Cal PREPARE

Detect ★ Investigate ★ Respond ★ Recover

CNS

The Analytical Hierarchy Process: A New Tool for Complex Decision-Making in Public Health Preparedness Workshop title

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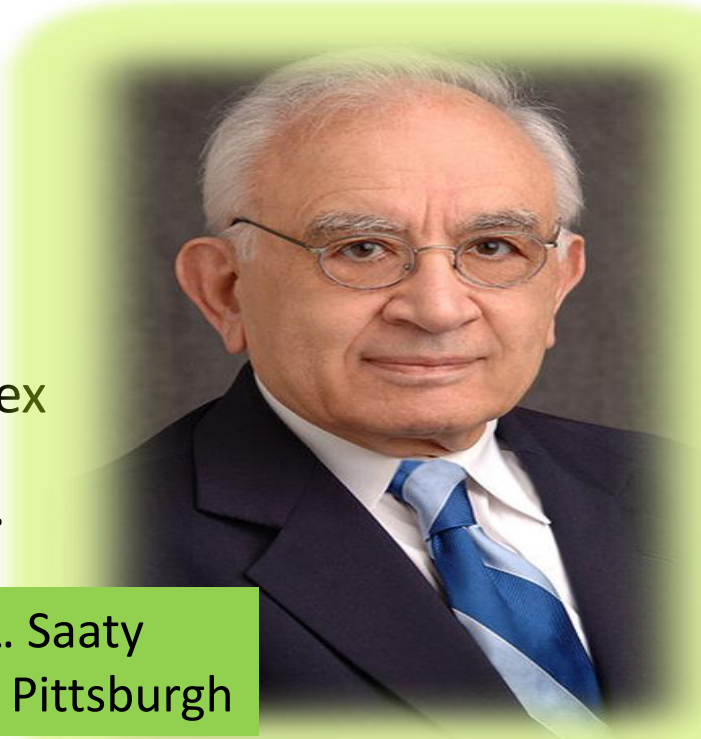
Presentation Goals

Analytical Hierarchy Process

- **Introduce Analytical Hierarchy Process (AHP)**
- **Demonstrate utility in everyday life**
- **Showcase AHP^2 (All-Hazards Preparedness)**

The Analytical Hierarchy Process

- When making complex decisions "numerous competing factors of the decision challenge ones cognitive ability to adequately evaluate and process the information" → intuition [+]
- A multi-attribute analysis technique that organizes complex systems/unstructured problems with many elements of different influence.
- Easy to use, automatable algorithm, well-accepted by policy makers.
- Uses stakeholder perceptions to find the most important elements influencing complex decisions (only as good as the experts).
- Mirrors our brains' decision making process.



Dr. Thomas L. Saaty
University of Pittsburgh

[+] Forman and Selly, "Decision by Objectives: How to Convince Others that You are Right", World Scientific, 2001, p. 310.

Our Complex System:

How to relate preparedness and response factors that may come into play during CRN emergencies?

- Multiple factors contribute to preparedness and response for chemical, radiological and nuclear (CRN) emergencies.
- Factors have different levels of importance depending on the situation – **NO 'one-size-fits-all' approach** to CRN emergencies.
- Input from ***EXPERTS*** is critical to generate valid findings and build recommendations to meet identified challenges.
- To meet this need we developed a straightforward, **customizable online AHP survey tool (AHP^2)** ← directly applicable.

Presentation Goals

Analytical Hierarchy Process

- Introduce Analytical Hierarchy Process (AHP)
- Demonstrate utility in everyday life
- Showcase AHP^2 (All-Hazards Preparedness)

Illustration of AHP through example:

How to buy a car

These cars are my possible choices. How should I decide?

In this case, only 1 or 2 experts!

5 **Context-specific survey & application of weights.**

4 **Calculate factor, subfactor, & criteria weights.**

3 **Pair-wise comparison survey of factors, subfactors, and criteria (context-independent).**

2 **Build hierarchy elements: factors, subfactors, criteria.**

1 **Select elements contributing to the overall problem.**

The context dependent => Comparison of cars



5 **Context-specific survey & application of weights.**

The context independent => comparison of different **attributes**

4 **Calculate factor, subfactor, & criteria weights.**

3 **Pair-wise comparison survey of factors, subfactors, and criteria (context-independent).**

2 **Build hierarchy elements: factors, subfactors, criteria.**

1 **Select elements contributing to the overall problem.**

Step 1:

Identify elements contributing to the overall problem

Choose a car based on key elements:

Handling Economy Power

= Factors

Secondary elements also contribute to choice…

(Factor)

Breaking Distance

Turning Radius

= Subfactors, Criteria

Construct the AHP Hierarchy

Steps Involved:

5. Context-specific survey & application of weights.
4. Calculate factor, subfactor, & criteria weights.
3. Pair-wise comparison survey of factors, subfactors, and criteria (context-independent).
2. **Build hierarchy elements: factors, subfactors, criteria.**
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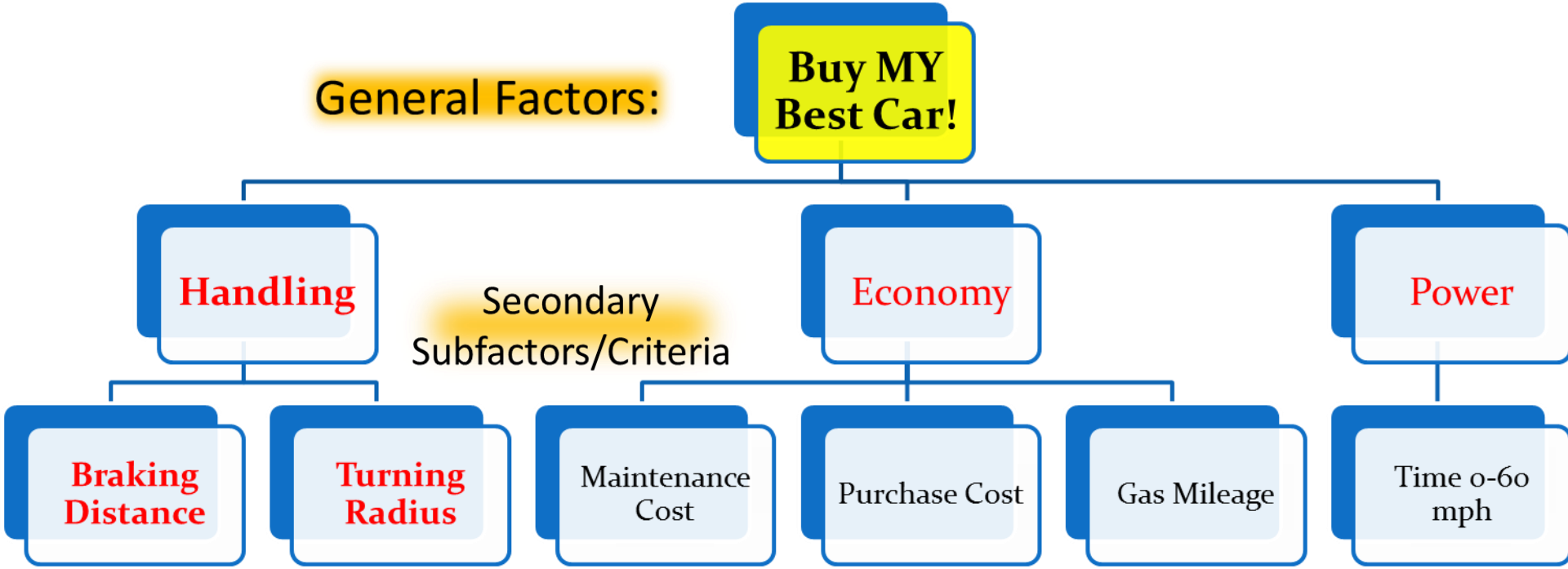
Step 2:

