فرآیند یکپارچه برنامه ریزی، زمانبندی و کنترل پروژه

بخش نهم:

استاندارد اجرایی: آنالیز ریسک و ساخت پذیری برنامه زمانبندی

(Schedule Constructability and Risk Analysis)

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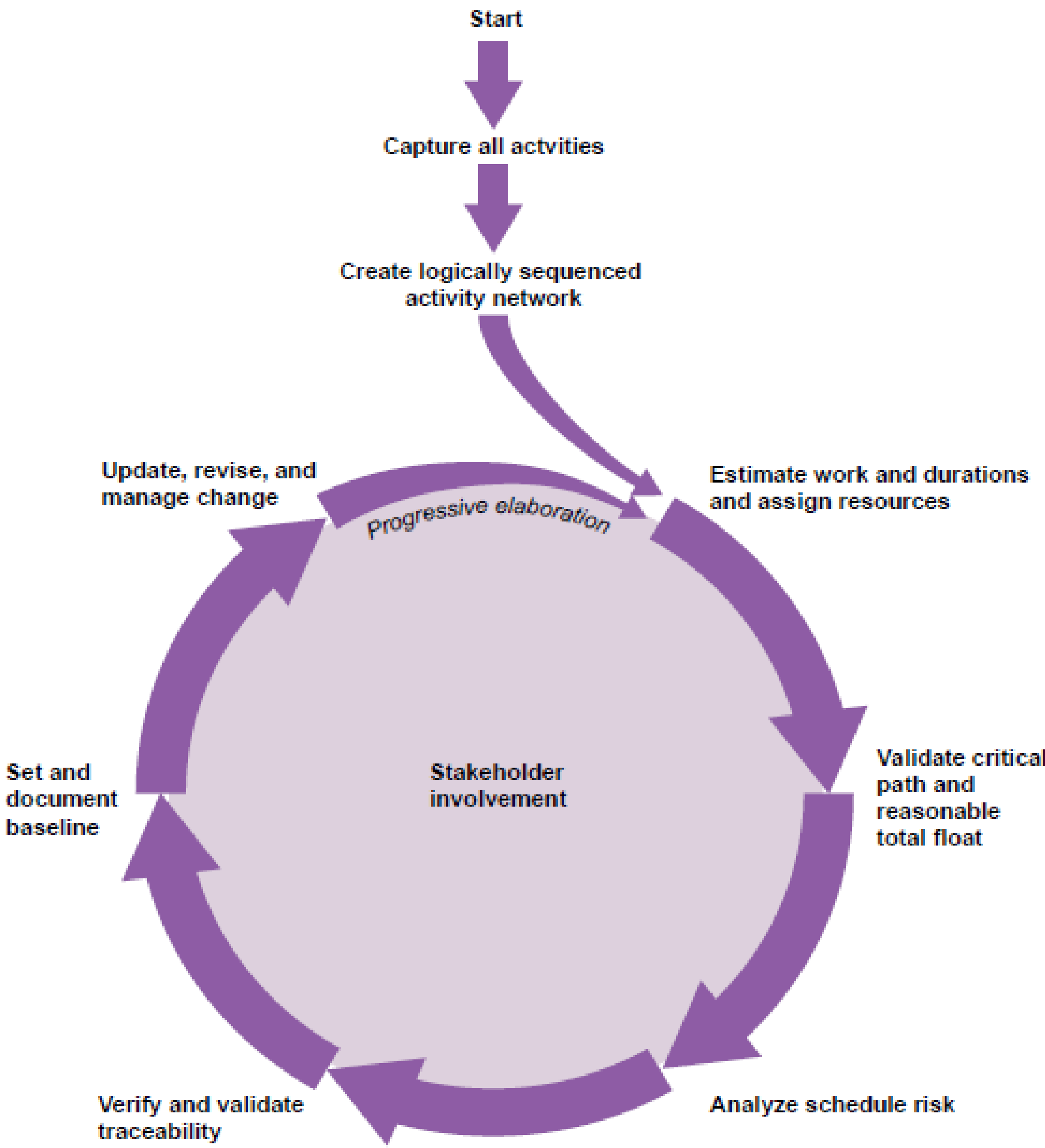
What we will learn?

- ❑ **Schedule constructability analysis**
- ❑ **Schedule risk analysis (SRA)**
  - ❖ Concept
  - ❖ Conducting an analysis
  - ❖ Collecting anonymous and unbiased risk data
  - ❖ Conducting standard schedule risk analysis
  - ❖ Sensitivity analysis
  - ❖ Probabilistic branching
  - ❖ Schedule contingency
  - ❖ Updating and documenting a schedule risk analysis
- ❑ **Checklist for a scheduler for conducting schedule risk analysis**
- ❑ **An auditor’s key questions and documents for conducting schedule risk analysis**

A process for creating and maintaining reliable schedules

- ❑ This is a cyclic process
- ❑ Elaborated through rolling wave process.



A process for creating and maintaining reliable schedules

Process step	Corresponding action	Section
Capture all activities	Capturing all activities	3
Create logically sequenced activity network	Sequencing all activities	4
Estimate work and durations and assign resources	Allocating and leveling resources	5
	Determining and assigning durations to activities	6
Validate critical path and reasonable total float	Critical path determination, assessment, and validation	7
	Ensuring reasonable total float	8
Analyze schedule risk	Schedule constructability and risk analysis	9
Verify and validate traceability	Verifying that the schedule can be traced horizontally and vertically	10
Set and document baseline	Setting, monitoring, controlling, and Maintaining a baseline schedule	11
Update, revise, and manage change	Setting, monitoring, controlling, and Maintaining a baseline schedule	11
	Updating the schedule using actual progress and logic	12

Schedule Constructability Analysis

Definition and objectives

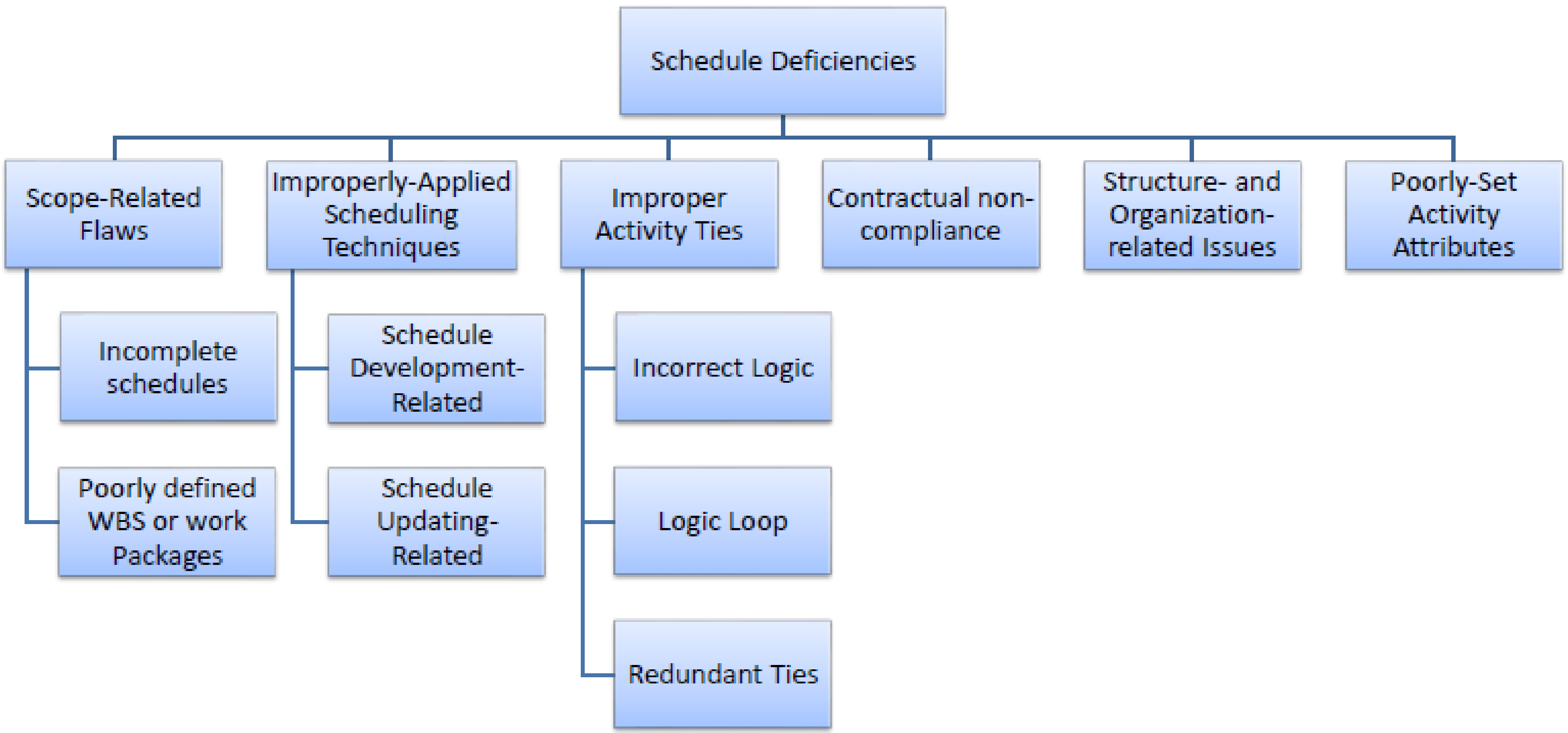
- A **schedule constructability review** **verifies** that the schedule under **investigation meets and/or exceeds** the **minimum requirements**.

