Risk Management

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Agenda

Introduction to Risks

Risk Management Process Elements

- **Planning**
- **Risk Identification**
- **Assessment – Severity, Cost**
- **Analysis – Prevent, Mitigate**
- **Closure**
- **Tracking, Management, Reporting**

Summary

What is Risk??

- The uncertainty that potential or known events may impact a project outcome.
- The measure of the probability and severity of adverse effects *(Chapter 3, Haimes, Handbook of Systems Engineering).*
- The product of the probability of an event not occurring and the consequence of not succeeding *(HRC INCOSE SE Basics Tutorial, August 2001).*

What is a Risk?

- PMI's (Program Management Institute) definition allows for positive or negative impact
- Ron's Definition: a future event that has some uncertainty of occurrence and has some negative impact if it occurs.
- Feb. 2002 issue of Cutter IT Journal has a 'debate' on these different definitions (R. Kohl defended the above defn)

What is Risk??

- Two Parts:
  1. Probability of Event Occurring
  2. Consequences of Event Occurring (including level of severity)

- Consequences can be expressed in many ‘units’, so choose carefully (or choose several!)
- Severity is subjective, so be careful

What is not a Risk?

- A past or current problem
  - Not a ‘future event’
- A certainty
  - Probability of occurrence = 1
- An impossible event
  - Probability of occurrence = 0
- A possible good thing
  - No negative consequence

- **Why Implement Risk Management??**

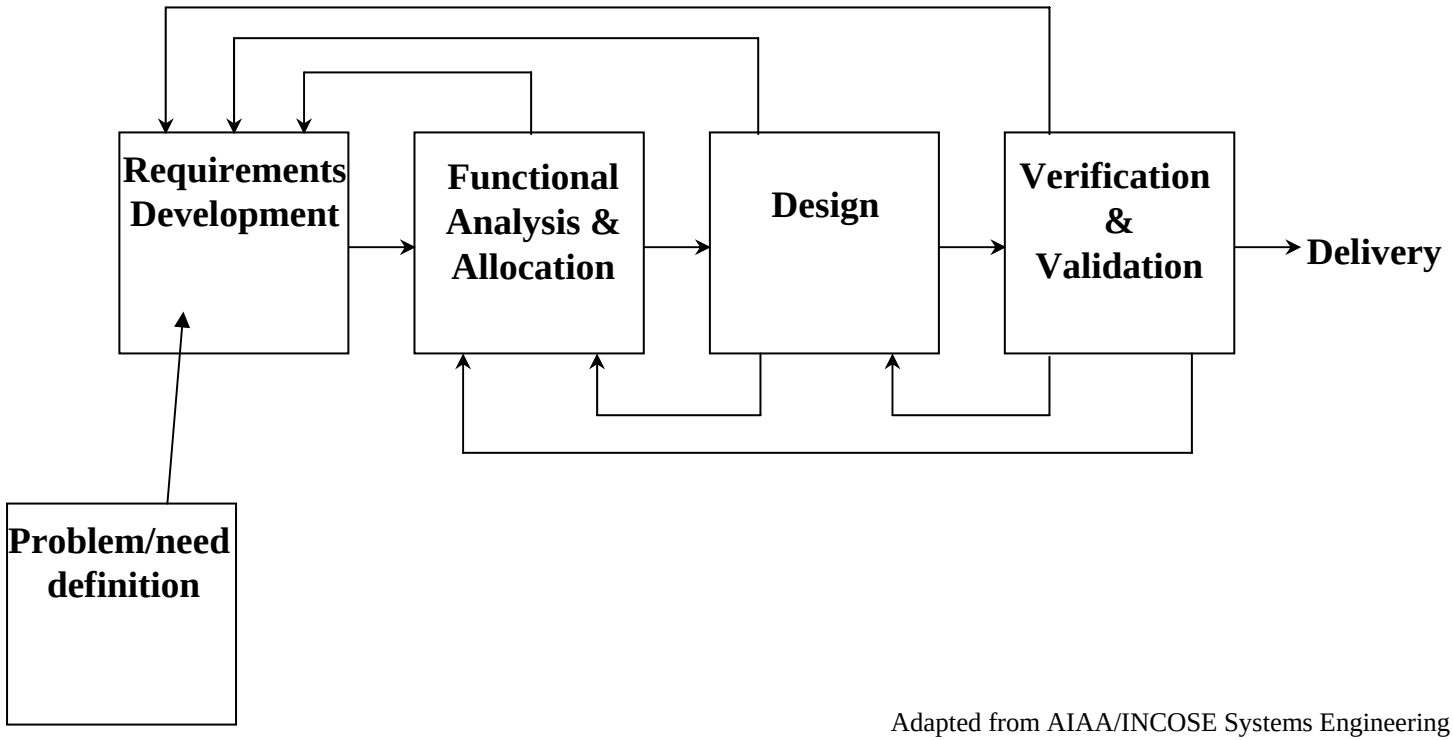
- Identify potential problem areas early
  - Prevent them from occurring
  - Develop a plan for dealing with the situations, if they occur

- Reduces chances of costly changes or reduces impact of unavoidable events: schedule delays, unexpected failures, etc.
- Increases the likelihood of success!!

When Should Risk Management Be Implemented??

- Planning begins before/at project startup
- Preliminary identification and assessment start at the earliest technical phase (Problem/need defn, Ops Con, Arch, etc)
- Risks are tracked and managed throughout the project/program life cycle
- Plans for reporting should be established early to avoid confusion in responsibilities later

Simple Project Life Cycle



Adapted from AIAA/INCOSE Systems Engineering Workshop presentations; Feb/Mar 2001

Risk Types

Three Most Recognized Types of Risk in Government and Commercial Practice

1. **Technical**
2. **Cost**
3. **Schedule**

Risk Types

1. **Technical**

- The degree to which technology is sufficiently mature and has been demonstrated as capable of satisfying program objectives.
- Technical risk is frequently the driver in development phase of a program.

Risk Types

2. **Cost**

- Availability and sufficiency of funding for the program.
- Government appropriations and funding cycles are also subject to political risks.
- Commercial programs are subject to market risks.

Risk Types

3. **Schedule**

- Adequacy of time allocated for the defined tasks.
- Includes effects of changes due to unpredictable events such as: program and technical decisions, time-to-market pressure, labor problems, weather and customer directed changes.