Build AHP Hierarchy for car scenario

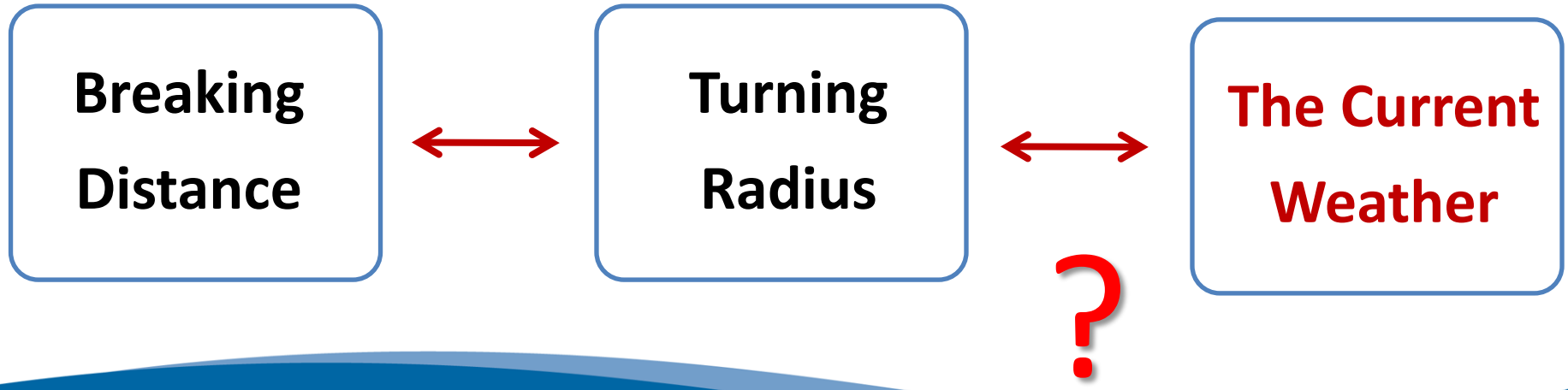
General Factors:



Alternatives (Context):

Important Caveat in Building the Hierarchy

Example: Does it make sense to compare these factors in buying a car?



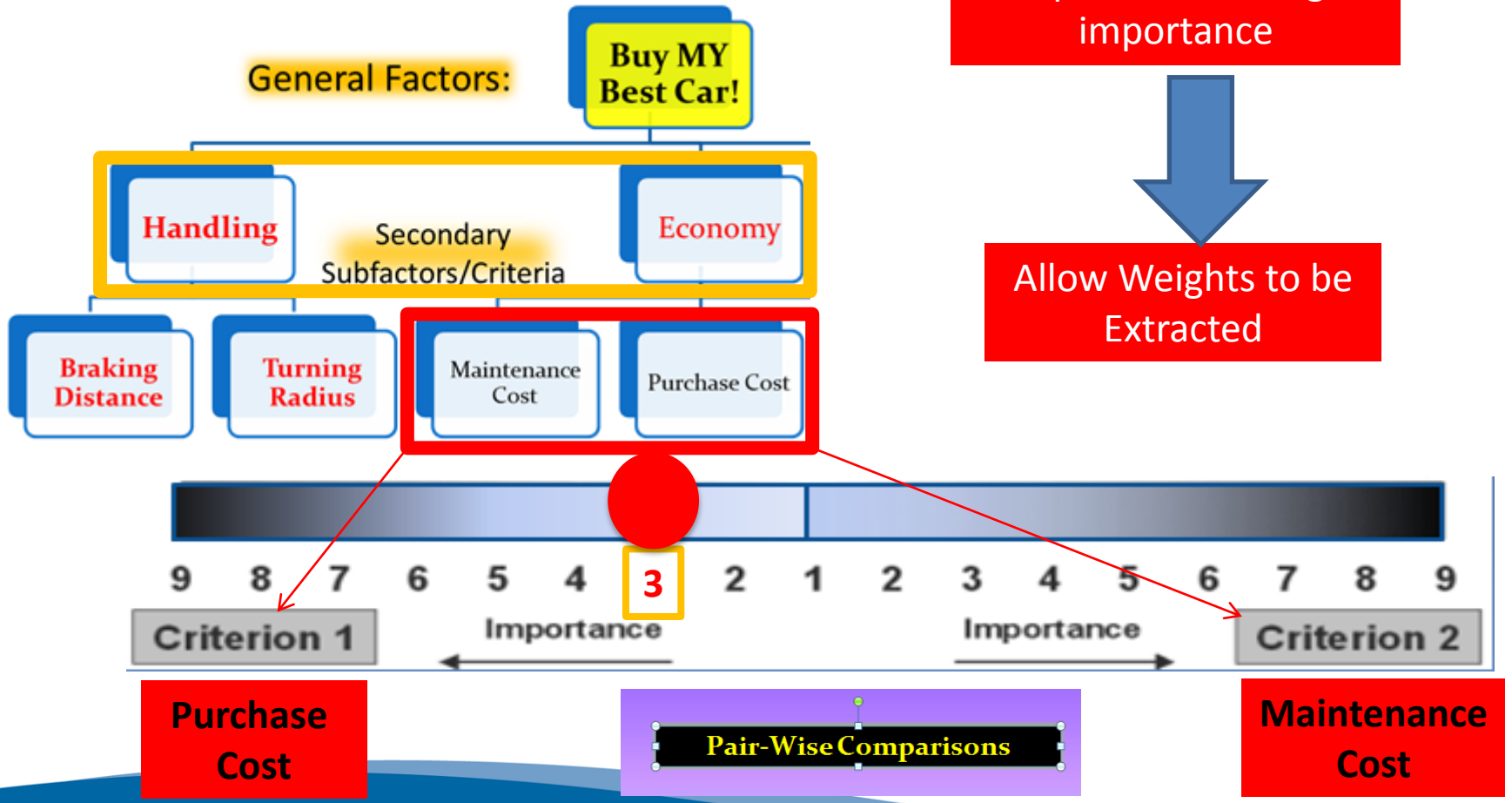
Steps Involved:

5. Context-specific survey & application of weights.
4. Calculate factor, subfactor, & criteria weights.
3. **Pair-wise comparison survey of factors, subfactors, and criteria (context-independent).**
2. Build hierarchy elements: factors, subfactors, criteria.
1. Select elements contributing to the overall problem.

