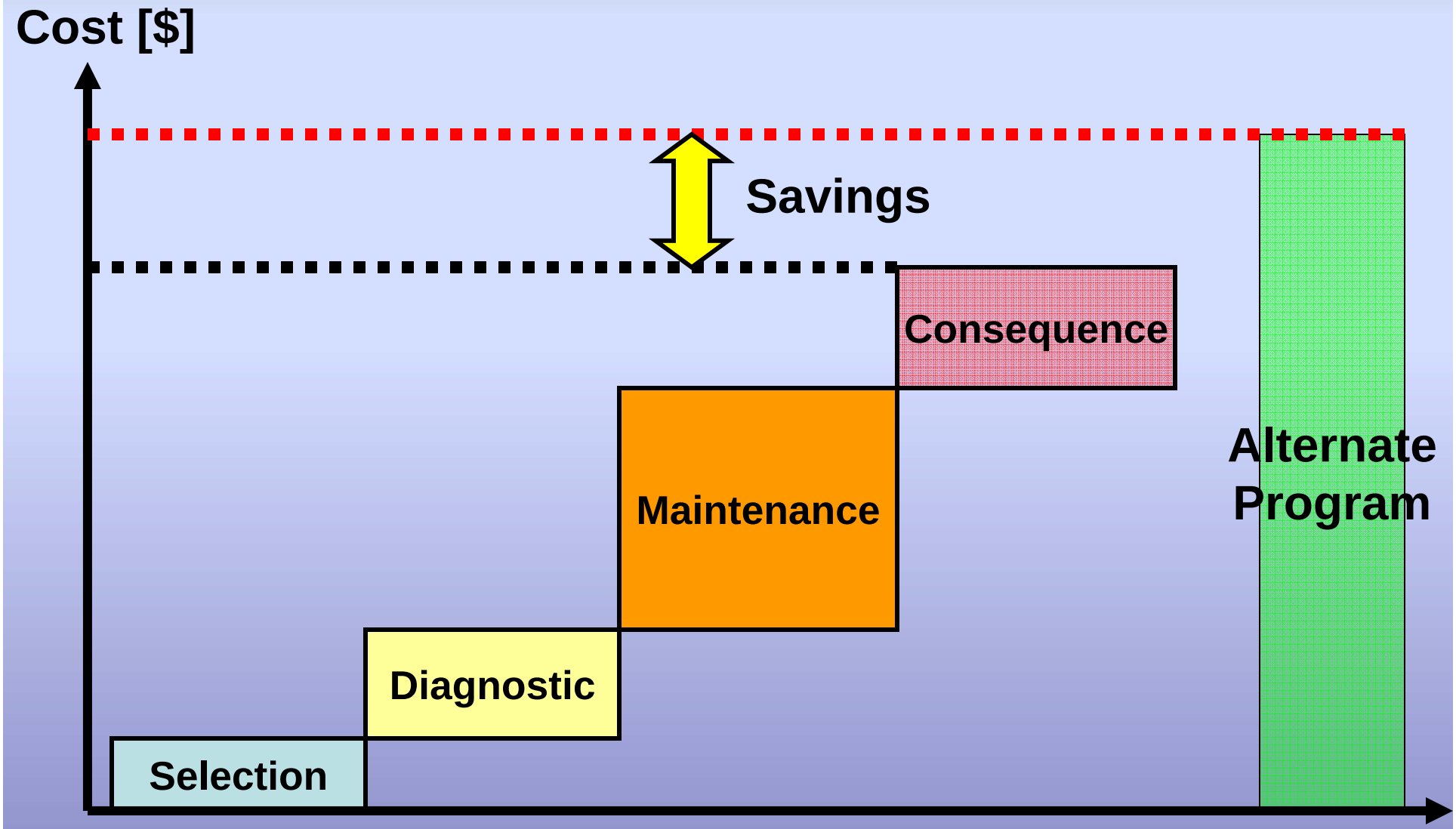
- **Consequence**

  Service failures occurring in target population during diagnostic horizon.