Risk Types

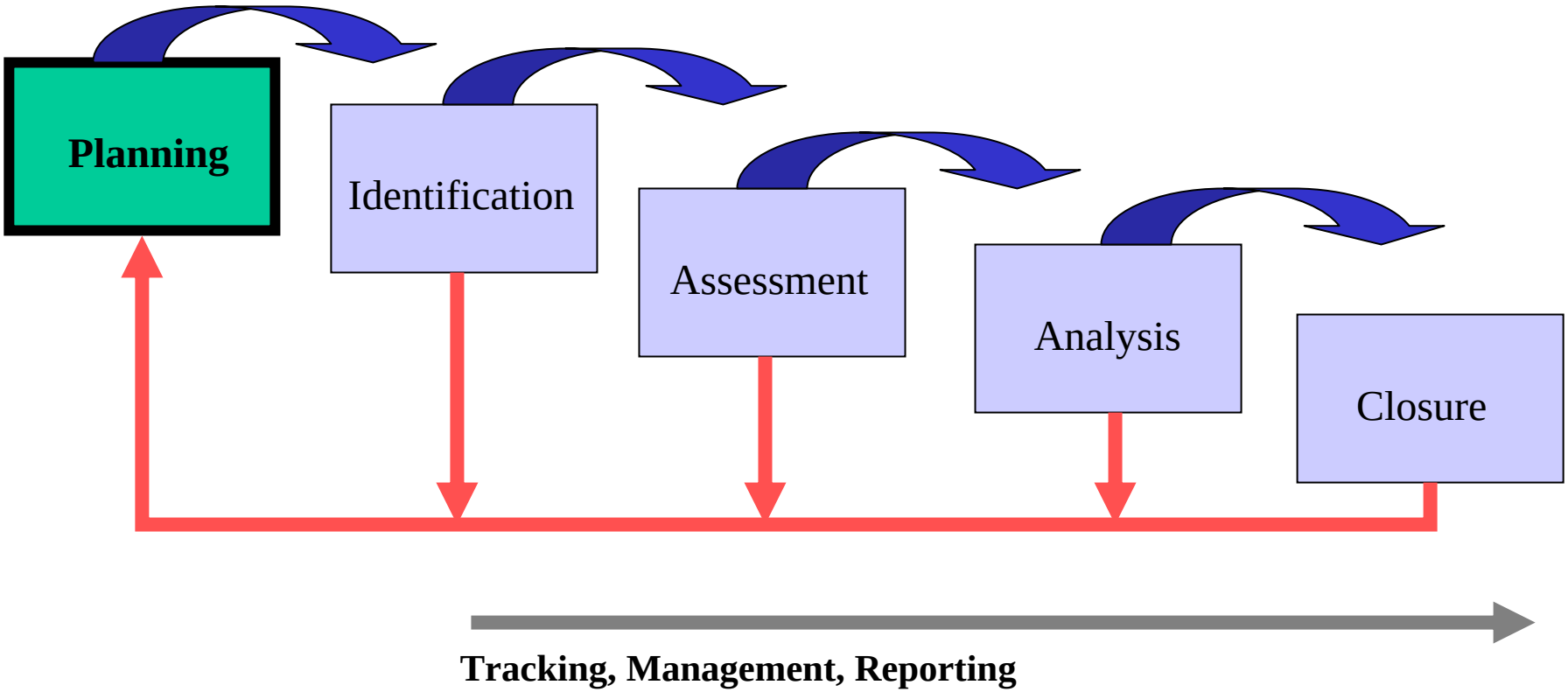
Others

- Adequate staffing, resources
- Professional/Enterprise reputation
- External
  - Political
  - Social
  - Regulatory/legislative

Risk Management as a Process

- **Risk Management Definition:**
  - The resources expended to understand, control and minimize the probability and consequence of an undesired event.
  - A diagnostic decision tool that enhances project management effectiveness and provides program/project managers information to evaluate choices and keep the program on track.
  - Just one of many tools in the PM's toolkit to run the project

Risk Management Process Steps



Planning

❖Overview

- Should be established prior to or during project startup
- Responsibility generally lies with the project manager or lead systems engineer with input from all team members
- Gain management buy-in
- Accommodate enterprise/organizational needs and interests

Planning

- Plan Components
  - Assessment Approach
  - Ranking Criteria
  - Tracking and Management
  - Reporting
  - Other processes, as needed
  - Resources needed (cost, staff, tools,etc)

Planning

- **Assessment Approach**
  - Qualitative vs. Quantitative
    - Qualitative = assessment based on experience
    - Quantitative = analysis based on mathematical formulas
  - Selection is dependent upon project resources, customer requirements, available tools, staffing experience

Planning

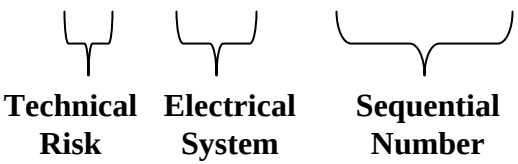
- **Criteria Establishment**
  - •Establish and clearly define values in Risk Management Plan at beginning of project
  - •Start simple (e.g. H, M, L) and expand only if warranted
  - •Choose an effective criteria assignment system
    - ➢Criteria should reflect feasible definitions based on the project

Planning

- **Tracking and Management**
  - Determine methods of tracking and management during planning phase
    - Spreadsheets, tables, electronic systems
  - Electronic management: select software package or development of custom system
    - Depending on schedule, can perform trade analysis to determine most suitable tracking and management system

Planning

- **Tracking and Management**
  - Establish risk identification system, for CM purposes
    - Based on system or project hierarchy
    - Based on risk types
  - Example: # T - ES - 00047



Planning

- **Reporting**
  - Establish reporting processes during planning phase to eliminate inconsistencies and delays during implementation
  - Report format, content, periodicity, roles and responsibilities should be defined early in project

Establish the RM Team

- **Roles, Responsibilities**

  • Project Manager: Defines RM needs, requests reporting format/content and frequency, final arbiter

  •Risk Manager: ‘owns’ the RM processes, supports the PM, supports the ‘risk owners’

  • Risk Owner: ‘owns’ a given risk, conducts analysis, prepares mitigation plans, reports to PM/Risk Mgr

Establish the RM Team

- Risk Review Board (aka Risk Management Board)