- Schedule constructability review **aims** to:
  - **Ensure** schedules properly represent the **steps** that need to be taken in **implementing the project**
  - **Verify** the **feasibility** of the **construction plan**
  - **Closely examine** project **schedules** and **determine** if they **satisfy** the requirements outlined in the **contract** and project **scope of work**
  - **Confirm** that they meet the **needs** and **expectations** of **project stakeholders**

Main considerations

1. Completeness
2. Structure and organization
3. Contract compliance
4. Reasonableness of activity attributes
5. Proper use of scheduling techniques
6. Reasonableness of activity relationships
7. Reasonableness of resource plans
8. Other considerations

Main schedule deficiencies



Completeness

- Reflects full scope of work
- Contains all necessary project activities and work packages
- Project work packages and activities are properly identified

Structure and organization

- Organized in a reasonable manner
- Uses a well-defined WBS
- Uses a proper layout (i.e., activity grouping)
- The schedule is clear, reasonably organized.

Remember WBS and structure?

Contract compliance

- Meets all contractual requirements
- Satisfies all the constraints that the contract imposes
- Contains proper contractual milestones
- Identifies all interim and ultimate contractual deliverables
- Satisfies time and resource constraints outlined in the contract

Remember first section?

Reasonableness of activity attributes

- Activity description
- Estimated durations
- Planned dates
- Actual dates
- Others:
  - Phase
  - Area
  - Responsibility
  - Progress steps
  - notes

Remember ICMS Standards?

Proper use of scheduling techniques

- Schedule development
  - Poorly-defined project and resource calendars
  - Too many constraints
  - Improper use of constraints in place of activity relationships
- Schedule updating

Remember resources, calendars, constraints, etc.?

Reasonableness of activity relationships

- The schedule accounts for the technical and technological constraints of performing the work
- The schedule accounts for site restrictions and physical and space constraints
- Other logic relationships

- Improper Activity Ties
  - Redundant
  - Incorrect Logic
    - Errors
    - Missing Logic
    - Out-of-Sequence
    - Improper use of lags and leads
  - Logic loops

Remember logic?

Reasonableness of resource plans

- Resources are assigned and planned for
- Resource constraints have properly been accounted for
- Resource calendars

Remember resource allocation and leveling?

Other considerations

- Consistency: different sections of the schedule are consistent in terms of
  - Timeline
  - Work priorities
  - Work sequence
- Activity definition (verb + noun, i.e., process + deliverable)

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How to perform constructability analysis?

- **Planner/Schedulers** are often required to run **schedule health assessments** on a **regular basis** (**at least monthly**).
- **Schedule health metrics** are **different** from **schedule execution metrics**.
- It is important to note that these metrics simply indicate a **potential issue** that needs either **mitigation** or **justification**.
  - The IMS should always represent the **program's path forward**.
    - ✓ **Refrain** from **constructing** a schedule that **does not represent** the program's path forward in order to achieve a **favorable schedule health assessment**.

Let's see a list of metrics often used to assess schedule health!

Don't forget that if you want to have comprehensive analysis, you should use all previous checklists!

How to perform constructability analysis?

DCMA

No	Check	Description	Limit
1	Logic	This check identifies missing links in schedules or that the logic link is sensible	5% ✔
2	Leads	Leads (negative lags) distort the total float that is available in the schedule and can impact resource demand, out turn dates etc.	0% ✔
3	Lags	Lags can impact the analysis of the critical path	5% ✔
4	Relationship Types	Most relationships should be Finish to Start, the number of Finish to Finish and Start to Start must be limited	10% ✔
5	Hard Constraints	Hard constraints can prevent the logic from driving the schedule	5% ✔
6	High Float	This identifies tasks that have more than two months' float and challenges whether the logic is flawed	5% ✔
7	Negative Float	This identifies incomplete tasks with negative float.	✔
8	High Duration	This identifies tasks that have longer than a two month duration	5% ✔
9	Invalid Dates	This is a schedule check on whether future tasks have actuals applied	✔
10	Resources	This checks that all tasks in schedule have either money or resources allocated to them	✔
11	Missed Tasks	This checks on a % basis the number tasks that have missed the baseline dates	5% ✔
12	Critical Path Test	This is a test on the critical path to see if there is broken logic when a slip is introduced	✔
13	Critical Path length Index	This is a measure on purely of the realism of the critical path	✔
14	Baseline Execution Index	The baseline execution index measures tasks accomplished (completed only) against tasks planned for completion	✔

How to perform constructability analysis?

Check For	Rationale	Remarks
Tasks Missing Logic (predecessors and successors)	Link discrete tasks to ensure a meaningful calculation of Total Float and projection of accurate forecast dates.	Metric expressed as number of tasks without a predecessor or successor or the percentage of tasks without logic. Tasks with a SS successor or FF predecessor are often included in this list.
Use of Leads (acceleration of a successor activity)	Leads may distort Total Float and the Critical Path. The reason a lead was used should be documented and have proper justification. The Critical Path may be adversely affected by the misuse of leads	Metric expressed as number of tasks with leads or percent of tasks with leads. Additionally, metric may be bounded by the size of the lead.
Use of Lags (delay of a successor activity)	During the status process, task owners often overlook updating lag values, which can result in an inaccurate predictive model. The reason a lag was used should be documented and have proper justification.	Metric expressed as number of tasks with lags or the percentage of tasks with lags. Additionally, the metric may bounded by the size of the lag.

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How to perform constructability analysis?

Relationship Types (SS, SF, FS, FF)	The Finish-to-Start (FS) relationship type provides a logical path through the program. A relationship type such as Start-to-Start (SS) or Finish-to-Finish (FF) can cause resource conflicts when the tasks are dependent upon one another while also taking place at the same time. The Start-to-Finish (SF) relationship type is counter-intuitive ("the successor can't finish until the predecessor starts") and should only be used very rarely and with detailed justification.	Metric is often the percentage of each relationship type. Some metrics measure only the percentage of FS relationships.
Hard Constraints (such as Must Finish On and Must Start On)	Using hard constraints prevents logical predecessors driving tasks and therefore prevents the schedule from being logic-driven. The critical path and any subsequent analysis may be adversely affected.	Metric is often the percentage of each type of constraint. Some metrics measure the percentage of hard constraints. Some metrics list the number of hard constraints.

How to perform constructability analysis?

High Float (High Slack)	A task with high total float may be a result of inaccurate or missing predecessors and / or successors. If the percentage of tasks with excessive total float is high, the network may be unstable and is not being logic-driven. Ensure that health metric thresholds are appropriate for the relative length of the program and consistent with oversight requirements.	Metric is often the number or percentage of high float tasks. Numerically define the term "high". Ensure the numerical definition is consistent with the overall length of the program.
Negative Float (Negative Slack)	A task with negative float is potentially driving key program milestones past contractual date requirements.	Measure the number or percentage of tasks with negative float.

How to perform constructability analysis?

Check For	Rationale	Remarks
High Task Duration	Higher duration tasking may not provide the necessary precision for future measurement of work completed without significant additional effort on the part of the program.	Measure the number or percentage of tasks with high duration. The SOW often expresses duration limits to ensure sufficient granularity of the schedule.
Invalid Forecast Dates	A task should have forecast start and forecast finish dates that are in the future relative to Timenow.	Measure the number or percentage of tasks with invalid forecast dates.
Invalid Actual Dates	A task should NOT have actual start or actual finish dates that are in the future relative to Timenow.	Measure the number or percentage of tasks with invalid actual dates.
Resource Loading	Where resource loading is a requirement, all tasks should be resource loaded, other than summary, milestones tasks.	Where resource loading is a requirement, the number or the percentage of non-resource loaded discrete tasks is often measured. Tailor this metric to be consistent with the local resource loading procedures.
Tasks Without Baseline	All tasks should have baseline elements from which the Performance Measurement Baseline (PMB) is established.	Measure the number or percentage of tasks without baseline elements (i.e. dates).

How to perform constructability analysis?