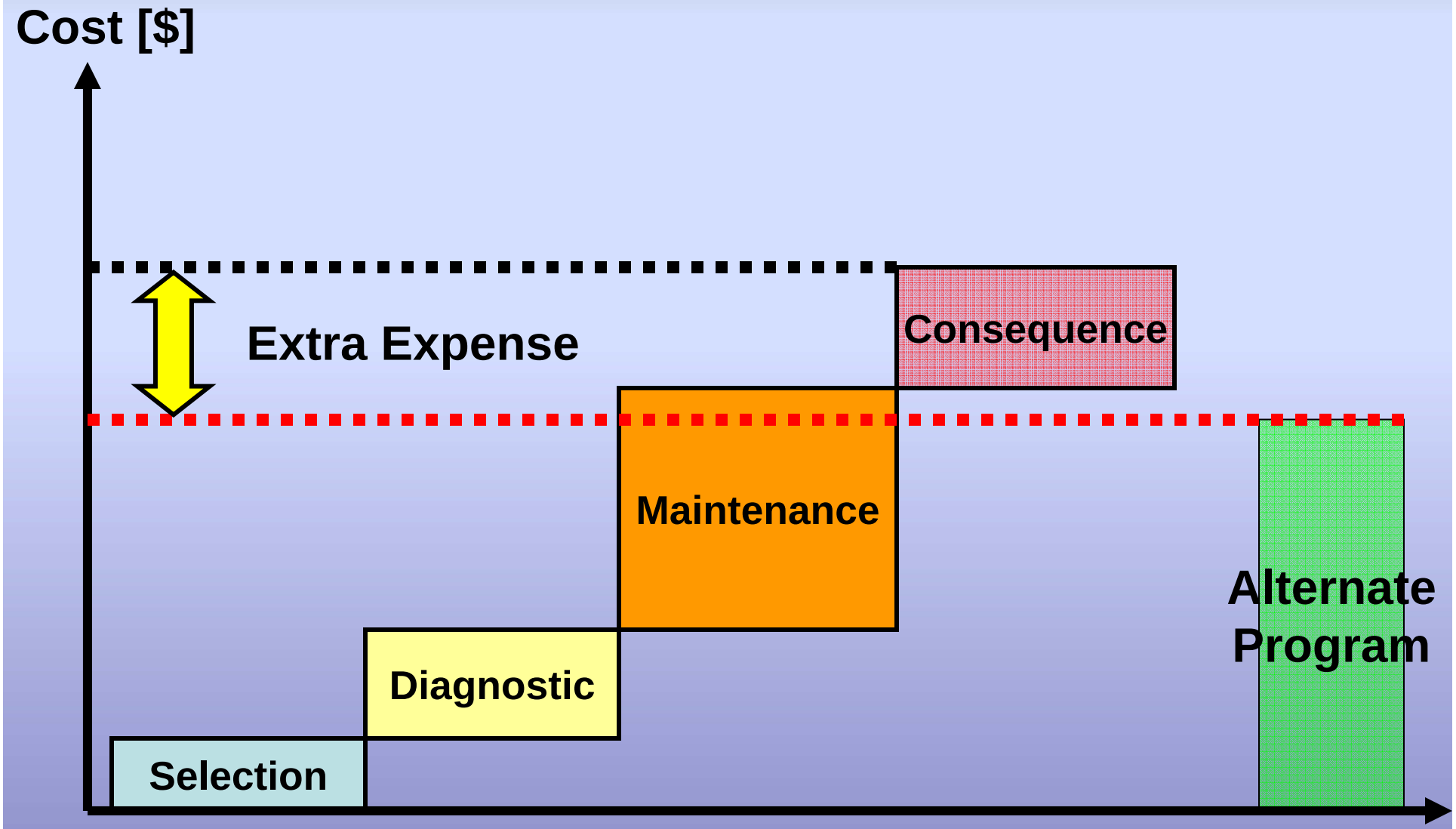
Diagnostic Program Costs



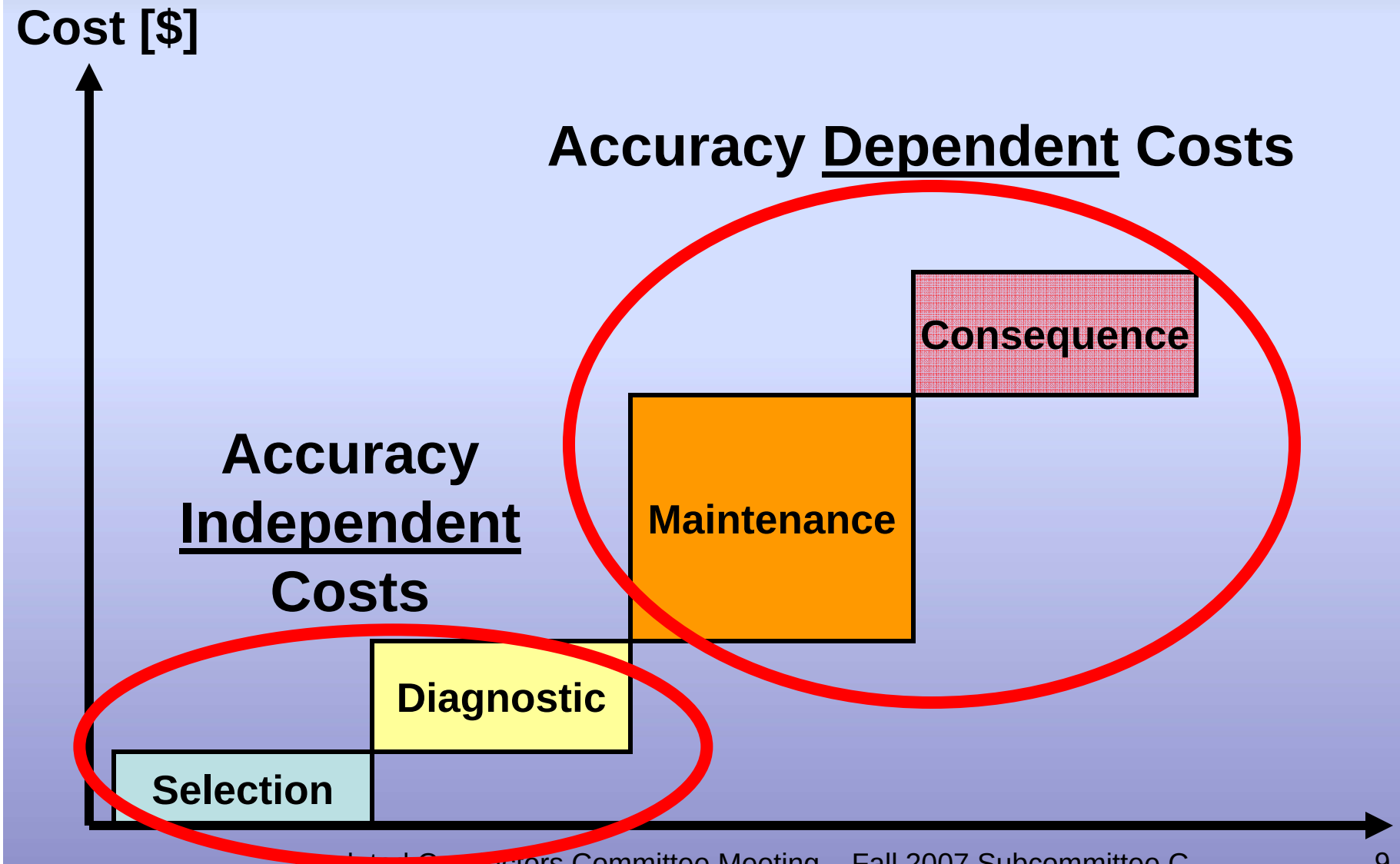
Program Savings



Program Additional Spending



Where does accuracy have an impact?