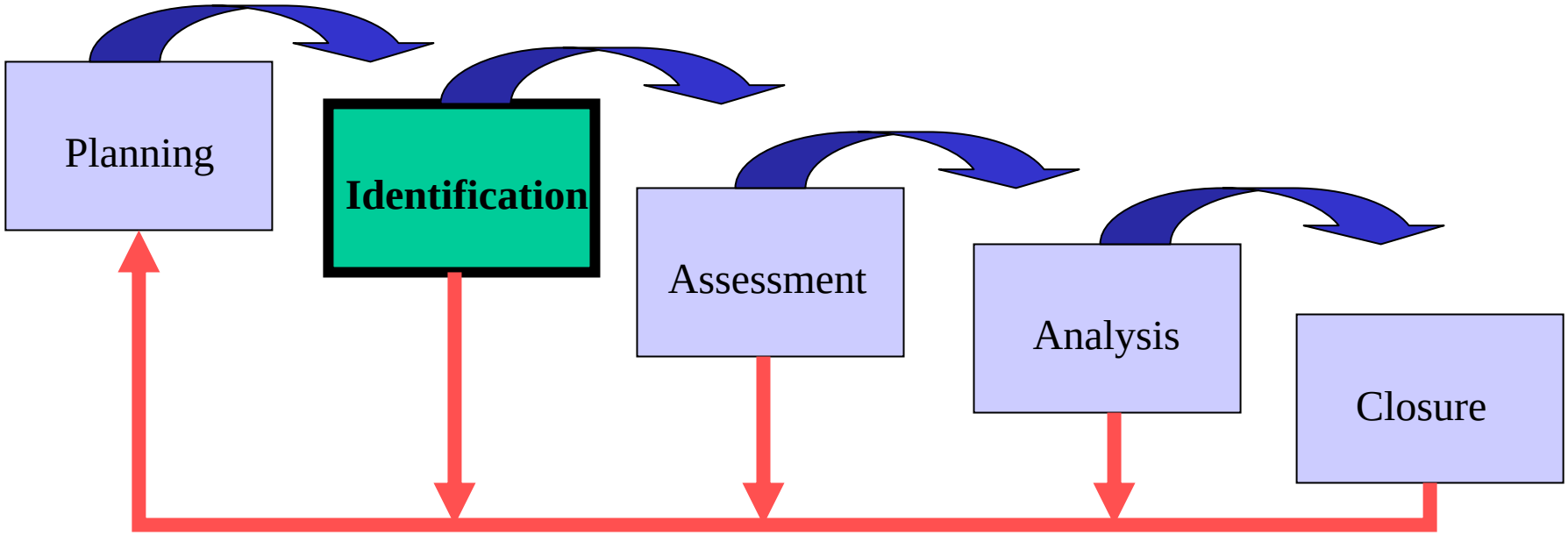
- The decision making body for risks on the project that approves/disapproves:
  - risks
  - risk plans
  - risk closures

- Composition should be like other decision boards (or combine with CCB)

Risk Management Planning - Summary

- Enterprise/organizational level needs
- Project level needs
- Scope of effort for each project
- Look at ‘big picture’
  - Cost, benefit
  - But almost impossible to not perform at some level
- Make management, technical commitment or else

Risk Management Process Steps



- Requirements
- Resources
- Responsibilities
- Methods

- Experts
- FMEAs
- FTAs
- History
- Program Documentation
- Business Case Analysis

- Quantify
- Tech Perf Measures
- ROI
- ROIC

- Deterministic
- Simulation
- Tech Perf Measures
- Business Case Analysis

- Prevention
- Mitigation
- Complete info
- Critical Items & Issues List

Identification

- Two most effective methods for identification
  - Experience (FTA, FMEA, Hazard Analysis)
  - Brainstorming
  - Never underestimate the power of dumb luck!

✓Experience-Based – impact of unmitigated risks from previous projects

✓Brainstorming – input from all disciplines, stakeholders

Identification

- **Risk Statement:**

- Similar to requirement development/verification planning: generate risk statement such that consequences and response/action plans can be clearly defined
  - Snappy, catch, meaningful title (one liner)
  - Understandable description of the risk (uncertainty and consequence)
  - (optional) some suggestion of a priority or ranking of this risk

Identification

- ***Examples:***
- **Risk 1:** Poorly defined project requirements

  "Requirements may not be clear or understandable to the entire team. There have already been occurrences of disagreements on certain requirements."

  ✓*Consequence: Incorrect or inadequate design, $$ impact*

  ✓*Prevention plan: establish and implement requirement definition processes; schedule formal requirement reviews*
- **Risk 2:** Inclement weather during construction phase

  ✓*Consequence: Schedule delays, material damage*

  ✓*Mitigation plan: Allow time in schedule for weather concerns*

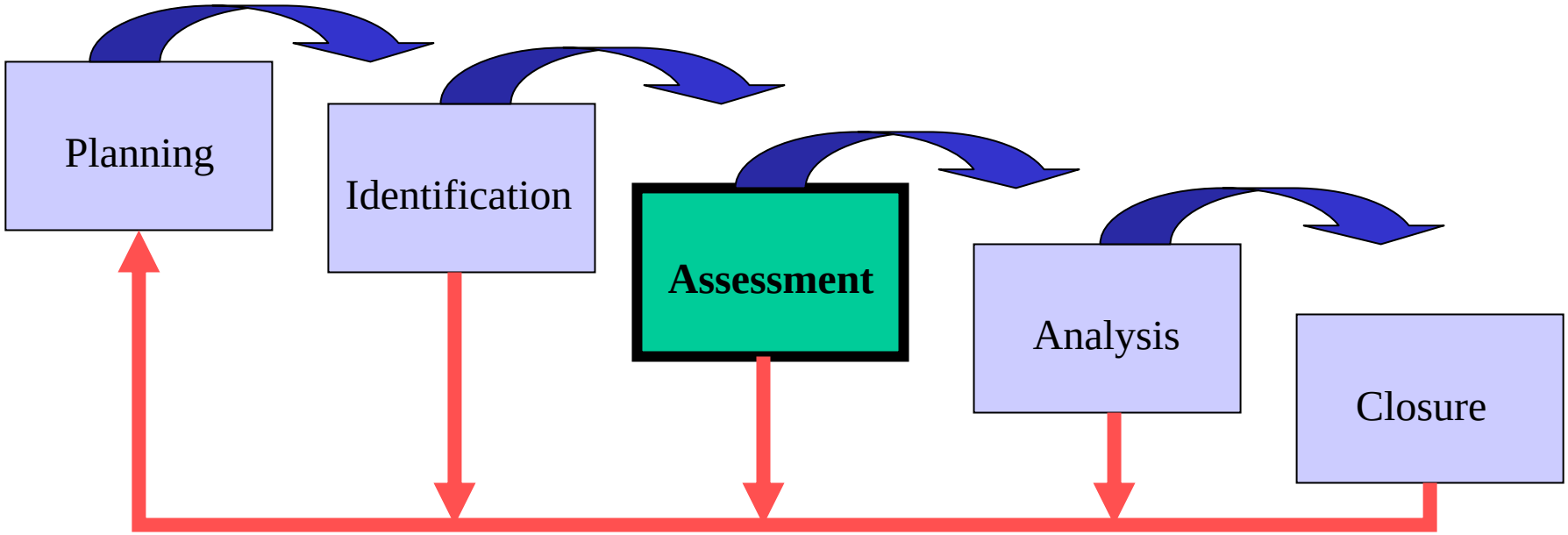
Approving Risks

- It is good to allow for nearly any potential risk to be captured and reviewed, at some level (Candidate Risks)
- The RRB (or other decision process) should determine if a candidate risk is approved for addition to the Risk List
- It is a good idea to retain information on all risks, for future use