Step 3:
Pair-Wise Comparisons

Elements of each level compared according to importance

Allow Weights to be Extracted



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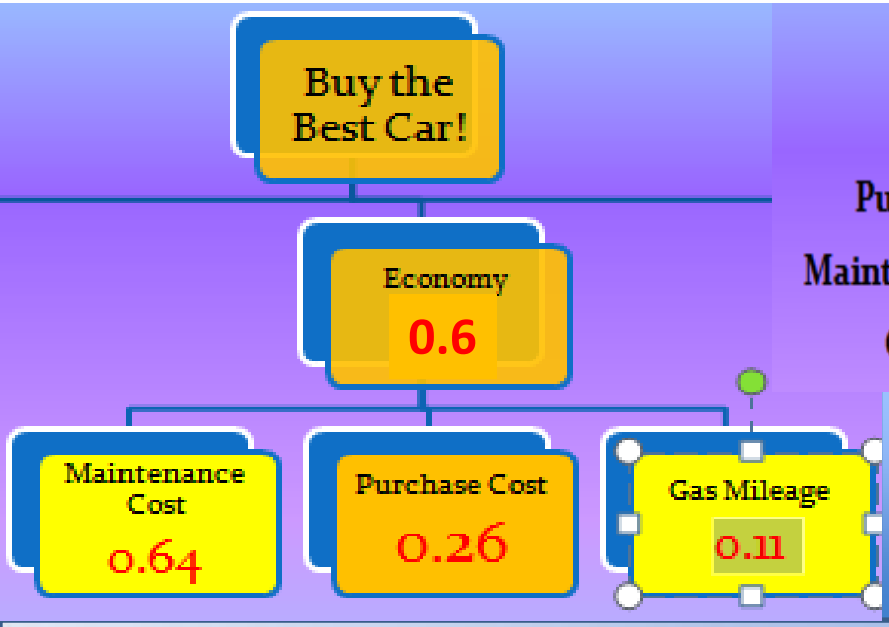
Step 4:
Calculate the Weights



	Purchase Cost	Maintenance Cost	Gas Mileage
Purchase Cost	1	3	5
Maintenance Cost	1/3	1	5/3
Gas Mileage	1/5	3/5	1

AHP ALGORITHM

WEIGHTS ARE:

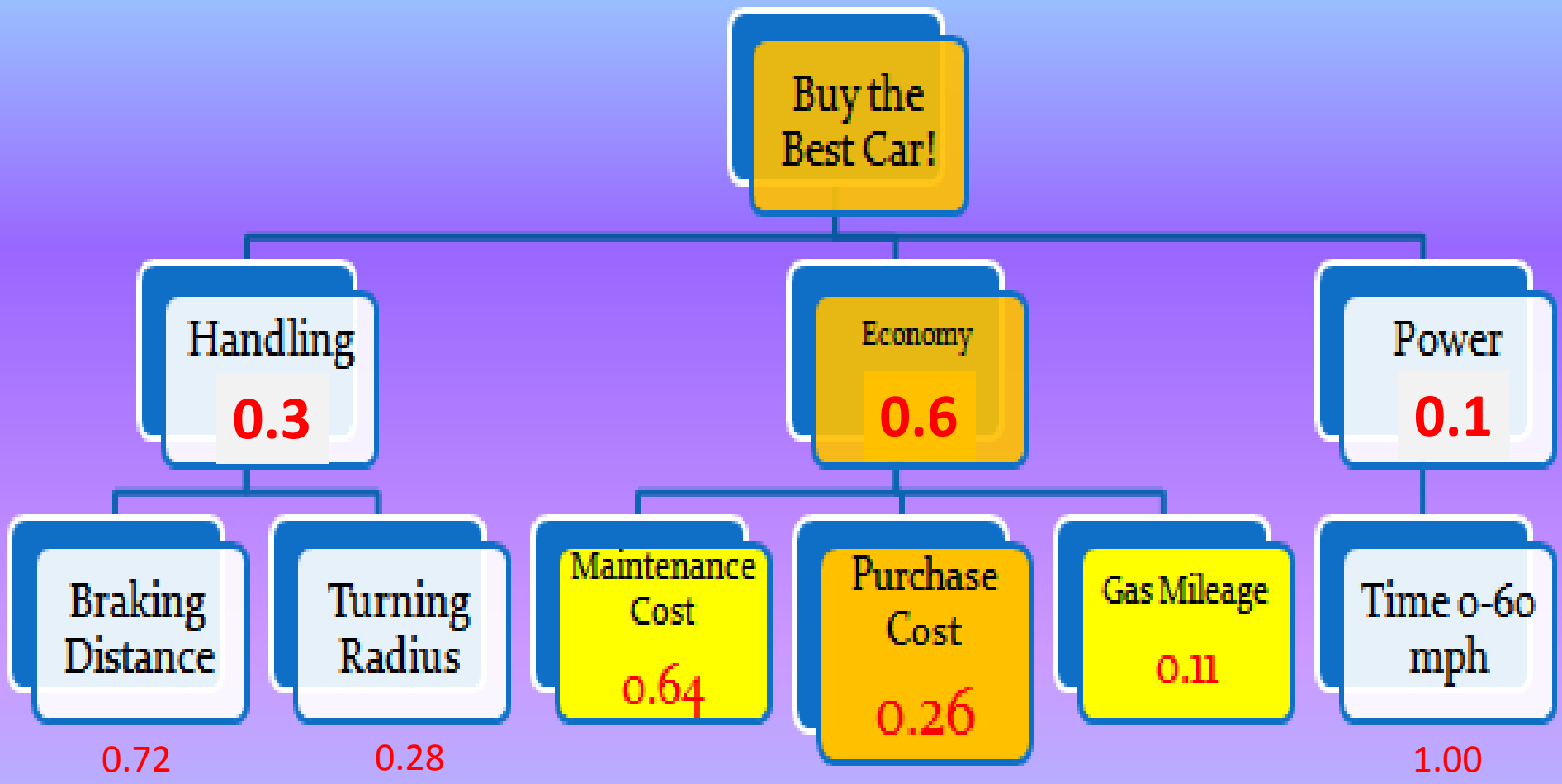
$W_{Maintenance} = 0.384$

$W_{Purchase} = 0.156$

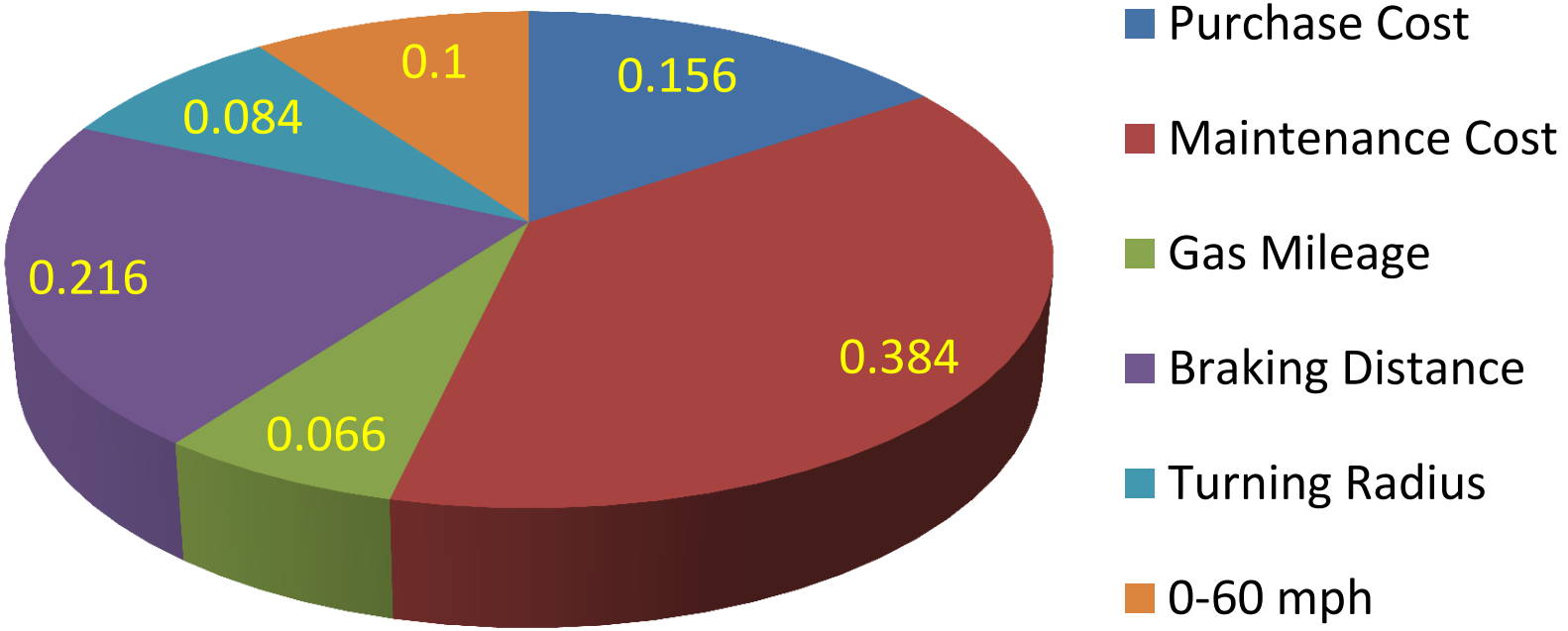
$W_{Gas\ Mileage} = 0.066$

BUILD TABLE OF WEIGHTS FOR ALL THE FACTORS, SUBFACTORS AND CRITERIA

Putting it All Together: The Final Weights



Putting it All Together: Potency (Profile of Weights)