Summary Task Logic	Summary tasks with logic can result in incorrect schedule date calculations or at a minimum, can reduce the precision of the schedule.	Measure the number or percentage of tasks with Summary Task Logic.
Planning Packages Requiring Detail Planning	Planning Packages need to be detail planned before they begin.	Measure the number of planning packages within the freeze period.
Out of Sequence Status	Out-of-Sequence tasks are those tasks where the execution is contrary to the logical relationship of the tasks. Typically, this occurs when an incomplete predecessor is "driving" a started task. This may result in inaccurate successor path forecast dates and Total Float Calculation.	Measure the number of Out-of-Sequence tasks.
Over-allocated Resources	Resource loaded schedules have the ability to show over-allocations that may hinder program progress.	Measure the number of tasks with over-allocated resources.
Vertical Schedule Integration Violations	All tasks should flow up to their summary tasks. Errors here limit the use of summary schedule to portray accurate program status.	Measure the percentage of tasks that fail vertical integration checks.

How to perform constructability analysis?

- A **number of commercial and government owned tools** are available to **automate schedule health assessments**
- These tools often come with the **DCMA 14 point assessment criteria.**
- **Schedule Health Assessment metrics** should have a **threshold guideline**.
  - The **importance of metrics** and the guidelines or standards may **vary** by **program phase and/or program type**.
- Programs should define the **exclusions** to the calculation of their **metrics**.
- **Most metrics** focus on the **remaining efforts** of the IMS **rather than past performance.**
- **Most metrics exclude milestones**, **summary tasks** and **LOE**, thereby focusing on **discrete tasks** that have effort associated with them.
- **Many metrics** may **exclude Planning Packages**.
- Most tools use **percentage calculations**.

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How to perform constructability analysis?

- Steelray Project Analyzer

Check	Tasks	Result	Thresholds
14C Hard Constraints	(1 tasks)	0.2%	5 10
14C Lags	(20 tasks)	4.1%	5 10
14C Leads	(25 tasks)	Non Compliant	
14C SF Relationship	(0 tasks)	Compliant	
14C SS Relationship	(10 tasks)	2.1%	5 10
Actual Start / Finish Dates in Future	(0 tasks)	Compliant	
Baseline Vertical Schedule Integration Error	(0 tasks)	0	0 1
Delinquent Tasks	(9 tasks)	Non Compliant	
Finish Date > Baseline Finish (I)	(0 tasks)	0.0%	5 10
Finish to Finish Relationship (I)	(13 tasks)	3.9%	5 10
Forecast Dates Prior to Status Date	(9 tasks)	Non Compliant	
Missing Predecessors	(4 tasks)	1.1%	2 6
Missing Successors	(1 tasks)	0.3%	2 6
Out of Sequence Tasks	(0 tasks)	Compliant	
Pred Complete, Task Not Started	(4 tasks)	0.8%	10 15
Summary Tasks With Predecessors	(0 tasks)	Compliant	
Summary Tasks With Successors	(0 tasks)	Compliant	
Should Start Tasks	(161 tasks)	33.3%	25 75

How to perform constructability analysis?

- RunAzTech by AzTech International LLC.

5,997 Total Tasks = 1,391 Summary Task(s) + 4,606 Detailed Task(s) [0 Ext'l Task(s)]

Statistics:	Detailed	Discrete	LOE	PPkg	Milestones	
Total Tasks	4,606	3,205	-	-	1,401	All Detailed Tasks (excludes Summaries)
Complete	3,152	2,240	-	-	912	Completed Detailed Tasks (have Actual Finish)
Complete %	68%	70%	0%	0%	65%	% Completed Detailed Tasks
Incomplete	1,454	965	-	-	489	Incomplete Detailed Tasks (no Actual Finish)
Incomplete %	32%	30%	0%	0%	35%	% Incomplete Detailed Tasks
In Progress	146	146	-	-	-	In Progress Detailed Tasks (have Actual Start)
In Progress %	10%	15%	0%	0%	0%	% In Progress Detailed Tasks
With Logic	1,055	711	-	-	344	Tasks with Logic (Predecessor & Successor)
With Logic %	73%	74%	0%	0%	70%	% Tasks with Logic
Missg Logic	399	254	-	-	145	Tasks missing a Predecessor or Successor
Missg Logic %	27%	26%	0%	0%	30%	% Tasks missing Predecessor or Successor
No Preds	166	104	-	-	62	Tasks missing a Predecessor
No Preds %	11%	11%	0%	0%	13%	% Tasks missing Predecessor
No Succs	309	203	-	-	106	Tasks missing a Successor
No Succs %	21%	21%	0%	0%	22%	% Tasks missing a Successor
Avg Ttl Flt < 0	-218d	-242d	0d	0d	-35d	Average Negative Total Float
Total Flt < 0	25	22	-	-	3	Tasks with Negative Total Float
Total Flt < 0%	2%	2%	0%	0%	1%	% Tasks with Negative Total Float
Avg Ttl Flt > 0	428d	449d	0d	0d	391d	Average Positive Total Float
Total Flt >= 0 <= 44	356	272	-	-	84	Band 1: Total Float >= 0 & <= 44
Total Flt >= 0 <= 44%	24%	28%	0%	0%	17%	% Tasks for Band 1
Total Flt > 44 <= 120	341	263	-	-	78	Band 2: Total Float > 44 & <= 120
Total Flt > 44 <= 120%	23%	27%	0%	0%	16%	% Tasks for Band 2
Total Flt > 120	732	408	-	-	324	Band 3: Total Float > 120
Total Flt > 120%	50%	42%	0%	0%	66%	% Tasks for Band 3
Avg Duration	41d	61d	0d	0d	0d	Average Task durations
Dur >= 0 <= 44	1,213	724	-	-		Band 1: Duration >=0 & <=44
Dur >= 0 <= 44%	83%	75%	0%	0%		% Tasks for Band 1
Dur > 44 <= 120	102	102	-	-		Band 2: Duration > 44 & <= 120
Dur > 44 <= 120%	7%	11%	0%	0%		% Tasks for Band 2
Dur > 120	139	139	-	-		Band 3: Duration > 120
Dur > 120%	10%	14%	0%	0%		% Tasks for Band 3

Conclusions

When you are ensured, the risk analysis should be conducted!

Schedule Risk Analysis

(Concept)

Schedule uncertainty and risk

- The terms **risk** and **uncertainty** are often used **interchangeably**, **but** they have **distinct definitions** in program risk analysis.
  1. ***Risk*** refers to decision-making situations under which **all potential outcomes** and their **likelihood of occurrences** are **known** to the decision-maker.
  2. ***Uncertainty*** refers to situations under which **either** the **outcomes** **and/or** their **probabilities of occurrences** are **unknown** or **little** to the decision-maker.

Stated another way, risk and its outcomes can be quantified in some definite way, while uncertainty cannot be defined because of ambiguity.

Definitions of risk and uncertainty vary across organizations, government agencies, and even fields of study. For example, some organizations consider risk as only the unfavorable outcome of an uncertain event.

Schedule uncertainty and risk

Techniques are designed to capture general uncertainties about the future, not unforeseen catastrophic events such as major earthquakes and large labor strikes.

Schedule Risk Analysis

(Conducting an analysis)

Conducting a schedule risk analysis – Objective of simulation

- Because **activity durations** are **uncertain**, the **probability distribution** of the **program's total duration** must be determined **statistically**, by **combining** the **individual probability** distributions of **all paths.**

An accepted way to do this is to perform a Monte Carlo simulation of the schedule with uncertainty and risk applied.

Conducting a schedule risk analysis – Objective of simulation

- From the **cumulative probability distribution**, the organization can **match a date** to its **degree of risk tolerance**.

- The **organization** can thus **adopt a plan** and **promise completion** on dates that are **consistent** with its **preferred level of confidence** in the overall integrated schedule.

Conducting a schedule risk analysis – General guide

- **Risk analysis** should **not** be **focused solely** on the **deterministic critical path**.
- It is important to represent **all work** in the schedule, because **any activity** can **become critical** under some circumstances.
- **Complete and correct schedule logic** that addresses the **logical relationships** between predecessor and successor activities is also **important**.
- The **analyst** needs to be **confident** that the **schedule network** has passed **constructability analysis**.

Conducting a schedule risk analysis – General guide

- **If** **time** or **resources** are **insufficient** to simulate the full program, or **if** **detail** in the future is **unclear**, perhaps because of **rolling wave planning**, the simulation can be performed with a **summary version** of the schedule.
  - By **reducing** the **number of activities** in the schedule, **times** necessary to conduct **risk analysis** will be **reduced**.
  - **However**, if a **summary schedule** is used, it is important that the schedule show **enough detail** to **yield practical results**.

Conducting a schedule risk analysis – General guide

- After the **risk information** is developed, the **statistical simulation** is run and the resulting **cumulative distribution curve** displays the **probability** associated with the **range of program completion dates**.

- The **results** indicate **when** the **program** is likely to **finish** **without** the program team's taking additional risk **mitigation steps**.