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

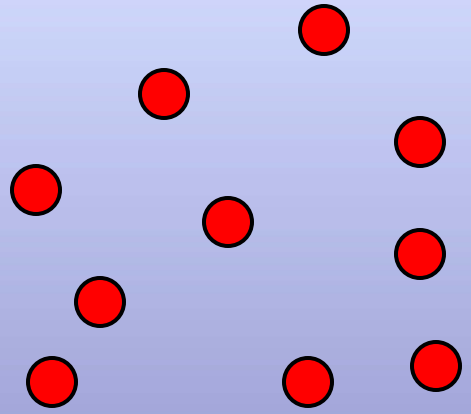
The target population contains both "Good" and "Bad" circuits

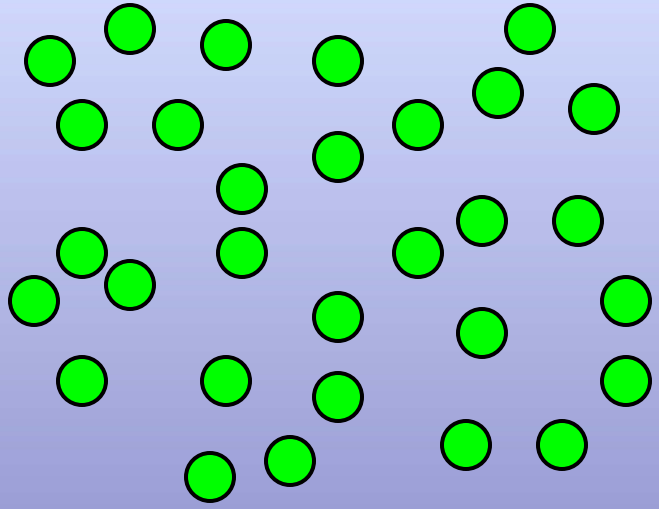
- "Good" – Will not fail within diagnostic horizon
- "Bad" – Will fail within diagnostic horizon

"Bad" Circuits

Target Population

"Good" Circuits





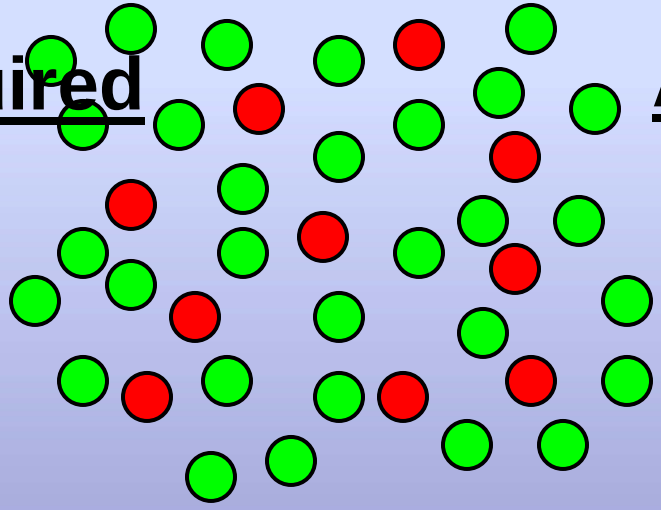
Diagnostic Operation

Applying the diagnostic will separate the population into:

- No Action Required group
- Action Required group

But all diagnostics are imperfect at some level

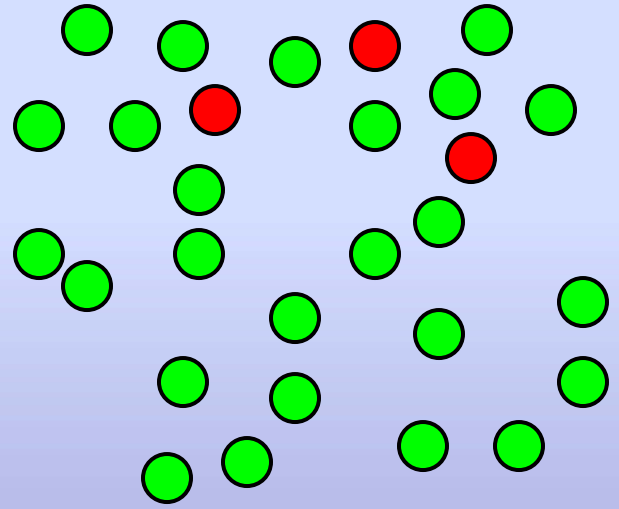
No Action Required



Action Required

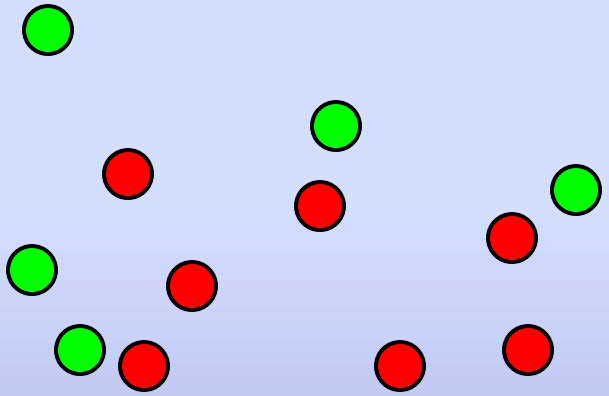
Population Analysis – Correct Diagnosis

No Action Required



Avoided Maintenance

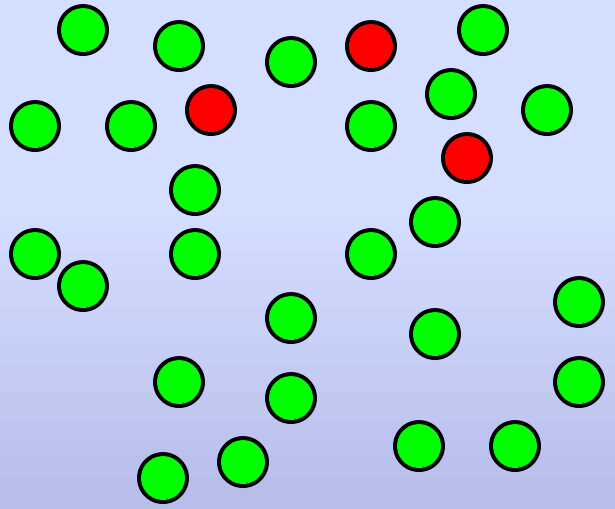
Action Required



Avoided service failures

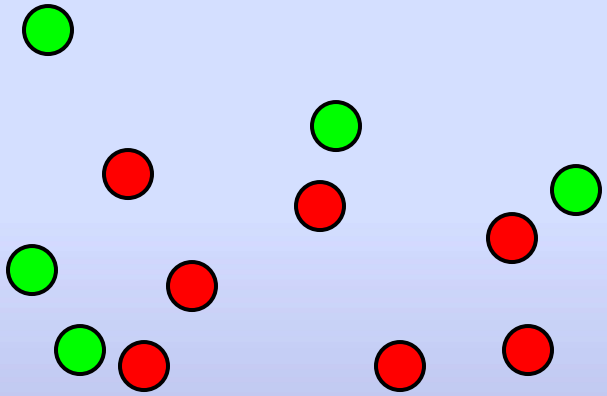
Population Analysis – Incorrect Diagnosis

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

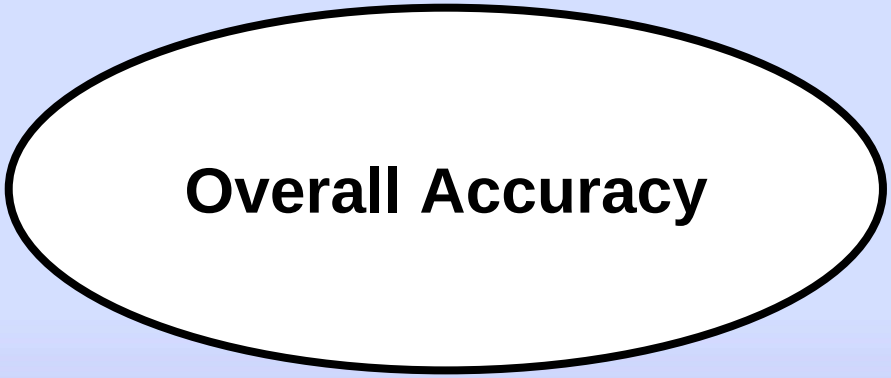
- Diagnostic was imperfect at separating "Good" from "Bad"
- "Action Required" and "No Action Required" each contain both "Good" and "Bad" circuits.

