Tools for Decision Analysis and Resolution

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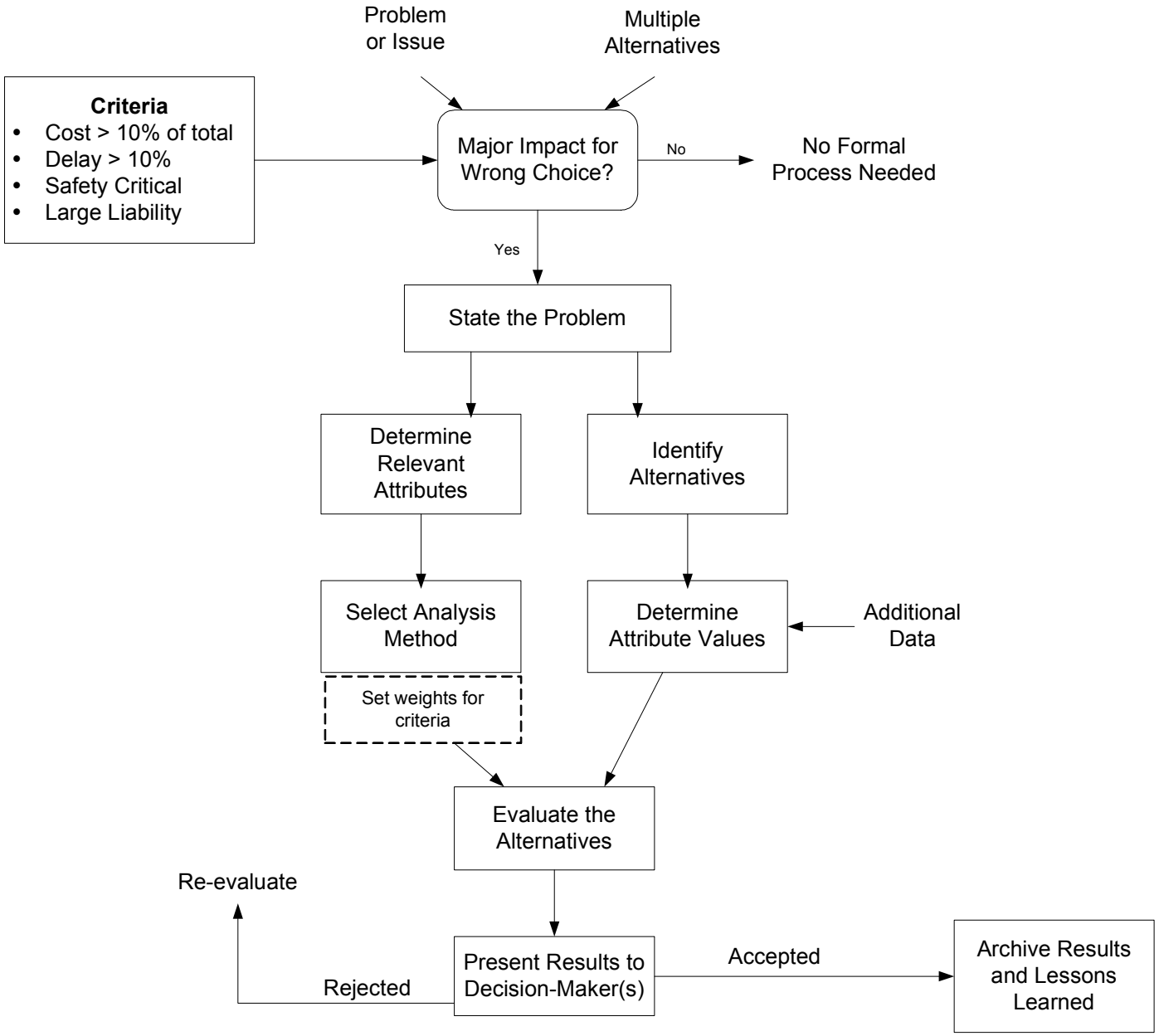
Topics

- **Motivation**
- **Process**
- **Descriptions of Methods and Examples**
- **References**

Typical Decisions

- Choose product features (with/without other constraints)
- Identify the “best” design option (trade studies)
- Decide whether to make, reuse, or buy
- Select a COTS component or tool
- Pick a vendor or subcontractor
- Choose a cost estimating method
- Select a risk mitigation approach
- Decide to bid or not
- Terminate software testing
- Modify work products that are already baselined


Problem or Issue
Multiple Alternatives
Criteria
• Cost > 10% of total
• Delay > 10%
• Safety Critical
• Large Liability
Major Impact for Wrong Choice?
No
No Formal Process Needed
Yes
State the Problem
Determine Relevant Attributes
Identify Alternatives
Select Analysis Method
Set weights for criteria
Determine Attribute Values
Additional Data
Evaluate the Alternatives
Re-evaluate
Present Results to Decision-Maker(s)
Rejected
Accepted
Archive Results and Lessons Learned

Approval Voting Example

Feature	Estimator					Total Votes
	1	2	3	4	5	
A		X				1
B		X	X		X	3
C						0
D	X	X	X	X	X	5
E	X					1
Total Votes By Voter	2	3	2	1	2	