- The **high-priority risks** can be **identified** and used to **guide** **further risk mitigation** action.

What if a schedule risk analysis shows more risk than is acceptable?

Conducting a schedule risk analysis – General guide

- **Activities**, **dependencies**, and **network** should be **reviewed** to **shorten** the completion.
- In **some cases**, the **scope** may need to be **reduced**.
  - **However**, the **initial estimates** should **not** be **changed** **without** **sufficient justification**.
    - ✓ **Changing durations** simply because an **earlier finish date** is **preferred** is likely to **increase** the **risk of delaying a project**.

Procedure

1. Collecting anonymous and unbiased risk data
2. Conducting standard schedule risk analysis
3. Sensitivity analysis
4. Probabilistic branching
5. Schedule contingency
6. Updating and documenting a schedule risk analysis

Schedule Risk Analysis

(Collecting anonymous and unbiased risk data)

Data collection

- A **schedule risk analysis** requires the **collection** of program **risk data**.

- **Risk data** should be derived from a **quantitative risk assessment** and should **not** be based on **arbitrary percentages** or **factors**.

- A **risk assessment** is a part of the **program's overall risk management process**.

- As **risks are identified**, **risk-handling plans** are developed and **incorporated** into the program's **cost** estimate and **schedule**, as necessary.

This analysis will be taught in Project Risk Management Course!

Data collection

- **Risk data can be collected in the form of:**

  1. **Three-point durations**
     - The three-point estimates represent **inherent uncertainty**, **estimating error**, and perhaps **estimating bias.**
  2. **Using the risk driver approach**
     - Risk drivers represent
       1. **Identified risk events** with **probabilities**
       2. **Likely effect** if they **occur**

Regardless of which type of risk analysis is performed, it is essential that subject matter experts (SME) be interviewed who are directly responsible for or involved in the workflow activities.

Schedule Risk Analysis

(Conducting standard schedule risk analysis)

Distribution curves

- There are a **multitude of distributions curves** **available** for programs to use during schedule risk analysis or assessment (SRA).

- Please **ensure** you understand the **available options** and the **rationale** for their use.

Let's see the most common

Distribution curves

1. **Beta Distribution**
   - **Use when:** you have a **high confidence** in 3 point durations
   - **Curve is:** **bell shaped** and falls **very quickly** from the peak
   - **Peak is:** **off center**

Beta Distribution (PERT): (P + O + 4ML) / 6

2. **Normal Distribution**
   - **More uniform** form of **Beta**
   - **Use when:** you have a **moderate confidence** in 3 point durations
   - **Curve is:** **bell shaped** and falls **quickly** from the peak
   - **Peak is:** **center**

3. **Triangular Distribution**
   - **Use when:** **risk is high**, **historically realized** or **unknown** or on **globally applied** 3 point durations
   - **Curve is:** **triangular shaped** distribution curve that **steadily decreases**
   - **Peak is:** **off center**

Triangular Distribution: (P + O + ML) / 3

Important notes before simulation

- **Hard Constraints** – **remove** hard constraints from the IMS prior to running an SRA
  - Hard constraints impact the forward and backward pass
- **Level of Effort (LOE)** – an LOE task should never drive discrete work.
  - It should be **excluded** from the SRA.
- **Planning Packages** – for SRA purposes treat Planning Packages the **same as every other discrete task** by ensuring they are logically linked in the network.

Note: ***when modeling 3 point estimates on milestones ensure that the succeeding relationships are all FS.***

- If a **Schedule Margin task is used** in the IMS, **its durations** should be **zeroed out** prior to running an SRA

Three-point duration estimates – Step 1: Example

- One way to **capture** schedule **activity duration uncertainty** is to collect various estimates from **individuals** and a **review of actual program performance**.

- In an **actual program schedule risk analysis**, these would be developed from **in-depth interviews** of **persons** who are **knowledgeable** in **each** of the **WBS areas** of the program.

Estimated Durations for a Section of the House Schedule

ID	Description	Minimum remaining duration	Most likely remaining duration	Maximum remaining duration
A1870	Install drywall on walls and ceilings	3	4	6
A1880	Inspect drywall screws	1	1	2
A1890	Finish drywall (tape and mud)	3	5	6
A1900	Install ceiling insulation	1	1	2
A1910	Apply drywall texture	2	3	4
A1920	Apply wall finishes (stain and paint)	2	3	4
A1930	Install tile in bathroom and kitchen	2	3	5

Source: GAO | GAO-16-89G.

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Three-point duration estimates – Step 2

- **To model** the risks in the simulation, the risks are represented as **triangular distributions** specified by the **three-point estimates** of the activity durations.
  - In other words, the **3-point estimates** represent **all the risk** in the project.
  - **Distributions** other than the triangular are **available** as well.

- Once the **distributions** have been **established**,

  a **statistical simulation** (typically a **Monte Carlo simulation**) uses **random numbers** to select **specific durations** from each activity probability distribution, and

  a **new critical path** and **dates** are calculated, including **major milestone** and **program completion dates**.

Three-point duration estimates – Step 3

- The **Monte Carlo simulation** continues this random selection **thousands of times**, creating a
  1. **New program duration estimate**
  2. **Critical path each time**
- The **resulting frequency** distribution displays
  1. Range of program completion
  2. Probabilities that activities will occur on these dates

This method is most often used when it is unfeasible or impossible to compute an exact result with a deterministic algorithm.

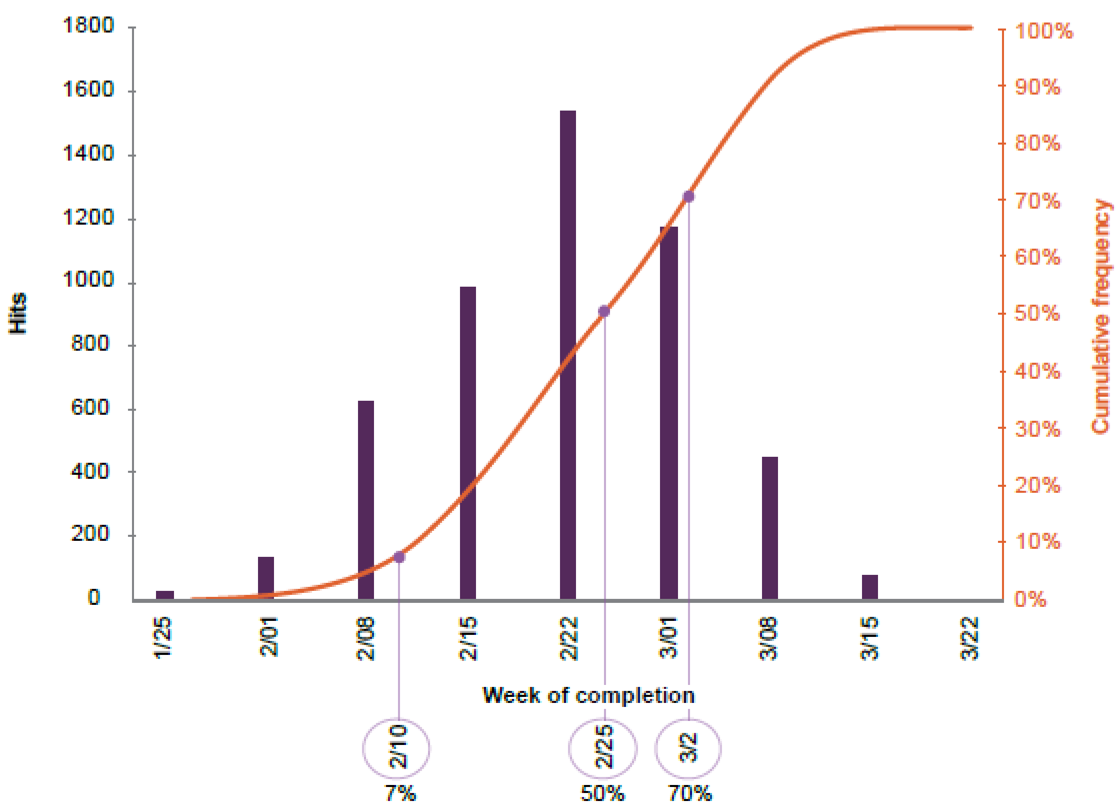
Prior to conducting an SRA, programs define the **probability thresholds**

This **threshold** is completely **dependent** on the program and customer specificities.

Three-point duration estimates – Step 3: Example

- **Risk histogram** or **confidence level histogram**
- Deterministic schedule shows Feb 10 (7%)
- A contractor planning for 70 percent certainty would promise completion on March 2, about a calendar month later than originally planned.