5 **Context-specific survey & application of weights.**

The context dependent Comparison of cars

4 **Calculate factor, subfactor, & criteria weights.**

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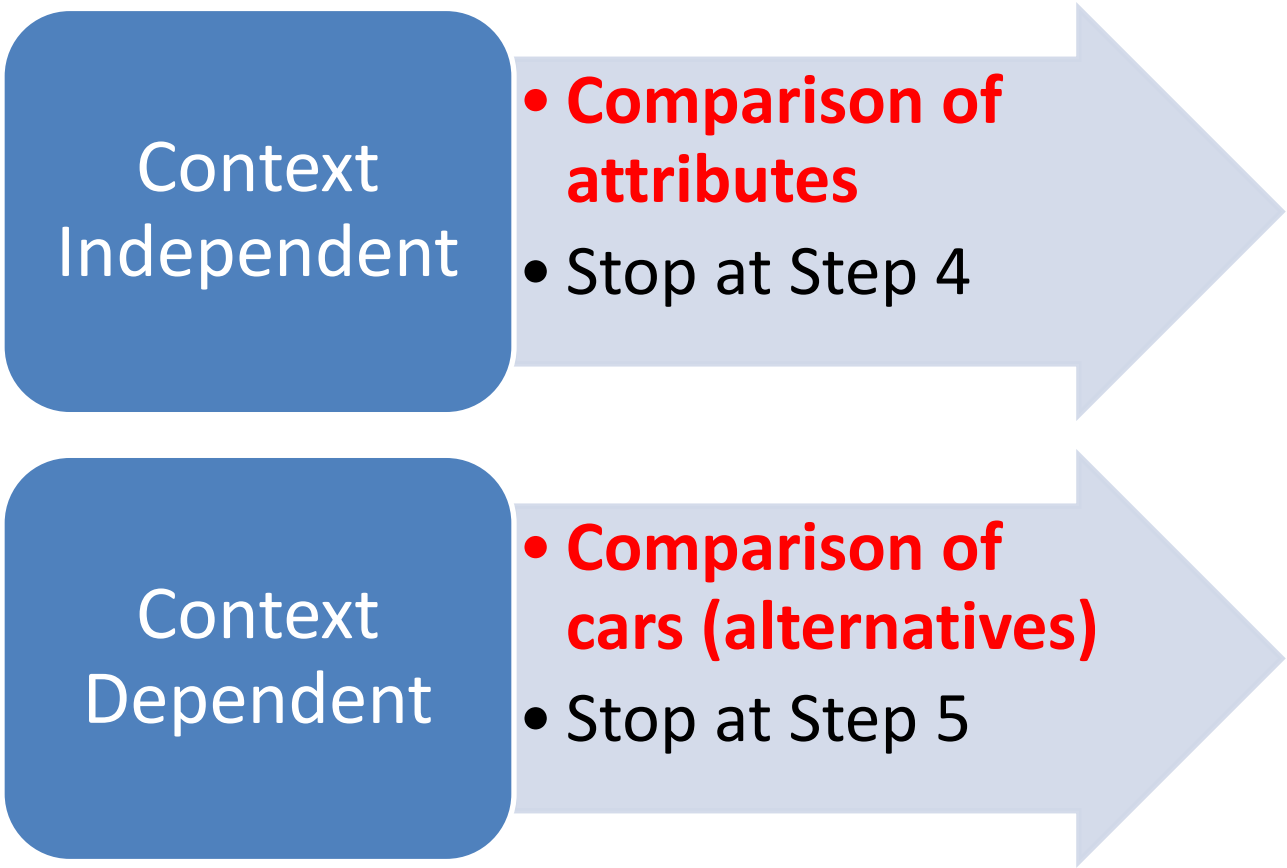
Context Dependence



Step 5:

Weights Applied to Context: Which Car is the Best?

Compare the different candidate cars for each

Alternatives (Context)!

Gas Mileage:

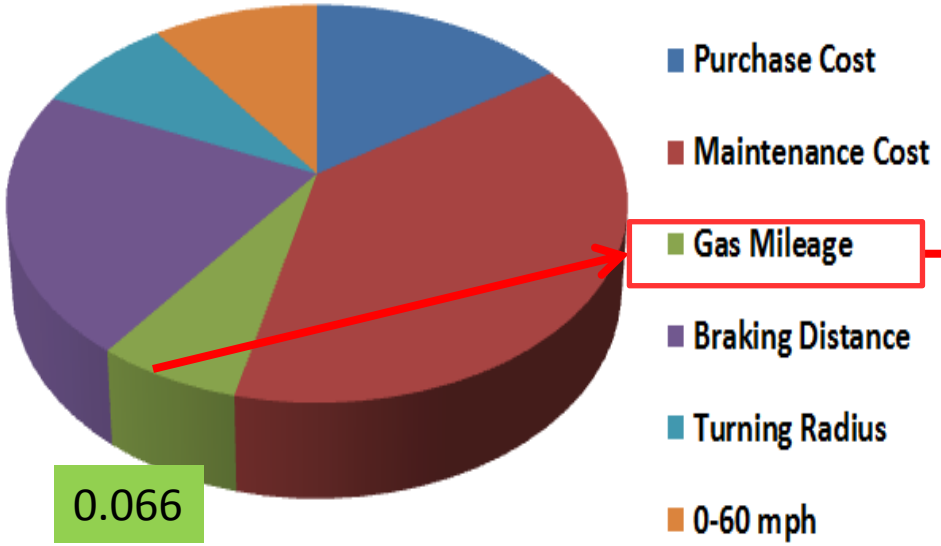
Trabant	1
Lexus	8
Ford	5

$W_{mileage} = 0.11$

RATING

Worst							Most Favorable		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
●									
							●		
				●					

Favorability Rating: The Mileage Partial Score



Gas Mileage Score (Brand)
= 0.6*0.11*(Rating for Brand)
=(0.066)*(Rating for Brand)

	RATING	MILEAGE PARTIAL SCORE
Trabant Score =	1.0 (engine)	-> 0.066
Ford =	5.0	-> 0.33
Lexus=	8.0	-> 0.53

Favorability Rating: The Final Score

$$\sum_{i=1}^{Criteria} (Potency)_i (Score)_i = Total\ \text{Score}$$

Trabant Score = 2.25 (engine)

Ford = 7.36

Lexus= 4.37 (too expensive)

$W_{\overline{Purchase\ Cost}} = 0.844$

$W_{Purchase\ Cost} = 0.156$

(Trabant: Weight Purchase cost (0.156) high, brand rating high (9) so for purchase cost partial rating is high (1.40) but the rest of attributes the total partial scores are low (0.84)!

	$Score_{\overline{Purchase\ Cost}}$	$Score_{Purchase\ Cost}$
Trabant	1.40 (rate=9)	0.84
Lexus	0.56 (rate=1)	4.21

The Ford Wins!