Risk Identification Summary

- (re)Use known areas of risk as starting point
- Use past experiences in enterprise/org
- Use past experiences in domain
- Use ‘subject matter experts’
- Capture Risks in useful format
- Better to build bigger list, early in lifecycle
- Establish effective CM/controls of this list

Risk Management Process Steps



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Assessment/Analysis

- **Criteria Application:**
  - Qualitative assessment requires simplistic values assigned for probability of occurrence and level of severity
  - Quantitative requires calculation of probability and severity factors for mathematical analysis

Qualitative Assessment

- **Criteria Development**
  - Simplified criteria
  - Severity of Consequence
    - Low, Medium or High
  - *Probability of Occurrence*
    - Use number between 0 and 1
    - or L, M or H

Qualitative Assessment

- ***Probability of Occurrence***
  - ❖Low or "1"

    = minimal or unlikely chance of occurrence

    • Examples:
      - ✓One occurrence per 1000 years
      - ✓One occurrence per 50,000 units produced

Qualitative Assessment

- ***Probability of Occurrence***
  - ❖ Medium or "2"

    = medium or somewhat likely chance of occurrence

    - Examples:
      - ✓ One occurrence per 10 years
      - ✓ One occurrence per 1000 units produced

Qualitative Assessment

- ***Probability of Occurrence***
  - ❖ High or "3"

    = maximum or very likely chance of occurrence

    • Examples:
      - ✓ One occurrence per year
      - ✓ One occurrence per 50 units produced

Qualitative Assessment

- ***Consequence of Occurrence***
  - ❖Statement that defines actual impacts of risk occurring

Example:

Project/System = House

Risk = Direct hit from F-4 tornado

Consequence/Impact = People are injured or killed; house is severely damaged or completed destroyed

Qualitative Assessment

- ***Severity of Consequence***

  - Value that assigns a level of severity to the event

  - Low or "1" = Minor or no injuries, minimal or no structural damage, cost impact of <$50,000, schedule impact of <30 days

Qualitative Assessment

- ***Severity of Consequence***

  - Medium or "2" = Physical injury or impairment, medium structural damage (no loss of key components), cost impact of $50,000 to $500,000, schedule impact of 30 – 90 days

Qualitative Assessment

- ***Severity of Consequence***

  - High or "3" = Loss of life, major structural damage or complete destruction, cost impact of >$500,000, schedule impact of >90 days

Qualitative Assessment

- ***Severity of Consequence***

  - ❖Can also assign cost and/or schedule as separate items of severity
  - ❖Identify cost/schedule as separate line items on worksheets

Qualitative Assessment

- ***Assessment***

Tornado Example:

Project/System = House

Risk = Direct hit from F-4 tornado

Consequence/Impact = People are injured or killed; house is severely damaged or completed destroyed

Probability = 1

Severity = 3

Composite number = 2

Appendix B – risk consequence scale

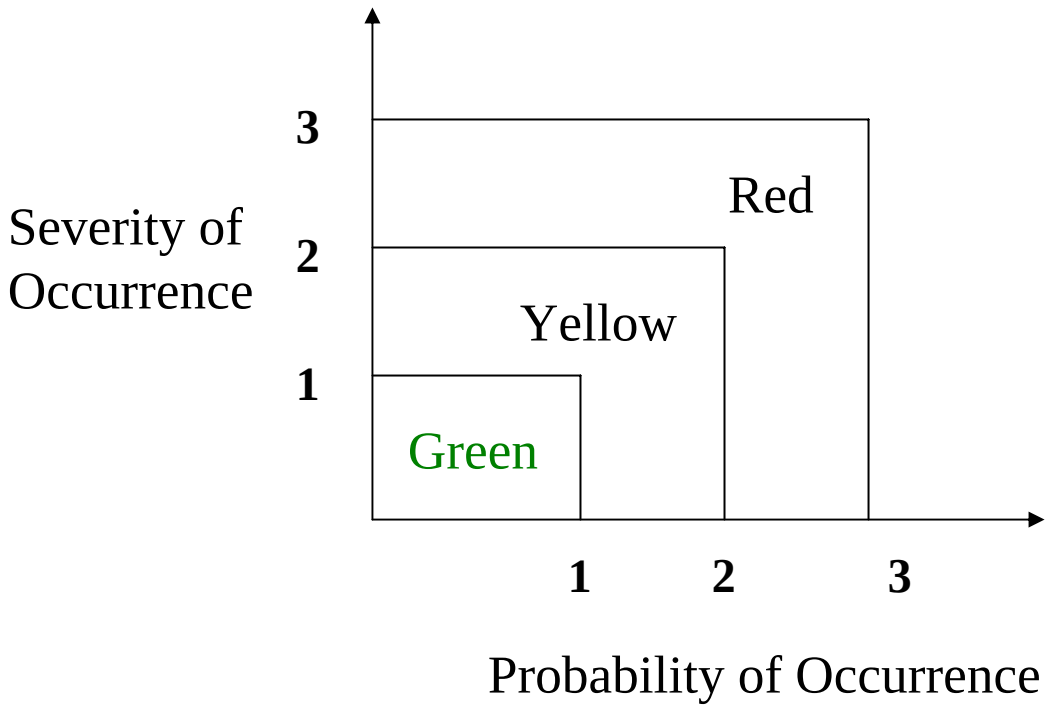
Level	Cost	Performance	Schedule
5	A cost increase >20% is anticipated	Unacceptable performance will exist. Performance requirements cannot be met. Major system redesign is required.	A schedule slip > 6 weeks is anticipated
4	A cost increase >15% and < 20% is anticipated	Moderate performance degradation will exist. Performance requirements cannot be met. Moderate system redesign is required.	A schedule slip > 4 weeks and < 6 weeks is anticipated
3	A cost increase >10% and < 15% is anticipated	Some performance degradation will exist. Performance requirements cannot be met. Moderate redesign of one or more system elements is required.	A schedule slip > 2 weeks and < 4 weeks is anticipated
2	A cost increase >5% and < 10% is anticipated	A slight performance degradation will exist. Performance requirements can be met, but performance margins are eliminated. Minor redesign of system elements is required.	A schedule slip > 1 week and < 2 weeks is anticipated
1	A cost increase <5% is anticipated	A negligible performance degradation will exist. Performance requirements can be met, and adequate performance margins will exist. Redesign of system elements is not required.	A schedule slip of < 1 week is anticipated