The Cumulative Distribution of the House Construction Schedule



Source: GAO. | GAO-16-89G

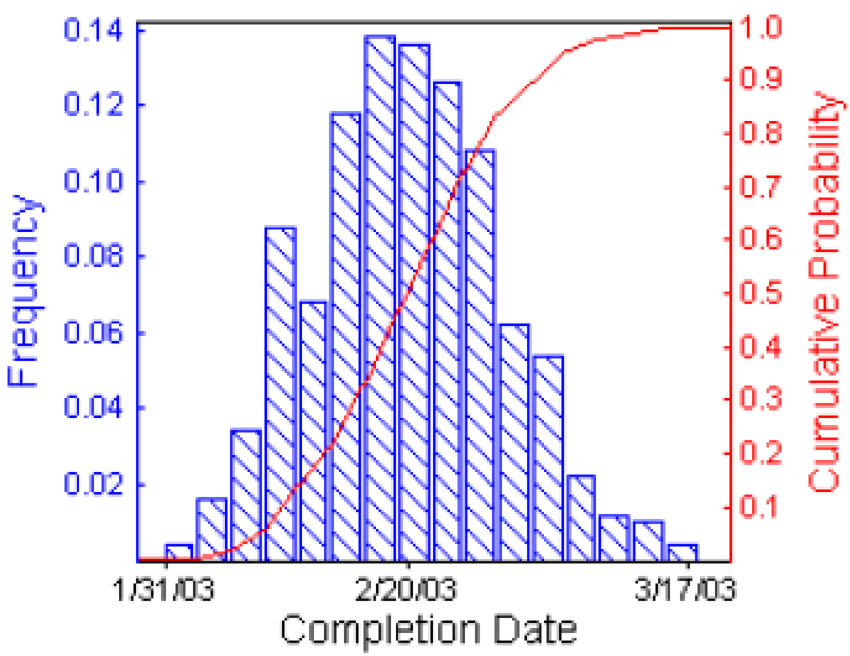
This can be plotted for each activity as well, finish date, start date, etc.!

Three-point duration estimates – Step 3

Date: 1/16/02 1:06:25 PM
Samples: 500
Unique ID: 1
Name: Widget

Completion Std Deviation: 5.65d

Each bar represents 2d



Completion Probability Table

Prob	Date	Prob	Date
0.05	2/7/03	0.55	2/21/03
0.10	2/10/03	0.60	2/21/03
0.15	2/12/03	0.65	2/24/03
0.20	2/13/03	0.70	2/25/03
0.25	2/14/03	0.75	2/26/03
0.30	2/17/03	0.80	2/27/03
0.35	2/18/03	0.85	2/28/03
0.40	2/19/03	0.90	3/4/03
0.45	2/19/03	0.95	3/5/03
0.50	2/20/03	1.00	3/17/03

Three-point duration estimates – Disadvantages

- **Probability distributions** for durations **derived** from **risk interviews**.
  - The **risk** may be **caused by** lack of materials, poor labor productivity, poor weather, last-minute design changes, or some serial combination of all four risks.
  - It is also possible that the **subject matter experts** (**SME) has increased** the **pessimistic duration** estimate to account for **general uncertainty**, in effect accounting for **"unknown unknowns."**

- The result of the **three-point duration** is a **recommended amount** of schedule contingency that covers both **quantified risks** and **some level of uncertainty**

*but gives **no indication** of which risks are **most likely** to affect the schedule.*

Three-point duration estimates – Disadvantages

- The 3-point estimate **applied** **directly** on **activity durations** represents **only the** **impact** of some risk(s) on the duration and has **no clear concept of the probability of a** **risks' occurring**.

- The 3-point estimates may be a **good way to represent** **duration estimating error**, which has a **100% probability of occurring** but an **uncertain impact**.

Risk drivers

- A **second way** to determine schedule **activity duration uncertainty** is to
  1. **Analyze** the **probability** that **risks** from the **risk register** may **occur**
  2. **What their effect** on schedule activities will be if **they do occur**

- **With this approach:**
  1. **Probability distribution** of **risk impact,** expressed as a **multiplicative factor,** is estimated on the duration of activities in the schedule
  2. **Risks** are **assigned** to **specific activities** in the schedule

If a risk does not occur in an iteration, then the scheduled duration does not change for that activity.

Risk drivers – Step 1

- **Once the risks are identified** from the **risk register**, **certain risks data** are collected:

  1. **Probability of occurring:**
     - In **any iteration** during the **Monte Carlo simulation** a risk will **occur or not** depending on **this probability**.
       - ✓ If the **probability** is **less than 100%,** it will **occur** in that **percentage of iterations**.
         - Probability of 70% means, it will occur in 70% of iteration.
         - **If it occurs**, it will occur **for all activities it affects**, and **if it does not** occur it will **not affect any of those** activities.

Risk drivers – Step 2

- **Once the risks are identified** from the **risk register**, **certain risks data** are collected:

  2. **Impact on project activities' durations (and costs) if it does occur:**

     - This impact is specified as **a range of possible impacts**, stated for instance low .95, most likely 1.05 and high of 1.25.
     - These **three points** define a probability of impact **multiplicative impact** factors.
     - **If** the **risk occurs** on **some iteration**, the **durations and costs** of the **activities** in the schedule that the **risk is assigned to** will be **multiplied** by the **same impact factor** that is **chosen** from the impact range for **that iteration**.

Risk drivers – Step 3: Example (only the duration)

- The table for risks, likelihood and effects is developed.

Some Identified Risks for a House Construction Schedule

Risk	Likelihood of risk	Effect on remaining duration		
		Optimistic	Most likely	Pessimistic
Design is incomplete	80%	95%	125%	150%
Site investigation is inadequate	30	100	120	135
Material is unavailable	25	100	125	130
Material is late or defective	35	95	110	130
Inspectors are unavailable	30	125	150	200
Rework will be necessary	25	100	110	135
Materials are purchased incorrectly	10	100	110	130
Soil conditions are poor	25	100	115	135
Owner makes changes	50	95	110	130

Source: GAO | GAO-16-89G.

Risk drivers – Step 4: Example (integrated duration and cost)

- The table for risks, likelihood and effects is developed.

A simple table showing these data as they might evolve from the risk interviews is shown below:

			Duration Impact Ranges (%)			Cost Impact Ranges (%)		
Risk ID	Risk Description	Prob	Min	M L	Max	Min	M L	Max
1	S/C - Design Complexity may Challenge Engineers	40	90	110	135	100	105	110
2	S -Site Conditions / Site Access may Slow Logistics	50	100	110	125			
3	S/C-Equipment Suppliers may be busy	60	100	105	120	100	110	120
4	S - Capable Management may not be Assigned	40	90	105	115			
5	S -Environmental Agency May be Slow	50	95	110	135			
6	S - Activity Duration Estimates is Inaccurate	100	90	105	115			
7	C - Cost Estimate is Inaccurate	100				95	105	115
8	S/C Key Engineering Personnel may be Unavailable	65	95	105	120	90	100	110

Risk drivers – Step 5: Example

- In addition to **discrete** **threats** and **opportunities**, we can include **uncertainties**.

Some Uncertainties for a House Construction Schedule

Uncertainty	Likelihood of risk	Effect on duration		
		Optimistic	Most likely	Pessimistic
Productivity of labor	100%	95%	100%	110%
Efficacy of general contractor	100	90	100	125
Schedule estimating error	100	95	105	115

Source: GAO | GAO-16-89G.

Risk drivers – Step 6

- The **risks** and **uncertainties** are then **assigned** to the **activities** and **resources** they affect.

- A **risk** can be **assigned** to **multiple activities** and the **durations** of some activities can be **influenced** by **multiple risks**.