SET MUST BE AS COMPLETE AS POSSIBLE!

Presentation Goals

Analytical Hierarchy Process

- Introduce Analytical Hierarchy Process (AHP)
- Demonstrate utility in everyday life
- Showcase AHP^2 (All-Hazards Preparedness)

$AHP \times AHP = AHP^2$

What is the AHP^2 Tool?

- Application of AHP to research public health preparedness;
- A multi-criteria survey method to analyze complex decision-making in public health preparedness;
- New online tool for public health officials to enhance all hazards preparedness.

How Can AHP^2 be Utilized?

- **Facilitate complex-decision making to systematically prioritize needs:**
  - **Prioritizing stakeholder needs in preparedness exercises;**
  - **After action evaluations (exercises & events);**
  - **Recognizing vulnerabilities of specific population groups;**
  - **Determining allocation of resources;**

Example: AHP^2's Utility for Public Health

Scenario: H5N1 outbreak in your local jurisdiction.

- **Questions:**
  - How would you best allocate resources during an H5N1 outbreak?
  - Optimize preparedness for an H5N1 outbreak
- **Utility:**
  - AHP^2's pair-wise comparison provides clarity on **resource prioritization (resources become the attributes compared)**.
  - Determine unanticipated challenges in responding to potential future events (identify priority resources).

Welcome to the AHP for Decision Making

Created by Cal PREPARE, a CDC Preparedness and Emergency Response Research Center (PERRC) based at the Center for Infectious Diseases & Emergency Readiness (CIDER), UC Berkeley School of Public Health, and the James Martin Center for Nonproliferation Studies (CNS)

Brief Overview

This survey makes use of an expert group decision-making process known as
dual gaps with respect to their own agencies' emergency preparedness strategies. Through in-house testing with CNS researchers, we estimate that th

Overview of the Analytical Hierarchy Process

The AHP survey will proceed in three steps:

- **Select** - In this step you will select criteria that you deem play a role under f
- **Compare** - In the second AHP step, you will be ranking the importance of y
u deem relevant to the concept of All-hazards Preparedness.
- **Scenario specific questioner** - In the third step, you will be asked a rang

Protecting Your Anonymity

We are committed to protecting your privacy in this survey. As soon as your su

Online Support

Should you at any point in the process encounter technical difficulties, or requir
no point will your private information or survey results be viewable by CNS support staff during this process.

Thank you for your participation!

Introducing AHP²

Participant name is known but link between data and name is removed from the data

Provide support if participant has problems orienting the program

Next

CNS AHP for Decision Making

Home Logout (05b2c6f30295efa2f5d3bd896)

Welcome to the AHP for Decision Making

Created by Cal PREPARE, a CDC Preparedness and Emergency Response Research Center (PERRC) based at the Center for Infectious Diseases & Emergency Readiness (CNS)

Brief Overview

This survey makes use of an expert group decision-making process known as the Analytical Hierarchy Process (AHP). It will elicit public health experts' perspectives on th strategies. Through in-house testing with CNS researchers, we estimate that t[830,429] should take between

The information in these boxes can be tweaked by the survey manager

Overv

The A

- Se al All-hazards Prepar
- Co ted criteria to one anc
- Sc ia-specific questions

Prote

We are committed to protecting your privacy in this survey. As soon as your survey is completed, your name will ly, and removed fr

About you

The information below is voluntary

Where do you work?

- Where do you work?
- Local Health Department
- Federal Government
- Non-Profit Organization
- State Health Department
- Academic Inst
- Contractor
- Other

CNS AHP for Decision Making

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[850,451]

Overview of the Analytical Hierarchy Process

The AHP survey will proceed in three steps:

- **Select** – In this step you will select criteria that you deem play a role under five general All-hazards Prepar
- **Compare** – In the second AHP step, you will be ranking the importance of your selected criteria to one anc
- **Scenario specific questioner** – In the third step, you will be asked a range of criteria-specific questions

Protecting Your Anonymity

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Online Support

About you

The information below is voluntary

Where do you work?

What is your position/level?

- What is your position/level?
- Executive Senior Manager
- Manager
- Individual Contributor
- First Responder
- Academic
- Other

Steps Involved:

5 Context-specific survey & application of weights.

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GOAL

How would you allocate **resources** during an H5N1 outbreak?

Step 1: Select Elements Contributing to Problem

Factors represent overall categories. In our H5N1 demonstration, factors consist of a health department's operational divisions during an infectious disease outbreak and resources represent the criteria.

- **The Factors (5):**
  - Research
  - Preparation
  - Detection
  - General Response
  - Medical Response

Factors necessary to decrease length of the survey. Definitions very important.

- **The Criteria (18)**
  - Public Information Education
  - Laboratory Diagnostics
  - Equipment Preparation
  - Stockpiling Vaccines/medicine
  - Alternate Care Sites
  - Area plan coordination/training
  - Communication
  - Field Detection
  - Medical Personnel Education
  - Epidemiology
  - Patient Research
  - Agricultural Environmental research
  - Vaccine-related research
  - Incident Evaluation
  - EMS/Hospital Equipment
  - Veterinary Response
  - Volunteer Organizations

CNS AHP for Decision Making

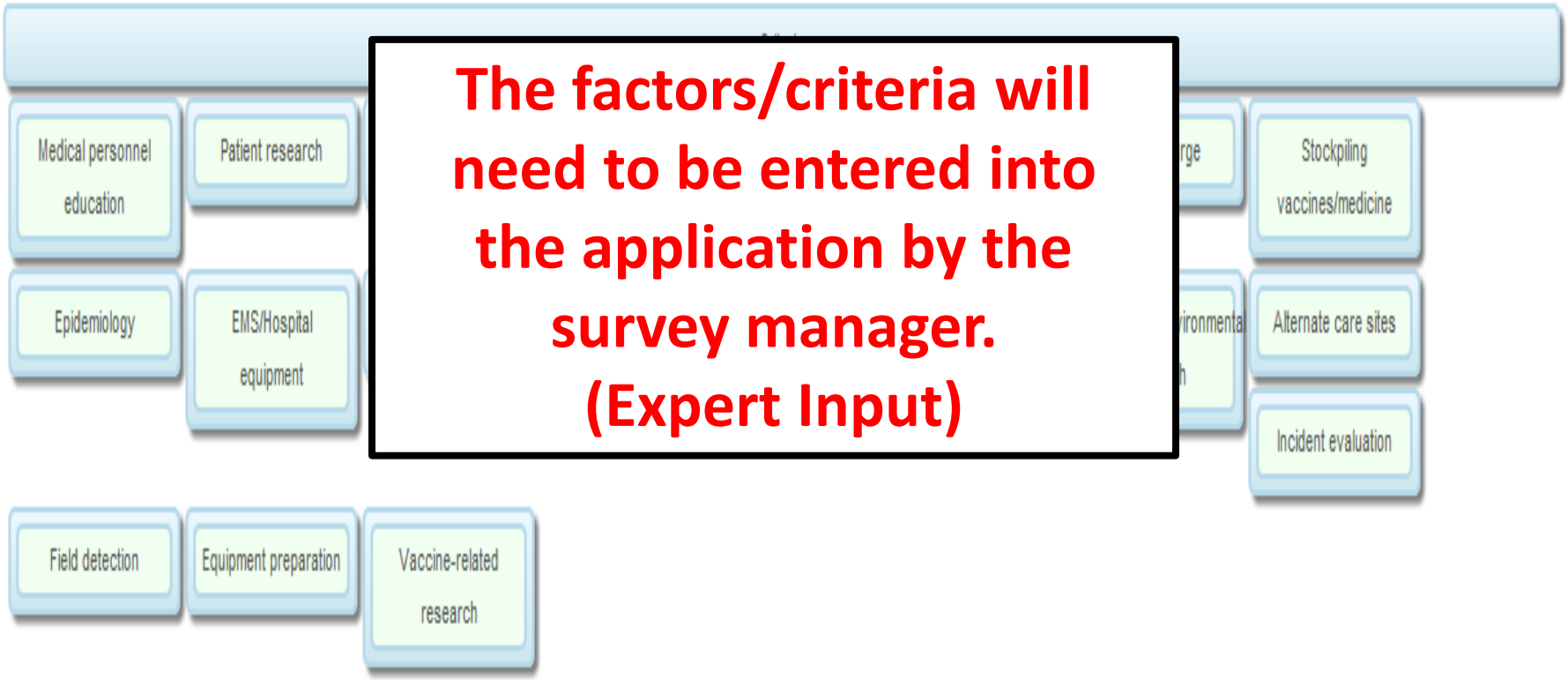
Monterey Institute of International Studies
A Graduate School of Middlebury College