Steps of Nominal Group Technique

1. **The Facilitator asks each person to identify the N "best" items (N = L/5)**
2. **Each person chooses and ranks the N "best" items, ranking them from 1….N. ("N" is the most preferred. "1" is the least.)**
3. **The Facilitator records rankings for each item from all persons**
4. **The Facilitator totals the values for each item.**
5. **The items with highest totals are selected.**
6. **Optionally, discuss top few items, revise item descriptions and repeat process.**

Example of Nominal Group Technique

Feature	Estimator					Total Votes
	1	2	3	4	5	
A		3	2		2	7
B	3	2	1	3	3	12
C						0
D	1	1	3	1	1	7
E	2			2		4

Multivoting

1. Give each person V votes (V ≈ M. Alternately, V = L/3.)
2. Each person allocates one, two or even all votes to one or more items
3. The Facilitator asks each person for their votes
4. The Facilitator totals the votes
5. The group eliminates the items with the fewest votes
6. Optionally, discuss the top few items, and revise the item descriptions.
7. Repeat the process with the revised list if needed

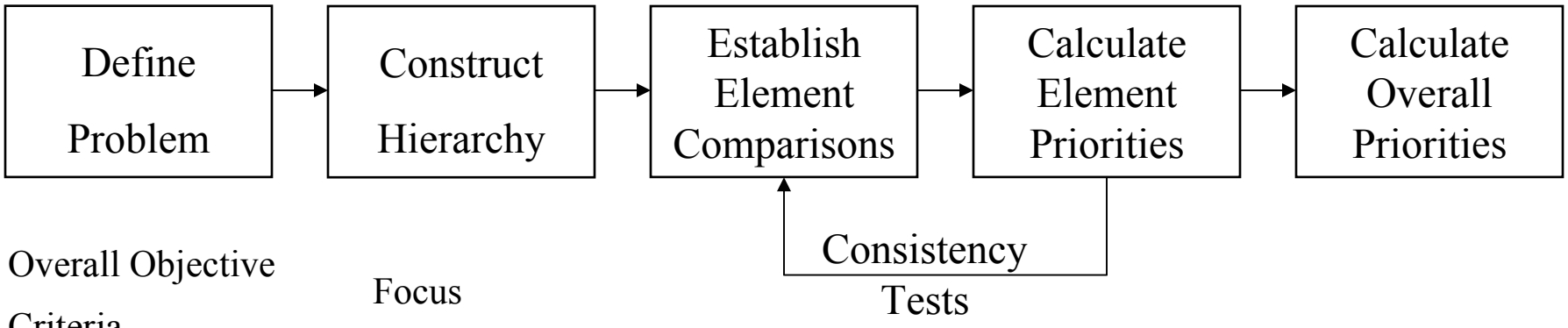
Multivoting Example

Feature	Estimator						Total Votes	Rank
	1	2	3	4	5	6		
A							0	-
B	3	1	1	1	1		7	1
C			1	1		1	3	3
D		1			2		3	4
E		1	1	1		1	4	2
F							0	-
G						1	1	5
H							0	-
Total Votes Cast	3	3	3	3	3	3		

The Analytic Hierarchy Process (AHP)

- **AHP allows one person or a group to:**
  - **Structure a complex decision**
  - **Identify criteria and factors (concrete or intangible)**
  - **Measure the interactions among them in a simple way**
  - **Combine the data to obtain the relative priorities of the alternatives**
- **Examples of criteria:**
  - **Objective Criteria**
  - **Technical Data**
  - **Cost Estimates**
  - **Subjective Criteria**
  - **Benefits**
  - **Risk Information**
  - **Preferences**
  - **Political Factors**

Steps of the Analytic Hierarchy Process



Overall Objective
Criteria
Factors
Constraints
Scenarios
Stakeholders
Sources of Data
Experts