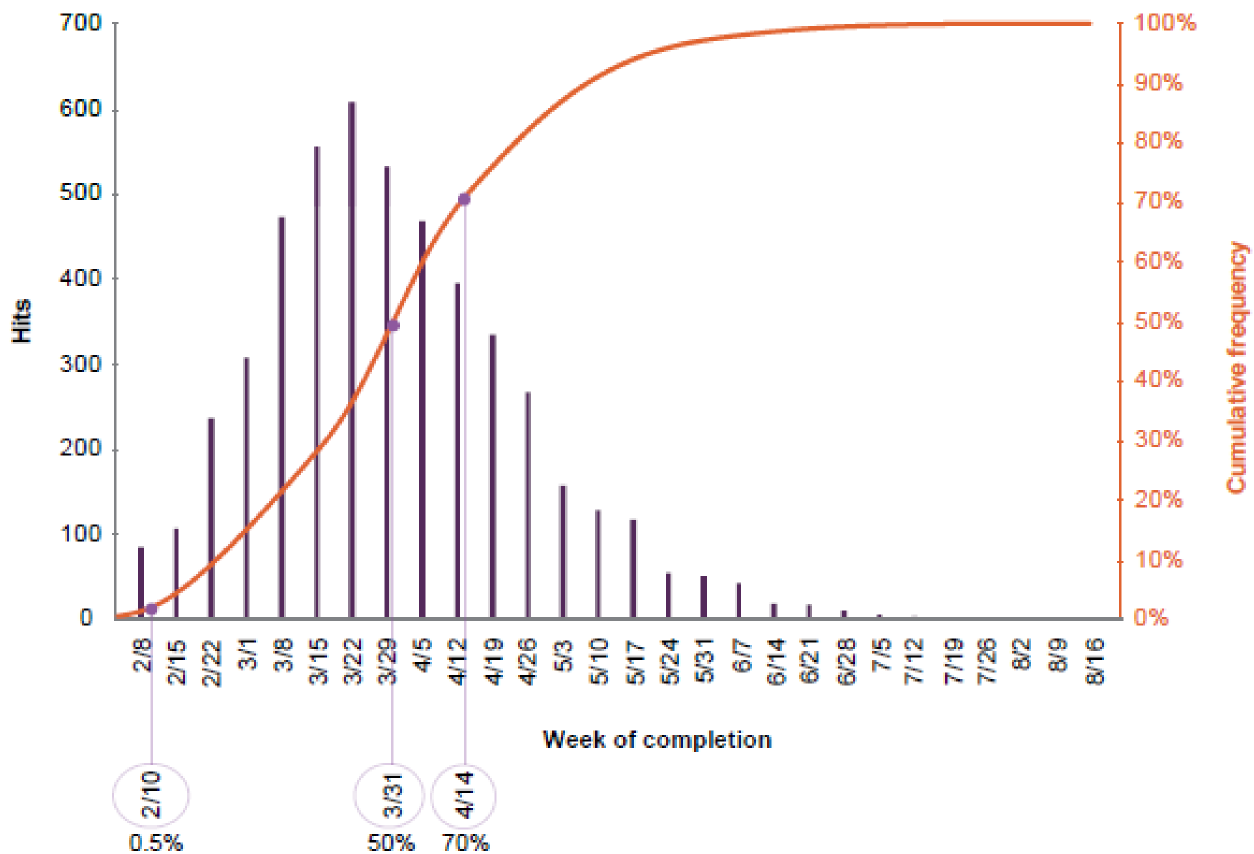
- With the **risk driver method,** the risks and uncertainties shown in **previous tables** will appear as factors that **multiply** the **durations of the activities** they are assigned to, **if** they **occur** in the **iteration**.

Once the risks and uncertainties are assigned to activities, a simulation is run.

Risk drivers – Step 6: Example (time)

- Deterministic schedule shows Feb 10 (0.5%)

House Construction Schedule Results from a Risk Driver Simulation



Source: GAO. | GAO-16-89G

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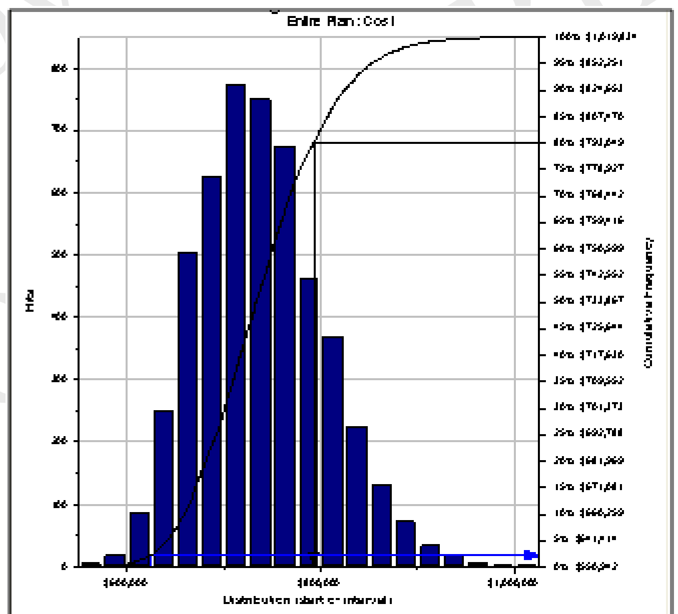
Risk drivers – Step 6: Example (cost)

- The **cost risk results** are shown below and help the organization develop the **appropriate cost contingency reserve**.
- That reserve might be the **difference between**
  - **Baseline cost** of $624 million (**less than 5%)**
  - **P-80 of cost** from the Monte Carlo simulation to be $793 million (**around 80%**)



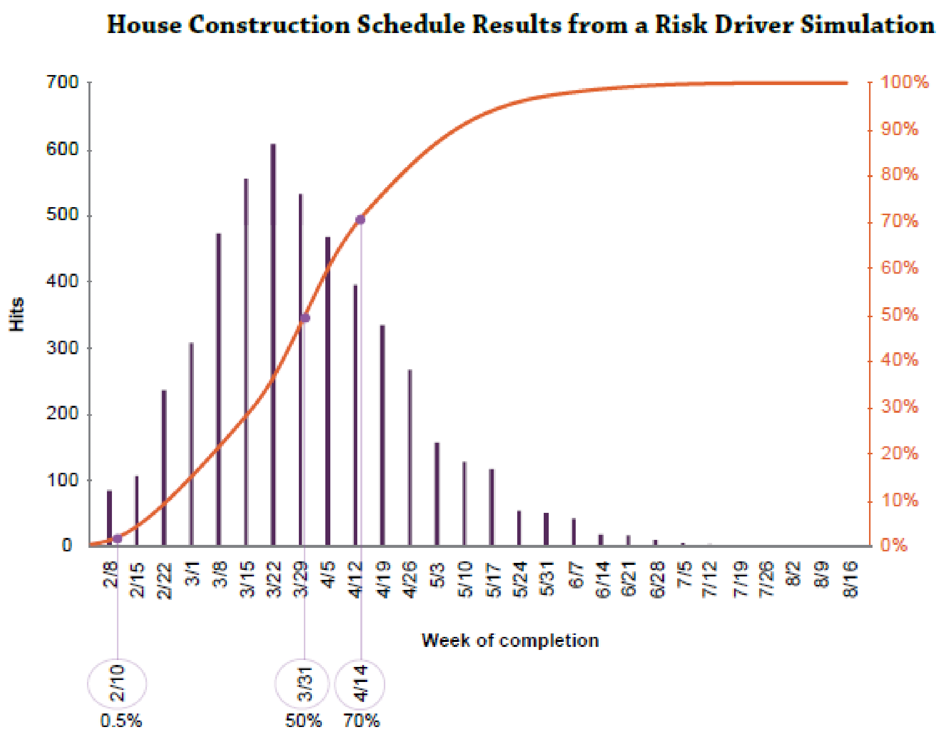
Risk drivers – Step 6: Example (integrated time and cost)

- Degree of cost-risk driven

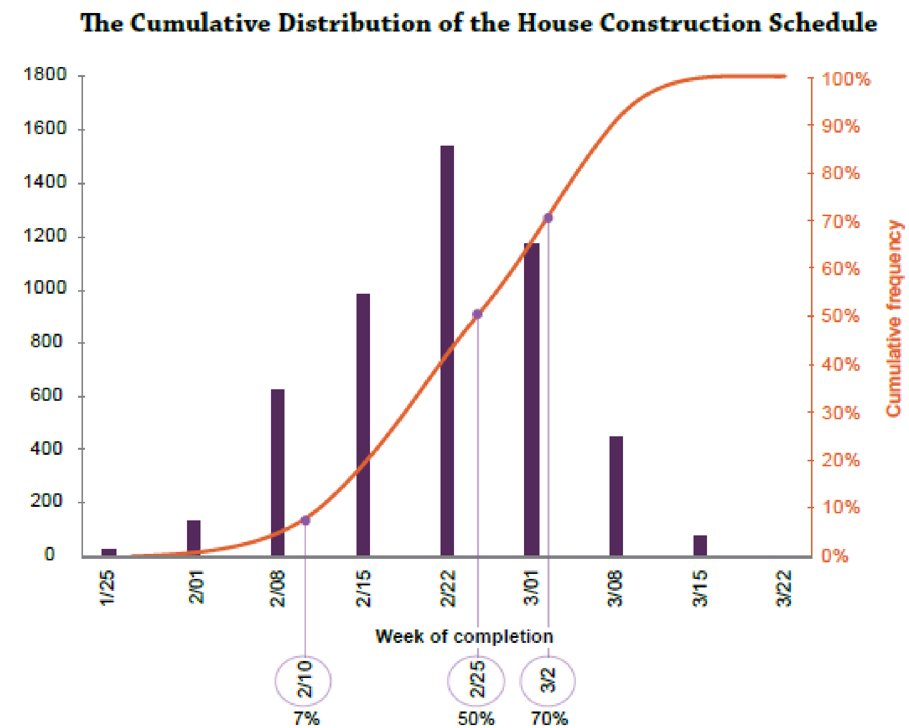
Decompose the Cost Contingency at the P-80		
	P-80	Marginal Impact
	($ millions)	
Contingency-Free Cost Estimate	624	
All Risks	793	
Cost Risks Only	702	78
Schedule Risks Only	727	103
Total Contingency All Risks	169	

Three-point estimates vs. Risk driver

- **Risk driver method** has caused a **wider spread** of uncertainty between the 5 percent and 95 percent confidence dates **compared** to the **three-point duration method**.