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

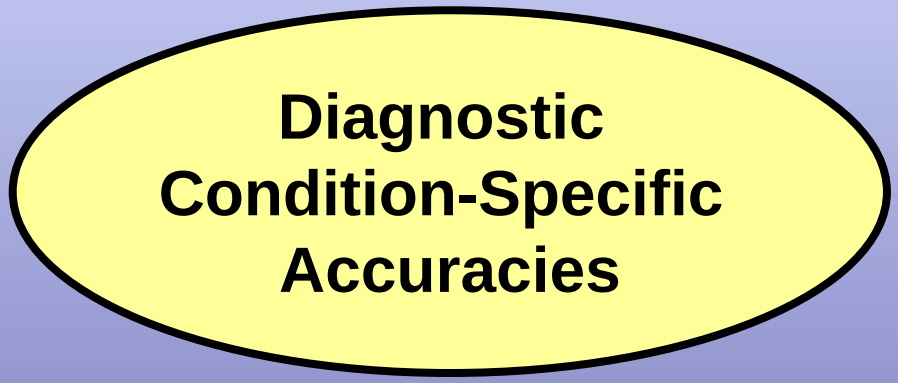
Overall accuracy - Not the average of the "No Action Required" and "Action Required" accuracies

Which accuracy should be used?

- Comparison of performance of diagnostic techniques

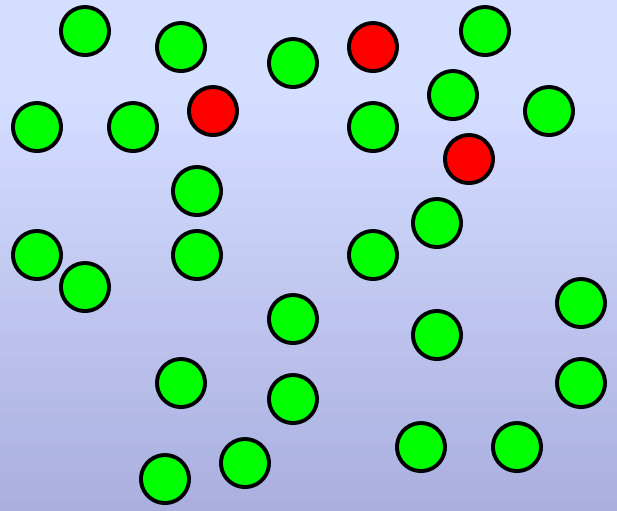


- Calculation of economic benefits from diagnostic program