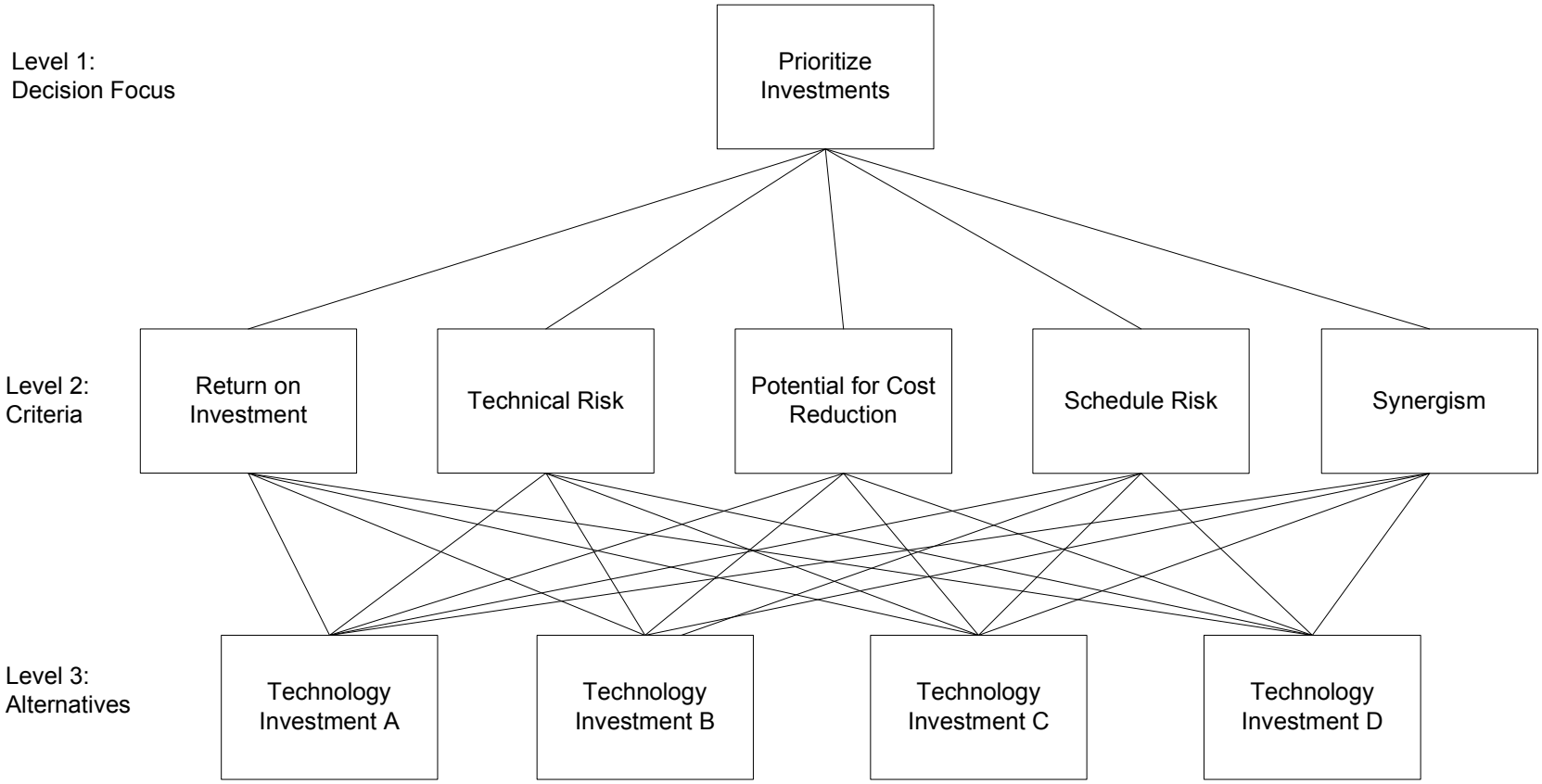
Focus
Levels
Clusters
Elements
Alternatives
Structure

Element Matrices
Experts/Groups
Pairwise Comparisons

Priority Vectors
Consistency Index
Consistency Ratio

Priority Vectors Synthesis
Overall Priority Vector for Hierarchy

A Hierarchy for Technology Investment



The Comparison Matrix for Criterion C

- **Rows and Columns are the alternatives**
- **Start with A_1 in left column; compare with all other alternatives wrt criterion C**
- **Use Saaty's scale to measure comparisons**
- **Use reciprocal values for elements below the diagonal**

Criterion C	A_1	A_2	A_3
A_1	1	a_{12}	a_{13}
A_2	$1/a_{12}$	1	a_{23}
A_3	$1/a_{13}$	$1/a_{23}$	1

AHP Rating Scale

Verbal scale	Numerical Value
Equally important, likely or preferred	1
Moderately more important, likely or preferred	3
Strongly more important, likely or preferred	5
Very strongly more important, likely or preferred	7
Absolutely more important, likely or preferred	9

Paired Comparison Questionnaire

Criterion or Factor: _____

Does A dominate B or doe B dominate A with respect to the criterion factor?

Indicate how strongly using the appropriate comparison scale:

	Equal Importance		Moderate		Strong		Very Strong		Absolute
A over B	_____	_____	_____	_____	_____	_____	_____	_____	_____
B over A	_____	_____	_____	_____	_____	_____	_____	_____	_____
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Calculating the Priority Vector*

Criterion C	A_1	A_2	A_3
A_1	1	½	¼
A_2	2	1	¼
A_3	4	4	1
Column Totals	7.0	5.5	1.5

Steps

- Divide elements of each column by the sum of that column
- Add elements in each resulting row
- Divide each row sum by n

Criterion C	A_1	A_2	A_3	Row Sums	Priority Vector
A_1	0.14	0.09	0.17	0.40	0.13
A_2	0.29	0.18	0.17	0.64	0.21
A_3	0.57	0.73	0.67	1.97	0.66

*The eigenvector of the comparison matrix

Challenges Faced by Any Technique

- **People do not always make perfect decisions (due to ignorance, biases, or manipulative strategies).**
- **People may change their minds.**
- **You may not have enough resources (time, money) assign good ratings to all of the factors identified.**
- **You may fail to identify key factors that greatly affect the desirability of the alternatives.**
- **It may be difficult to identify orthogonal criteria. (This is not a serious drawback.)**