Source: GAO. | GAO-16-89G



GAO. | GAO-16-89G

Correlation

- The **activity durations** are **uncertain**, and the **degree** to which the **impacted durations** are **longer** and **shorter** together is called **correlation**.

- Correlation can be described as the **relationship between two variables**, in Schedule Risk correlation can exist between:
  - The **existence of risks**, that is – if a risk occurs, then another related risk is likely to occur
  - The **impacts of risks**, that is – the impact from one risk, is related to another impact.

Correlation

- The **activity durations** are **uncertain**, and the **degree** to which the **impacted durations** are **longer** and **shorter** together is called **correlation**.

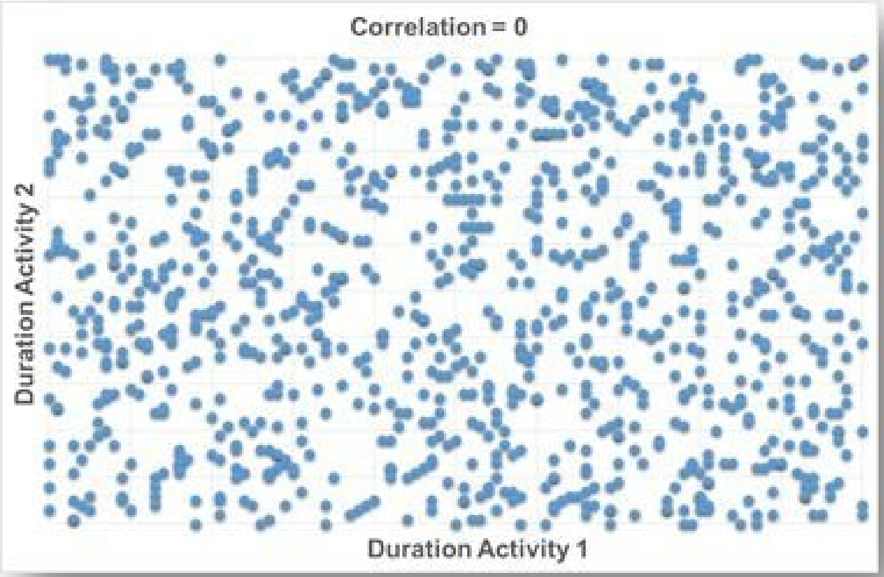
1. **Positive correlation**

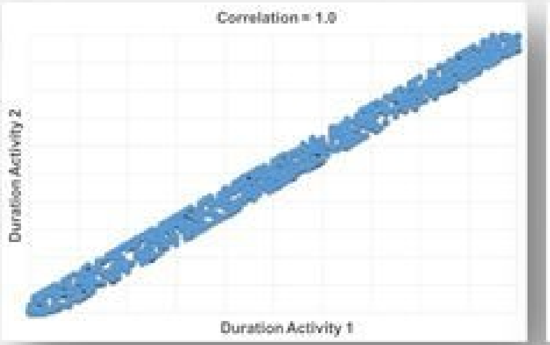
- When **two activity durations** are **both influenced** by the **same external force** and can be expected to **vary in the same direction** in any **consistent scenario**
  - *For example, if the same maturity of a technology is considered to estimate the duration of design, fabrication, and testing activities.*
    - ✓ *If maturity is not known, assume that design, fabrication, and testing activities would all be longer or shorter together.*

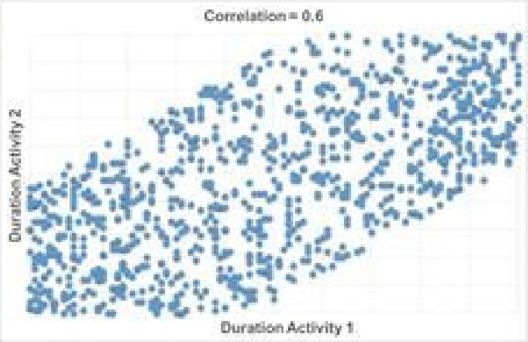
2. **Negative correlation**

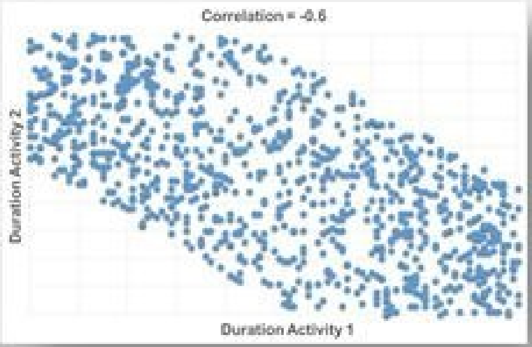
  - Opposite of positive correlation and less common

Correlation



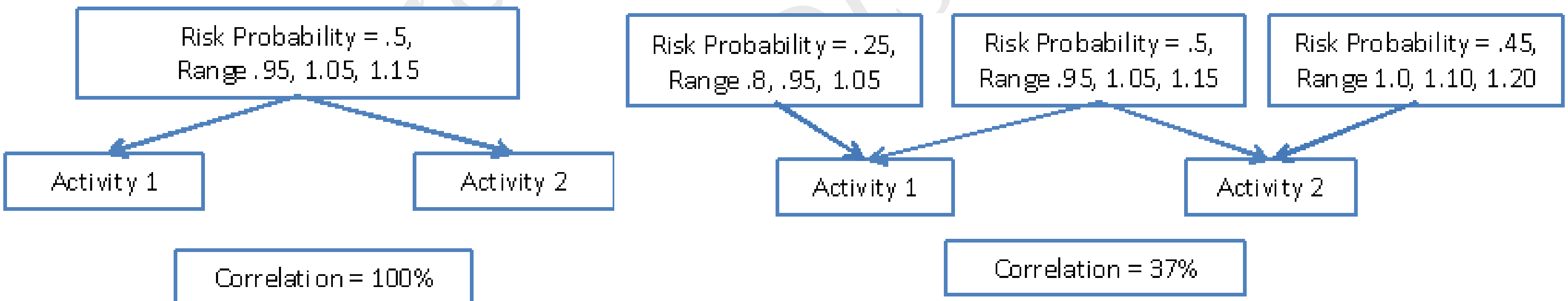






Correlation

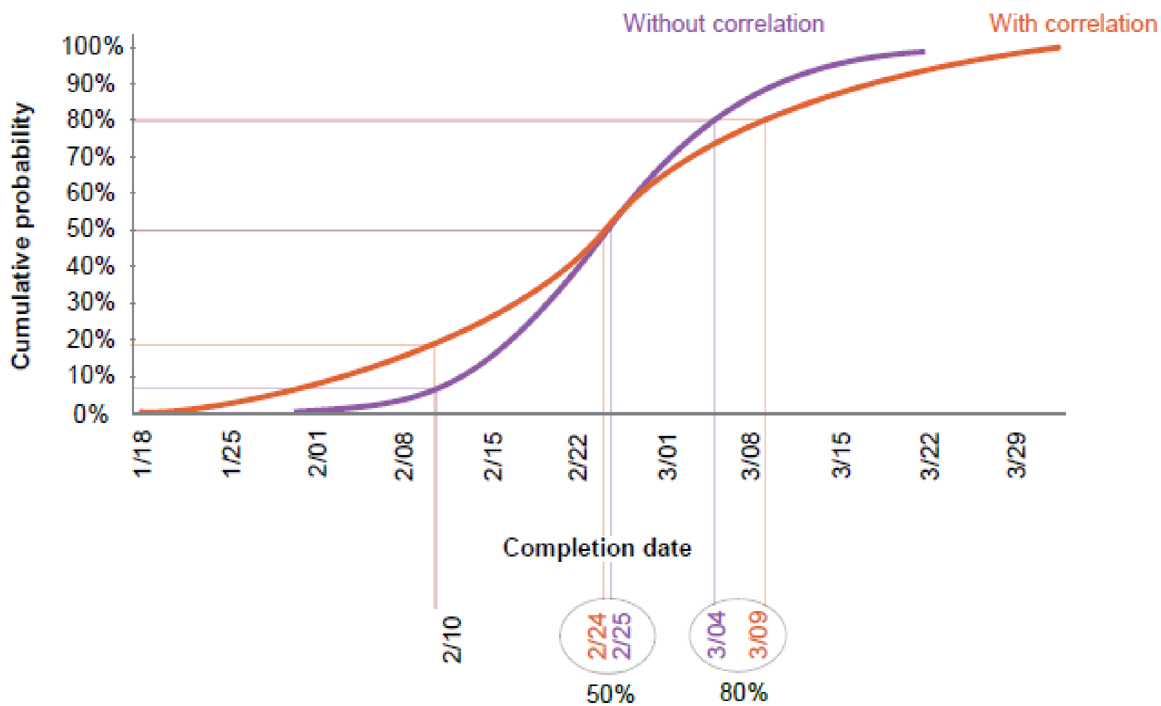
- There are **often** **no actual data** on correlation, so **expert judgment** is often used to set the **correlation coefficients**.
  1. If **one** and only one **risk** affects **two activities** they become **100% correlated**.
  2. If, however, there are **other risks** that affect **one activity**, the **correlation** between the two is **reduced**.