Home | Logout (05b2c6f30295efa2f5d3bd896)

Criteria Selection

Start over | Next

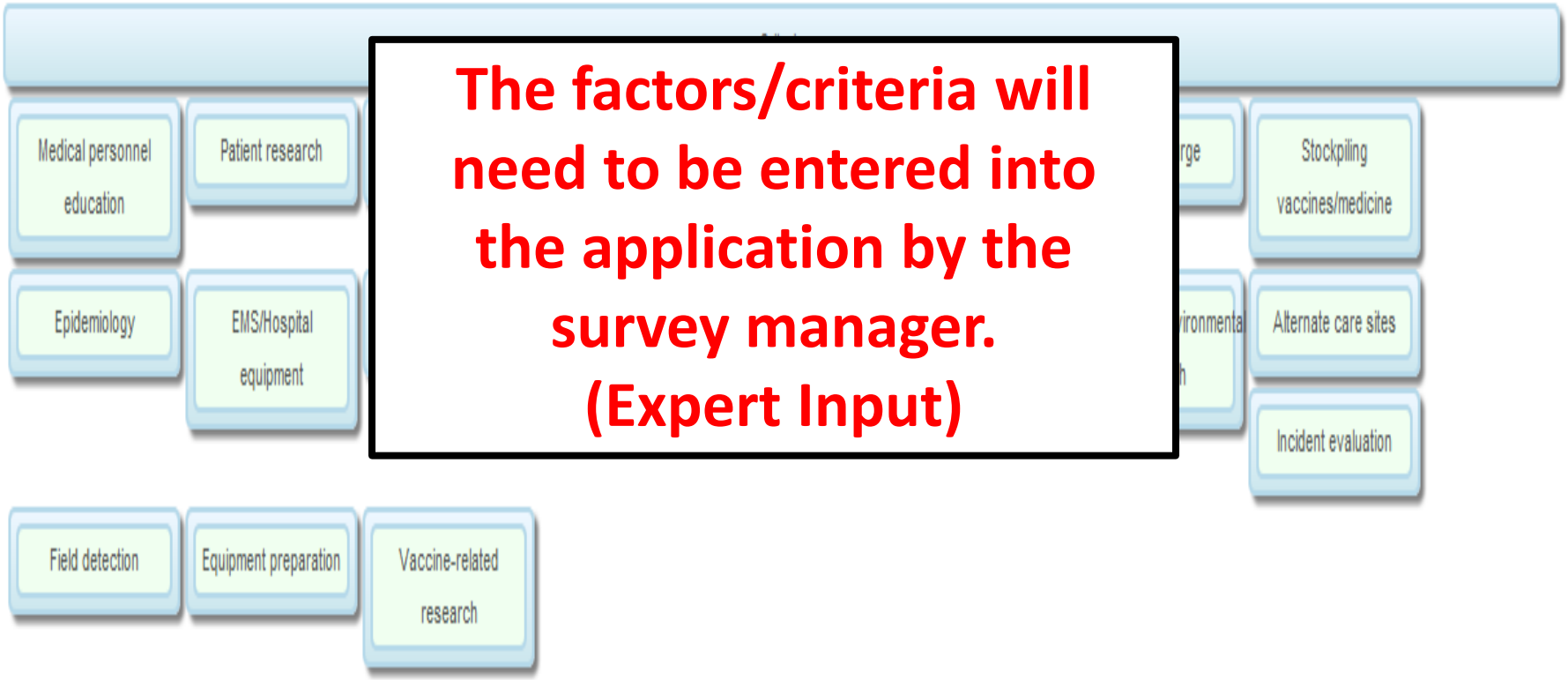
Decide which criteria tiles belong in each factor branch of the tree (bottom). Please familiarize yourself with the definitions of the criteria and the factors by moving your cursor over them. Click and drag the criteria tiles to a box under the factor tree where you think they best fit. Replace a criterion by dragging a new criteria tile over the old one. Delete a criterion by dragging the tile out of the box.



The factors/criteria will need to be entered into the application by the survey manager. (Expert Input)

Decide which criteria titles belong in each factor branch of the tree (bottom). Please Familiarize yourself with the definitions of the criteria and the factors by moving your cursor over them. Click and drag the criteria titles to a box under the factor tree where you think they best fit. Replace a criterion by dragging a new criteria over the old one. Delete a criterion by dragging the title out of the box.

Start over Next



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Steps Involved:

GOAL

4. Calculate factor, subfactor, & criteria weights.
3. Pair-wise comparison survey of factors, subfactors, and criteria (context-independent).
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1. Select elements contributing to the overall problem.

Criteria Selection

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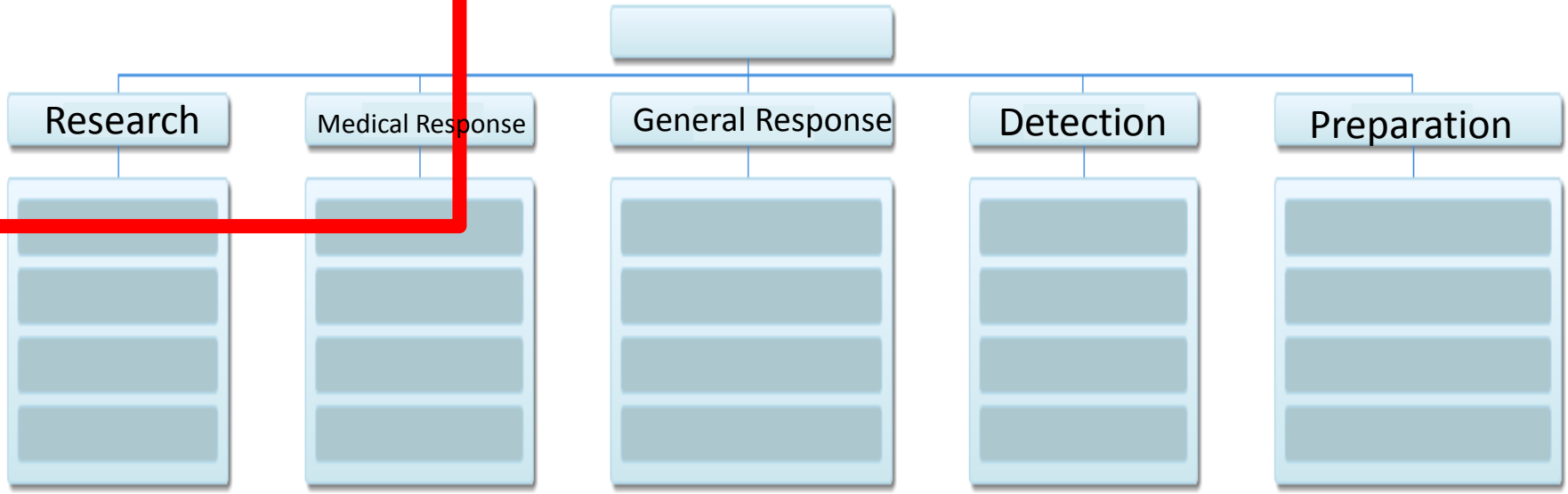
Decide which criteria tiles belong in each factor branch of the tree (bottom). Please familiarize yourself with the definitions of the criteria and the factors by moving your cursor over them. Click and drag the criteria tiles to a box under the factor tree where you think they best fit. Replace a criterion by dragging a new criteria tile over the old one. Delete a criterion by dragging the tile out of the box.