Risk Prioritization

- **Risk Prioritization:**
  - ➢ Prioritize based on predetermined criteria
    - Risk Type – Cost, Schedule, Technical
    - Consequence/Impact
    - Combination of Probability of Occurrence and Consequence

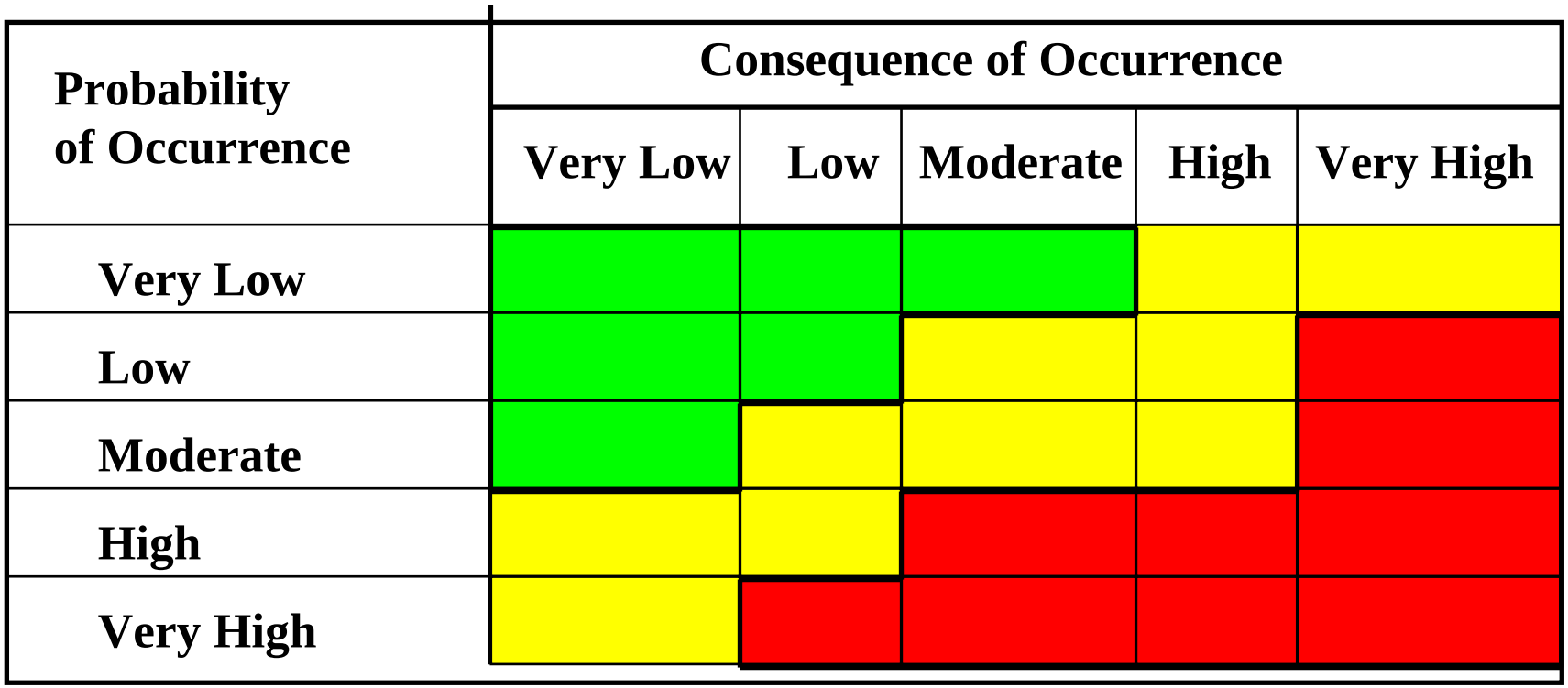
Risk Prioritization

- **Risk Prioritization:**



Qualitative Representation of Risk

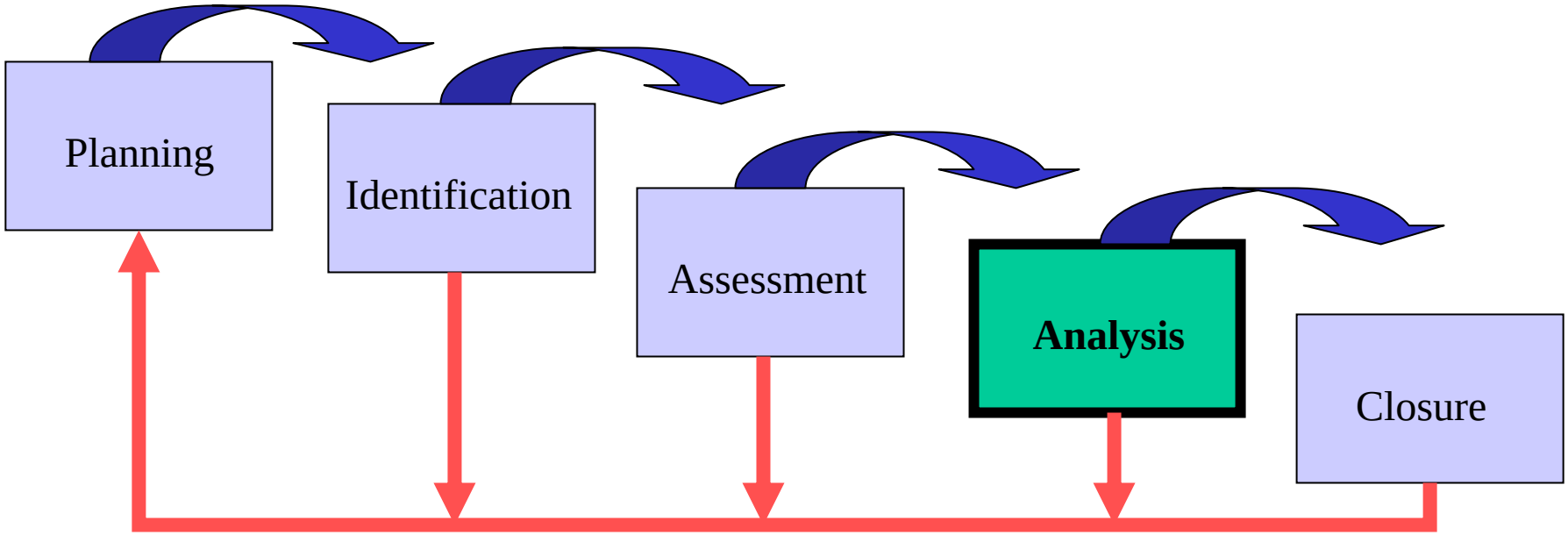
Qualitative risk representations are often used for quick evaluations and screening.