Performance of Diagnostic Program

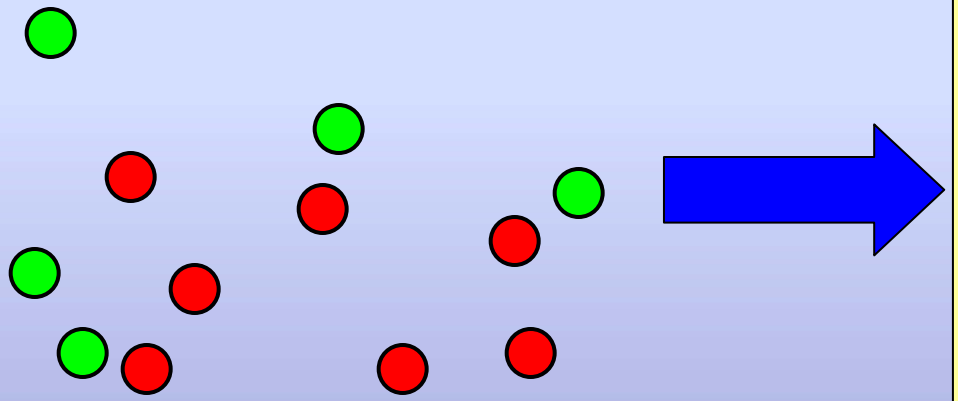
No Action Required



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

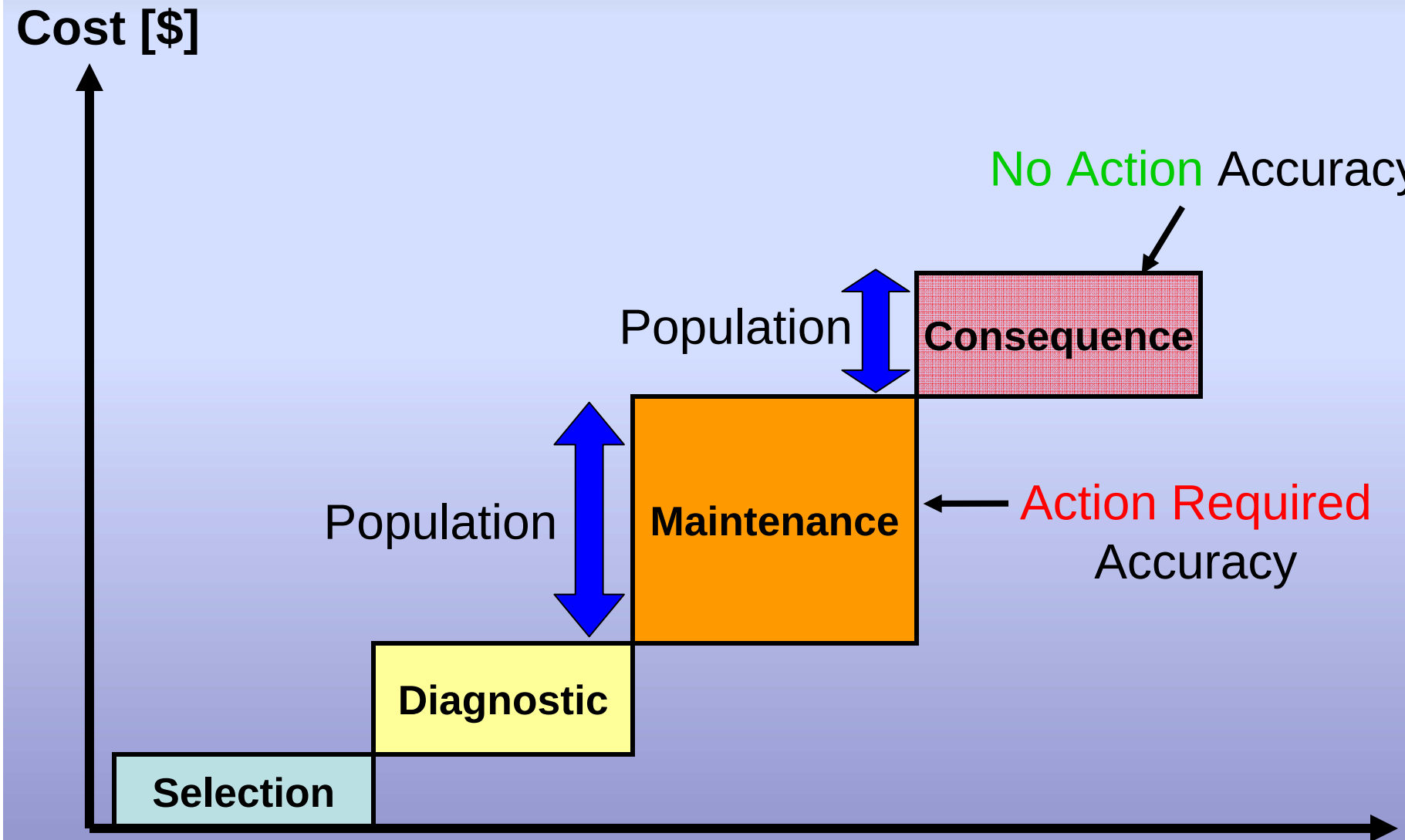
Performance of Diagnostic Program

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	**0.583**	**0.250**

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