Factor Tree



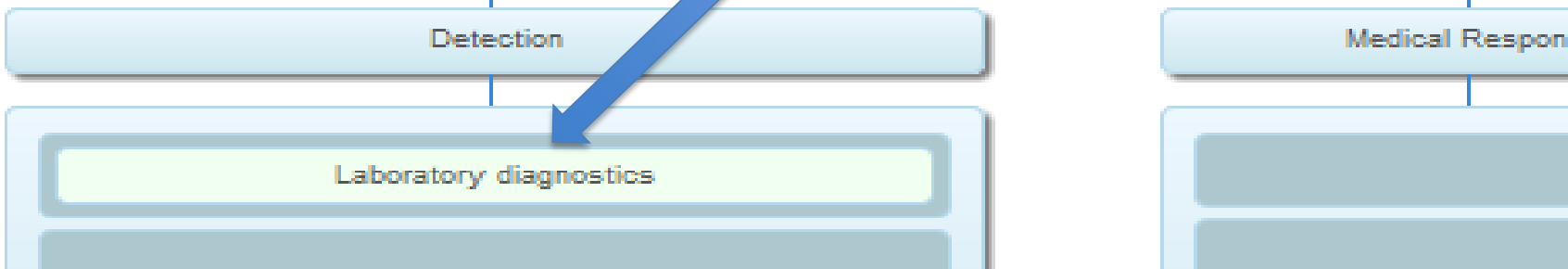
Criteria Selection

Decide which criteria tiles belong in each factor branch of the tree (bottom). Please familiarize yourse
think they best fit. Replace a criterion by dragging a new criteria tile over the old one. Delete a criteri

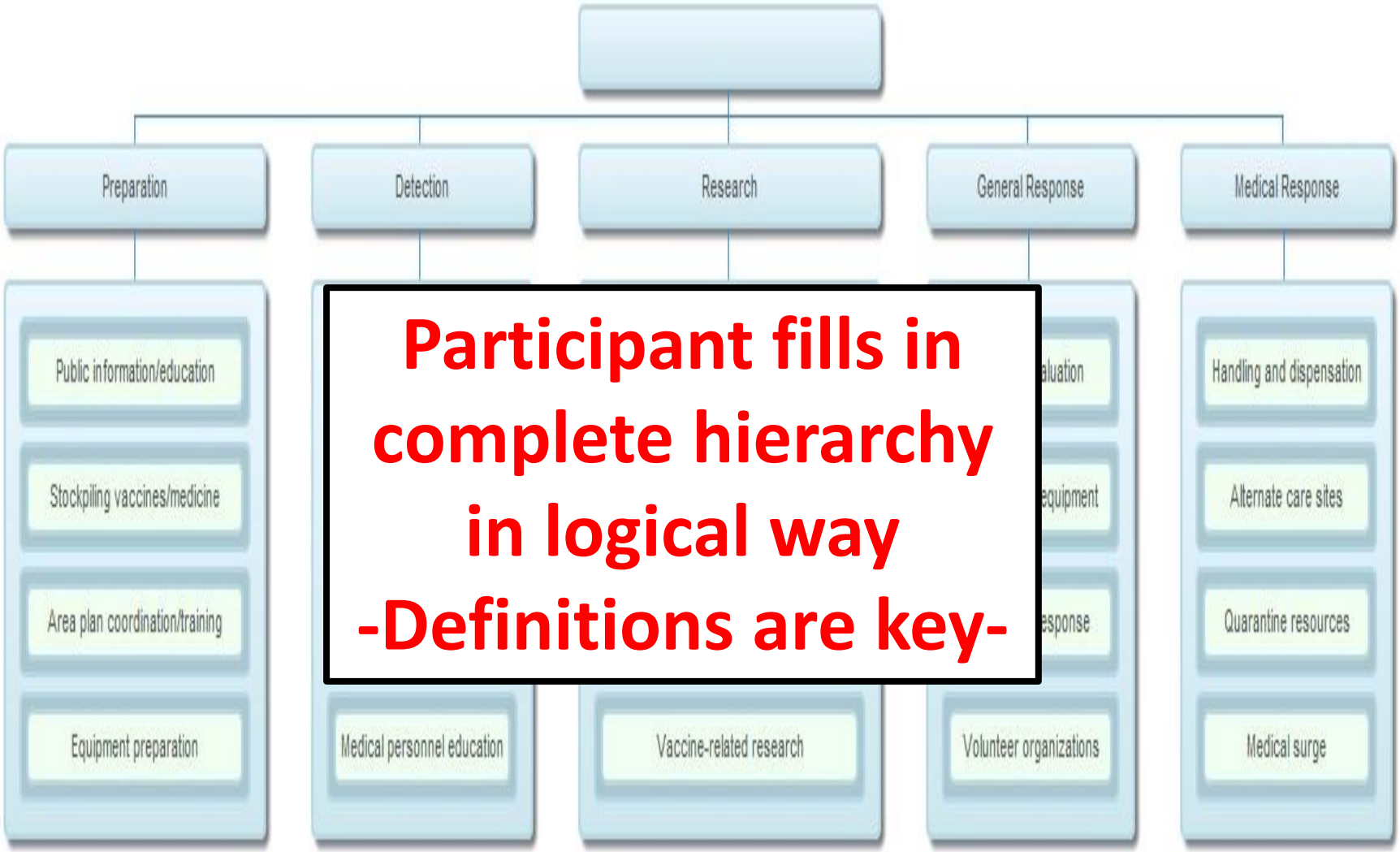
Vol
organ
paration
Vaccine-related research
Laboratory diagnostics
Patient
ital
nt
Veterinary respons
Quarantine resources

Drag Criteria

Factor Tree



AHP² H5N1 Factor Tree:



Steps Involved:

GOAL

4. Calculate factor, subfactor, & criteria weights.
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11 % Completed

CNS AHP for Decision Making

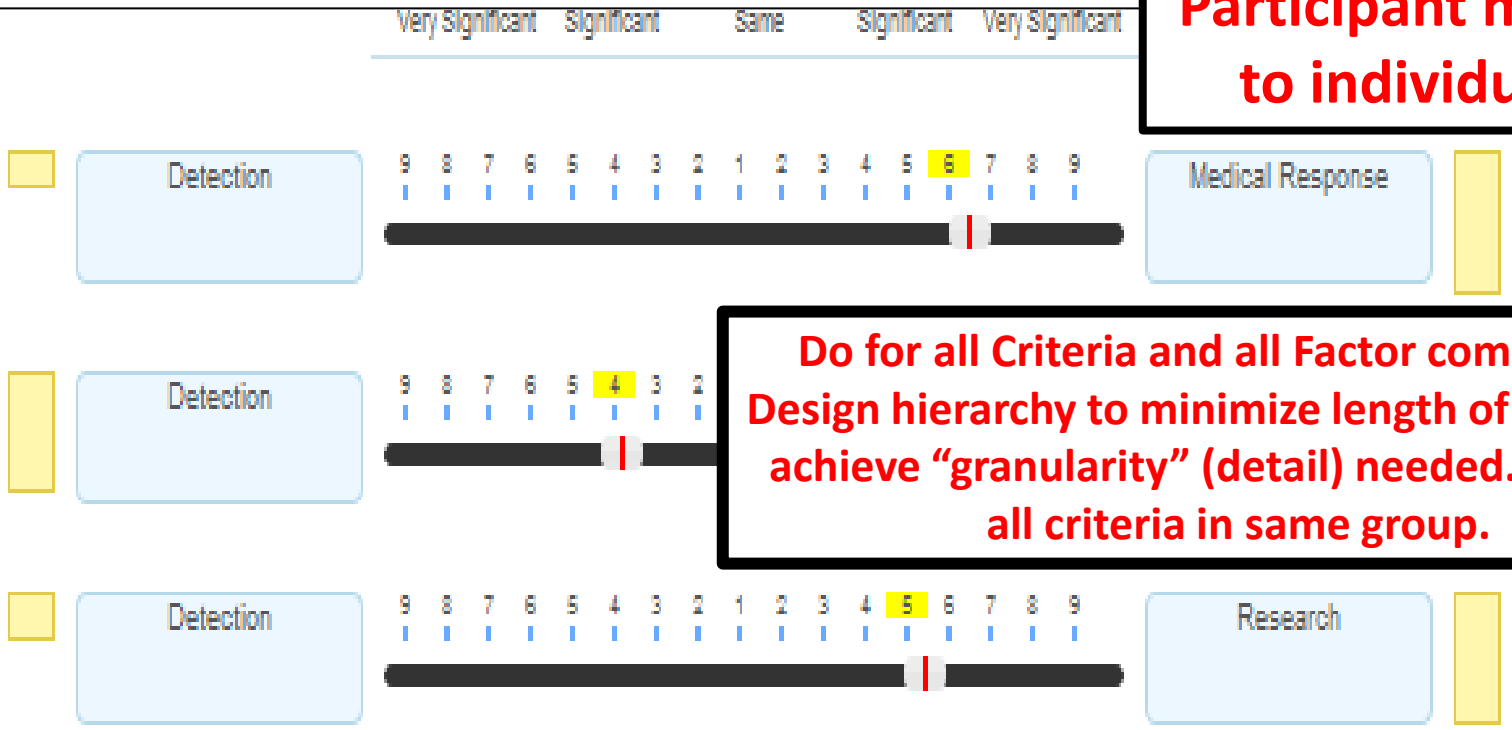
Home Logout (05b2c6f30295efa2f5d3bd896)

Progress Indicator

Factor Comparison

Please rate the relative importance of each factor. Move the slider closer to the factor you think is more important, or leave the sliders at 1 (equal importance). Sliders must be touched before moving to the next page

Participant moves slider to individual choice



Do for all Criteria and all Factor comparisons Design hierarchy to minimize length of survey but achieve "granularity" (detail) needed. Cant put all criteria in same group.

Steps Involved:

GOAL

4. **Calculate factor, subfactor, & criteria weights.**
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P-AHP: Determination of Potency

Once the user has completed the pair-wise comparisons - first of the factors, then of the criteria - the survey uses the AHP algorithm to calculate the weights.

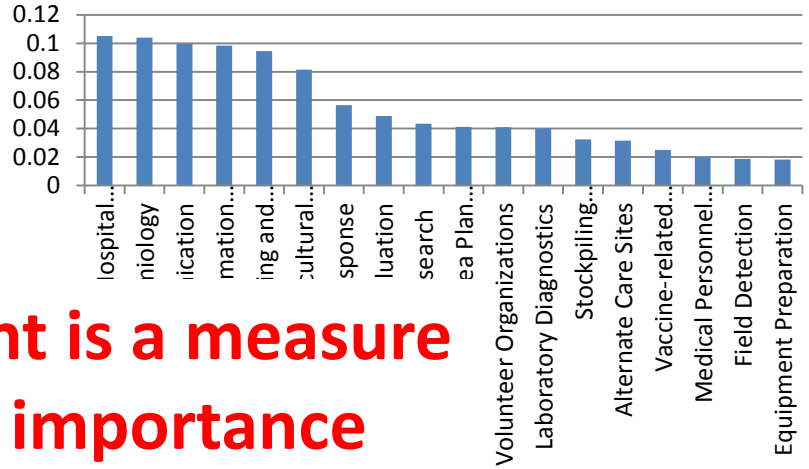
The results are not shown to the user, instead are recorded by survey manager. The manager must decide the degree to which this information is shared.

AHP² Determination of Potency

Epidemiology	0.248374
Incident Evaluation	0.189237
Patient Research	0.088705
Laboratory Diagnostics	0.076878
Communication	0.053223
Agricultural Environmental research	0.053223
Equipment Preparation	0.041396
Epidemiology	0.041396
Handling and Dispensation	0.041396
Medical Personnel Education	0.029568
Public Information Education	0.023655
Area plan coordination/training	0.023655
Alternate Care Sites	0.023655
Stockpiling Vaccines/medicine	0.017741
EMS/Hospital Equipment	0.017741
Vaccine-related research	0.011827
Veterinary Response	0.011827
Volunteer Organizations	0.006505

PRIORITIZATION OF RESOURCES ONE PARTICIPANT

P-AHP: Potency (average over many participants)



Weight is a measure of importance

EMS/Hospital Equipment	0.105062
Epidemiology	0.103992
Communication	0.0995
Public Information Education	0.098232
Handling and Dispensation	0.094454
Agricultural Environmental research	0.081554
Veterinary Response	0.056403
Incident Evaluation	0.048943
Patient Research	0.043458
Area Plan Coordination and Training	0.041218
Volunteer Organizations	0.041114
Laboratory Diagnostics	0.040144
Stockpiling Vaccines/medicine	0.032412
Alternate Care Sites	0.031593
Vaccine-related research	0.024952
Medical Personnel Education	0.019828
Field Detection	0.018772
Equipment Preparation	0.018369

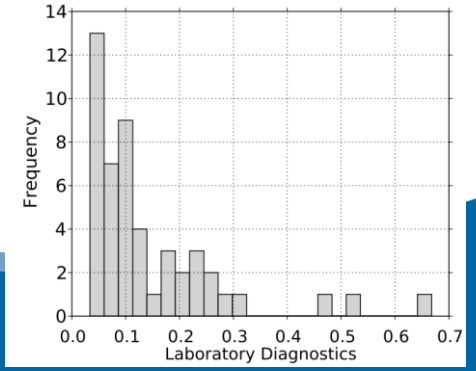
CAN BE USED AS A GUIDE FOR THE PRIORITIZATION OF RESOURCES

Why use AHP²?

- User friendly;
- Provides greater clarity (democratic);
- Multiple applications for survey use;
- Facilitates complex decision-making;
- Maintains user anonymity;
- Provides easy modification of questions and categories;
- It will be open source!

How is AHP² Different?

- We allow the participant to **select criteria** (weight profiles will be different)
- We allow the participant to **place the same criterion at the same level for several factors** (allow overlapping influence)
- AHP applications **tend to average pairwise comparison matrices** (before weight is calculated - inappropriate). We generate statistical distributions and mean.



IN SUMMARY…

- AHP is a multi-attribute decision technique – can be used for many applications;
- Requires expert input – only as good as the experts;
- New online tool for public health research: AHP^2
- Easily customizable and will be available to public health officials for emergency preparedness