General Risk Information			
RiskID:	247	CustomID:	
Risk Title:	No Software Functional Unit Provided To XXX		
Description:	The proposal assumed some form of Furnished Equipment to test XXX software. The current plans call for an SFRU to be provided, but much later than was originally assumed. This impacts the ability to properly test XXX software in the local lab area, causing travel and coordination of testing within the System Integration Lab (SIL).		
Category:	Test:Test Equipment		
Team:	PM	WBS:	1.2
IMP/IMS:		Other Ref.:	
Person Responsible:	Tbd	Risk State:	Open:Active
Rqmt:			
POC Counterpart:			
Ownership:	tbd		
ORD Para. [Gov't]:			

Risk Event Summary							
		Actual		Schedule		Baseline	
#	Event Title	Date	Risk	Date	Risk	Date	Risk
0	Risk Identified	1/12/2004	M 4-3				

Risk Management Process Steps



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Quantitative Risk Analysis

Two Approaches in Common Use for Systems Engineering

- Using ‘simple’ combinations of P and C to make decisions

-Monte Carlo Simulation Programs

Quantitative Risk Analysis

Monte Carlo Simulation Programs

•Analyzes risk variables by accounting for every value and weights each scenario by probability of occurrence

•Structure similar to deterministic model except that risk variable represented by distribution function

•Result is a probability distribution of possible model outcomes and assessed using statistical techniques

•Executed on commercial software such as @RISK®

•Reference: Quantitative Risk Analysis, David Vose, Wiley&Sons, 1996

Risk Exposure analysis

- **Risk Exposure:**
  - **RE = Prob (Loss) * Size(Loss)**
- **“Loss” – financial; reputation; future prospects, …**
- **For multiple sources of loss:**
- **RE = Sum [Prob (Loss) * Size (Loss)]**

  all sources

Risk Exposure analysis

- **Can be used to prioritize risks**
- **Can be used to assess project teams for risk impacts**
- **Can be used to decide what actions to take**
- **Can be used to quantitatively manage any such actions**
- **But it is not the only criteria by which decisions should be made!!**

Risk Reduction Leverage (RRL)

- **RRL = $\frac{\text{RE (BEFORE) – RE (AFTER)}}{\text{Cost to perform Risk Reduction}}$**
- Provides a quantitative ability to assess mitigation approaches
- Aids in management/technical decision making

Risk Reduction Leverage (RRL)

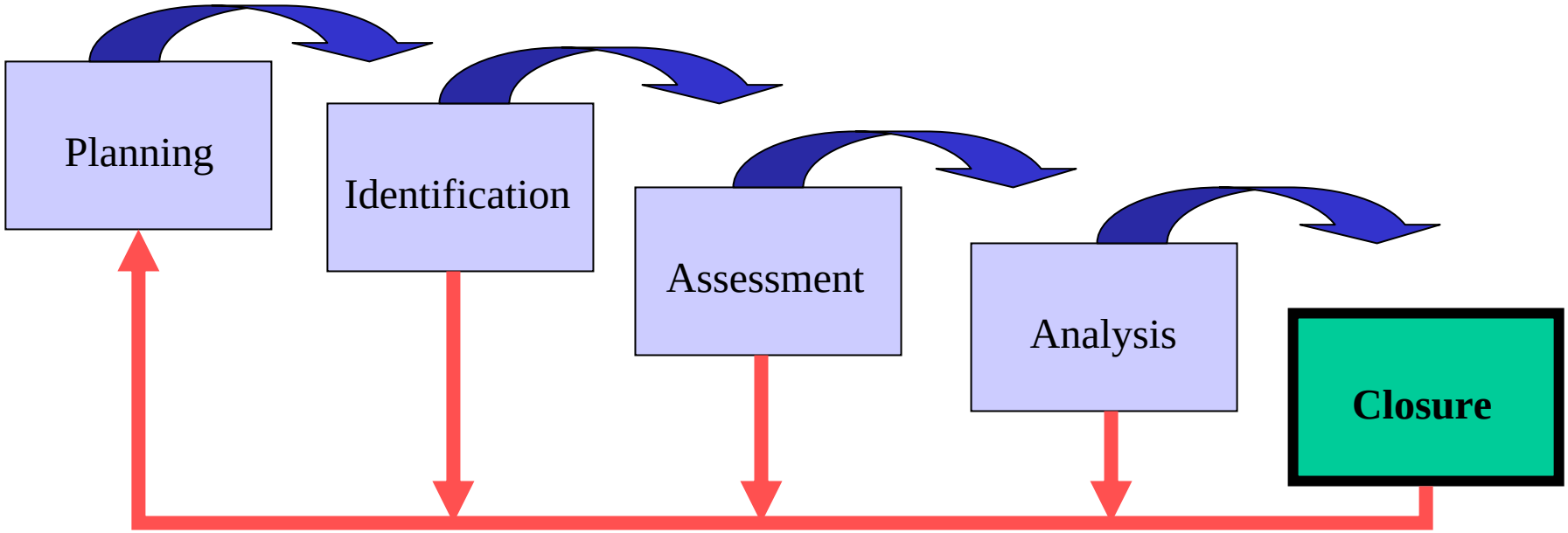
- Be sure to use ‘apples to apples’ cost comparisons
- Review RRL analysis occasionally, since these are guesstimates and things change
- Use peer reviews to increase confidence in RRL estimates

Quantitative Risk Analysis

Summary

- Quantitative risk analysis is a necessary tool for assessing the impact of risk resulting from decisions, program changes, etc
- Quantitative results improves risk decision making
- Ability to prioritize risks is invaluable

Risk Management Process Steps



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Closure

- Develop and assign actions during or after assessment/analysis
- Compile action closure information with risk worksheets or tracking reports (another CM opportunity!!)
- Decide on prevention/mitigation approach
  - also transfer or ignore
- Develop prevention/mitigation plans and actions
- Submit to approval process, baseline and implement

Risk Prevention and Mitigation

- **Prevention vs. Mitigation:**
  - Prevention – anticipate and resolve the problem before it occurs.
  - Mitigation – assume risk can not be prevented and develop plan for reducing consequence or reducing probability of occurrence, or both

Risk Prevention and Mitigation

- **Prevention vs. Mitigation Examples:**

  - Risk/consequence: Loss of key project personnel resulting in product delivery delays

    - ***Prevention:*** Salary/benefit increases, rewards for milestone successes
    - ***Mitigation:*** Promote remaining personnel with project knowledge; hire new personnel with directly applicable experience

RISK HANDLING PLAN

	Risk ID Number:	
Risk Title: *See Risk Identification Form*	**Date of initial plan:**	**Handling plan led by:**

Other contributors:

Select risk handling approach: **Avoidance** **Control** **Transfer** **Assumption**

Describe handling plan:

If handling method is CONTROL, compete the following sections

Risk Reduction Steps	**Schedule**	**Status**

Fallback Approaches and Decision Date for Use	**Use By**

HW Resources Needed	**Estimated Cost**	**Rationale**
	$	

SW Resources Needed	**Estimated Cost**	**Rationale**

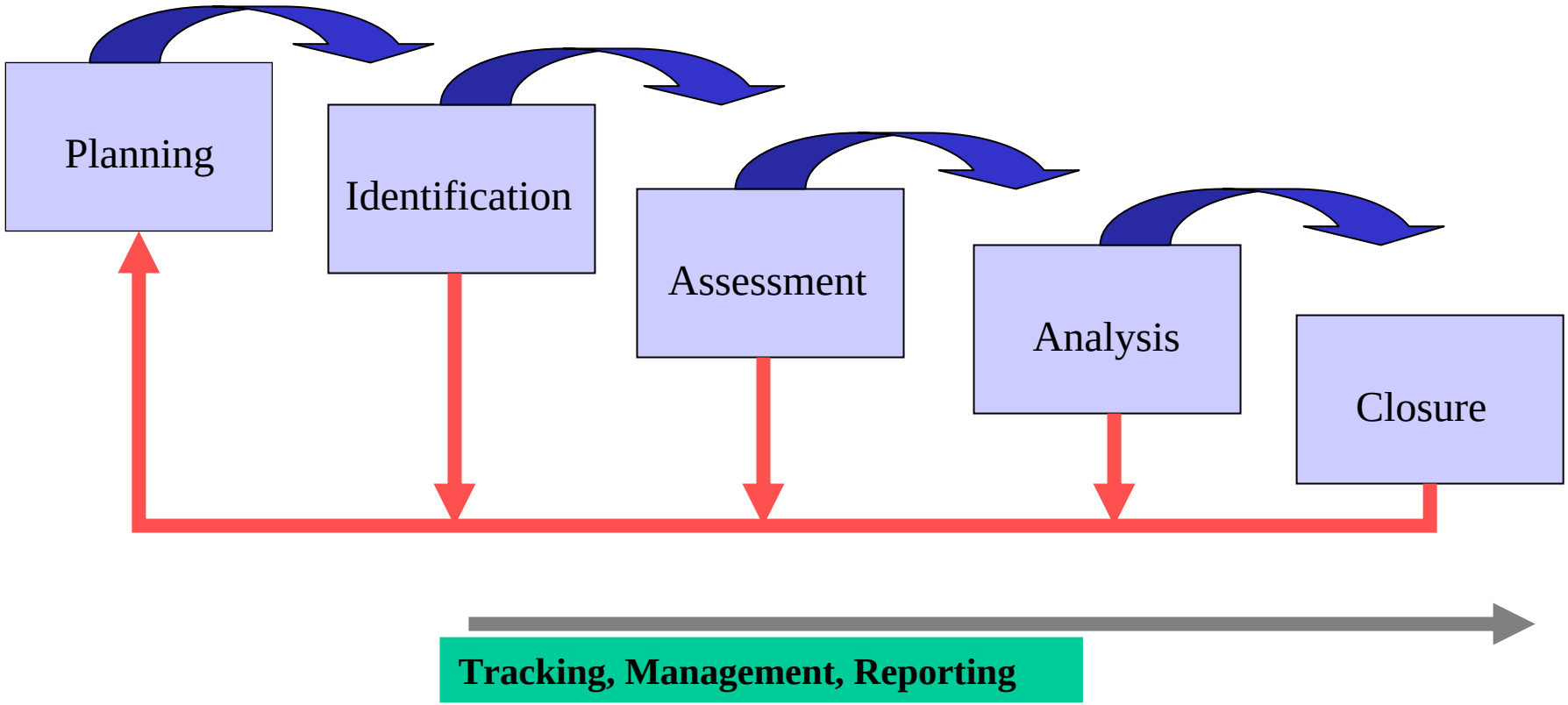
Other Resources	**Estimated Cost**	**Rationale**
Total Estimated Cost:	$	

Risk Management Board Recommendation/Comments: *(Precede each revision or comment with the date of entry)*

Closure

- Ensure that processes are ISO compliant if appropriate (records, etc.)
- Update Risk Management Plan as needed for each closed item
- Maintain archives/records to provide knowledge for future projects

Risk Management Process Steps



Tracking and Reporting

- Tracking systems should contain (at a minimum) the following data for each risk:
  - Risk identification number
  - Risk statement
  - Probability value
  - Consequence statement
  - Consequence value
  - Overall value (if appropriate)
  - Prevention and/or mitigation plans
  - Prevention and/or mitigation actions with actionee and due date
  - Closure data or references
  - Any additional reporting information

Tracking and Reporting

- Manage risks by providing detailed reports at team level and summary reports at management/customer levels
- High impact or priority risks should receive visibility at top levels (e.g. Top 5 or Top 10)
- Summarized versions of risk worksheets provide appropriate data for reports
- Monitoring change in Risk status is just as important as final resolution

Risk Management Process Effectiveness

What is a Process?

- Accepts inputs from some source
- Produces outputs/results to some recipient
- Consumes resources
  - Time
  - Money
  - Humans
  - Other stuff
- Entrance/Exit criteria
- Roles/responsibilities
- Steps/tasks/activities (transformations, algorithms, etc)
- Measurements (on any/all of the above)

Process Effectiveness

- Effectiveness = How well the actual output meets the expected output
- The size of this difference determines ‘highly effective’ or ‘highly ineffective’
- We will focus on base measures
  - most basic measurement
- Rather than derived measures or indicators
  - Using base measures in mathematical expressions

Risk Management Effectiveness

- What are the kind of symptoms we should be looking for?
- Who would care? Why?
- Which of the 5 major process areas are worth measuring effectiveness of?

Some Symptoms of ‘ineffectiveness’

1. Unexpected increase in risk impact
2. Risks not mitigated per mitigation plan
3. Risks that arise later in lifecycle but should have surfaced earlier
4. Risk mitigations that consume more resources than planned
5. Risks that ‘flare up’ or reappear

Some Effectiveness Measures (EM)

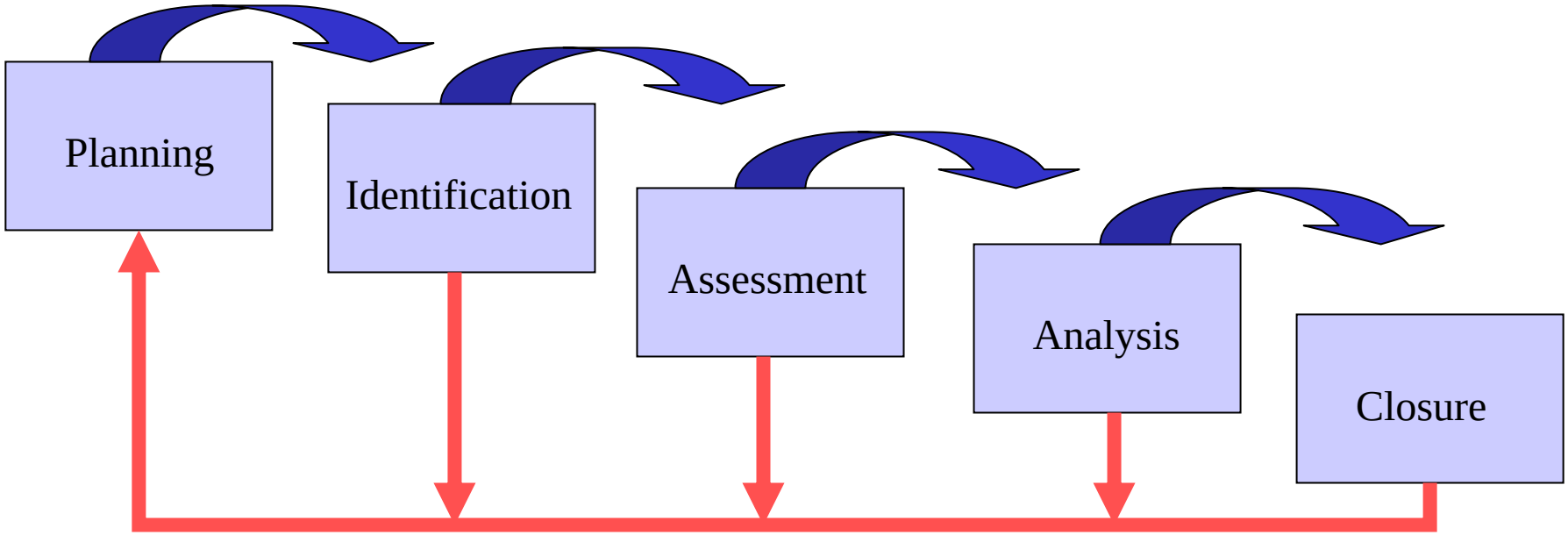
1. # of Problems that were never a Risk (identification)
2. Increase in risk impact (analysis)
3. Risks not mitigated per mitigation plan (mitigation planning or mitigation)
4. Risks that arise later in lifecycle that should have arose earlier (identification)
5. Risk mitigations that consume more resources than planned (monitor/control)
6. Risks that were rejected but surfaced later (analysis, decision making)

Who would care? Why?

- Risk Management leader
  - Demonstrates that RM is ‘working’
- Project Manager
  - Demonstrates good use of resources
- Customer
  - Good value from supplier/developer/integrator
- RM Technical Community
  - Identifies/validates ‘best practices’
- Process Engineering groups
  - Aides in identifying ‘process improvement’ areas
- More likely to arise in ‘more mature’ orgs?

Summary

Risk Management Process Steps



- Tracking, Management, Reporting, etc

External Risk Management Resources

- http://www.sra.org/
- Navy's Program Management Community of Pratice , click on 'Risk Mgmt' button
- http://www.pmcop.dau.mil/pmcop/
- http://www.techriskmgt.com/home2.html
- http://mars.jpl.nasa.gov/msp98/news/mco991110.html
- Australian based http://broadleaf.com.au/project_risk_examples/Default.htm
- http://www.riskdriver.com/net/index.html
- http://catless.ncl.ac.uk/Risks
- http://www.sei.cmu.edu/technology/risk/
- http://www.sei.cmu.edu/legacy/risk/kit/metrics.html
- http://www.standishgroup.com/chaos.html
- http://www.mailbase.ac.uk/lists/software-risk/

External Risk Management Resources

- http://www.incose.org/cmtes/rmwg.html - contains the Universal Risk List report
- www.construx.com - Construx website – click on SW Risks
- www.broadleaf.com.au - Broadleaf's website – commercial systems risks
- INCOSE Hampton Roads Chapter's Symposium on Risk
  - http://systems-engineering.larc.nasa.gov/~incose/sor/proceedings.html
- NASA's Lessons Learned Information Systems (LLIS)
  - http://llis.nasa.gov/
- NASA's Risk based Acquisition Management Systems
  - http://www.grc.nasa.gov/WWW/spaceiso/rbam/
- NASA's Code Q (Office of Safety and Mission Assurance) Risk page
  - http://www.hq.nasa.gov/office/codeq/risk/risk.htm
- IEEE 1540: Standard for Software Life Cycle Processes—Risk Management
- DoD Army Risk Management
- NASA (NPG 8000.4**)** Risk Management Procedures and Guidelines, April 2002
- Risk Management Guide for DoD Acquisition, Feb. 2001
- FAA COTS Risk Mitigation Guide: Practical Methods For Effective COTS Acquisition and Life Cycle Support