Correlation – Example

- **Correlation** between activity durations in the **three-point risk simulation**
- **90 percent correlation** was added between activities that are **related trades**.
- **Correlation** has **widened** the overall distribution.
- **50th percentile** is nearly the **same** in both cases
- **However**, the **80th percentile** increases by **one workweek**, from March 4 to March 9, when **correlation added**.

Probability Distribution Results for Risk Analysis with and without Correlation



Source: GAO. | GAO-16-89G

Correlation – Three-point vs. risk drivers

- **Three-point estimates** requires **estimating correlation coefficients**, often in the **absence** of **historical data**.
- In **risk driver method**, **assigning** a risk to **multiple activities** causes them to be **correlated**.
  - **Modeling correlation** with risk drivers **avoids** the **difficult task** of estimating a number of pair-wise correlations.

The Risk Driver Method models how correlation between activity durations

So we no longer have to estimate (guess) at the correlation coefficient between each pair of activities.

Confidence level

❑ **How to adopt confidence level?**

1. For some programs, the **80th percentile** is considered a **conservative promise** date.
2. Other organizations may focus on another probability, such as the **65th or 55th** percentile.

❖ However, because **schedule distributions** has a **greater tendency** to **finish late** than early, the mean of the distribution tends to be **larger than the 50 percent** confidence level.

- ✓ Hence, the **55th or 65th percentiles** are **not** as certain as the 80th percentile and may expose the program to **overruns if they are adopted**.

Factors such as project type, contract type, and technological maturity affect each organization's determination of its tolerance for schedule risk.

Schedule Risk Analysis

(Sensitivity analysis)

Purpose of prioritizing

- **Regardless of the method used**, it is important to **identify the risks** that **contribute most** to the program schedule risk.
  - **These risks** can then be **targeted** for **mitigation strategies**.

So, how to prioritize?

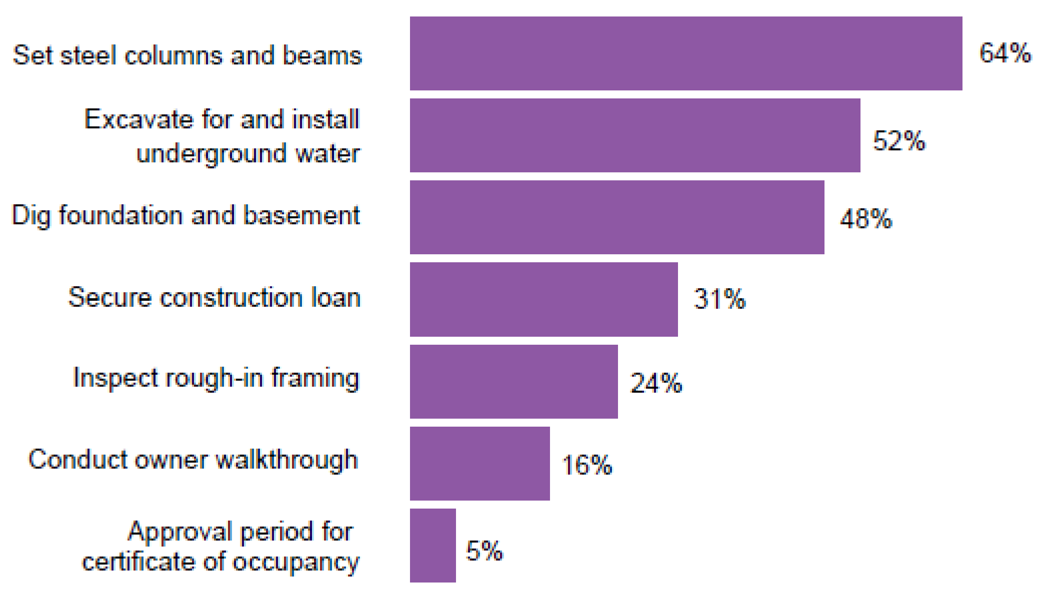
Prioritizing the risks to the schedule is one of the **main benefits of the Risk Driver Method.**

Prioritizing activities – Example

- The **Sensitivity Index** **ranks** the **activities** in order of their **likely impact** on the **outcome** and clearly shows **which activities** are having the **greatest effect**.
- **Sensitivity Index** can be **produced** by **most schedule risk software**.

- This **figure** shows a **schedule sensitivity index** for the house construction project.

Sensitivity Indexes for the House Construction Schedule



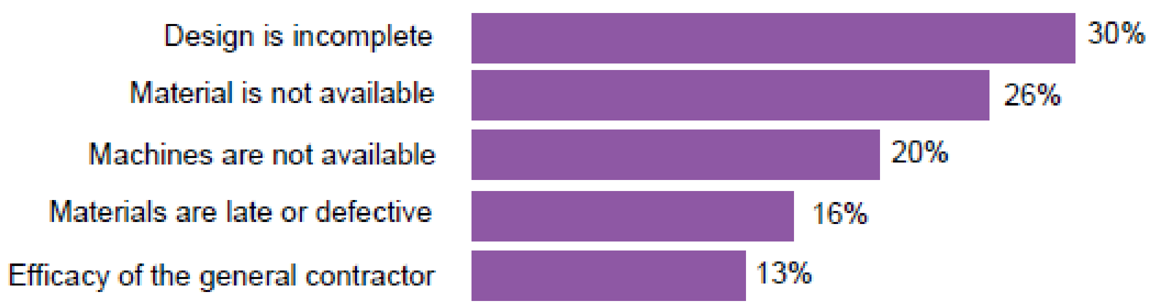
Source: GAO. | GAO-16-89G

Prioritizing risk index – Example

- A **tornado diagram** is a **common tool** used to show the effect on the output of **varying each input variable** at a time,
  keeping all the **other input** variables at their **initial (nominal) values**.
- **Tornado chart** shows the **correlation** between a **risk driver** and **project duration**.
  - It **shows** that **when** a **risk** is **assigned** to **several activities**, its **sensitivity measure reflects** the **entire correlation**,
    not just the **correlation of one activity** to the **project's duration**.

Using this information, the owner and general contractor can work together to ensure that the design is complete before the project begins, as well as identifying alternative sources for key materials.

Evaluation of Risk Sensitivity in the House Construction Schedule



Source: GAO. | GAO-16-89G

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Prioritizing risk index

- **Sensitivity indexes and correlation measures** are **useful starting points** for **assessing** the **possible magnitude** of **realized risks**, **but** they have **limited use** in **prioritizing risks**.
  1. Notice that **figure of sensitivity indexes** shows **activities**, **not the root cause risks**.
     - Thus, **while the chart is useful** for indicating **where risk** is the **greatest**, it **cannot be used** to **identify specific risks** for **mitigation**.
  2. And while **figure of evaluation of risk sensitivity** gives the **correlations** between **risk drivers** and **project duration**,
     - **No correlation** between **variables** considered.

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How to prioritize?

- **The general process is to:**
  1. **Run** the **SRA** using all **risks** and **uncertainties**.
  2. **Record** the **finish date** at the **desired percentile**—for example, 80 percent.
  3. **Remove** a **risk** (set probability to zero) and **run** the **SRA again** and **record** the **finish date** at the **desired %**
  4. **Compare** the **Steps 2 and 3**.
     - The **difference** in the **two dates** is the **expected contribution** (or **days saved**) of the **removed risk**.
  5. **Replace** the risk, **remove** the next risk, **rerun** to the SRA, and **compare** the 80th percentile date to **full SRA simulation** and calculate the difference in **days**.
  6. **Continue removing risks** and **uncertainties** **one by one** and **perform** the same process.

The risk with the highest contribution in days is the most important risk.

How to prioritize?

To identify the next most important risk,

the most important risk identified above is removed from the model

and

the process is repeated.

As the risks are removed and the next most important risks are identified, a prioritized list of risks and uncertainty can be created.

How to prioritize? – Example

- The **table** shows the **top 5 risks** and **their contribution** to the **80th percentile** date of April 23, 2026.
- The **results** in table are the **same** as the **risks identified** in the **figure of "evaluation of risk sensitivity"**, **although not** in the **same order**.
- The **order** is likely to be **different** because as **risks are removed** from the simulation, **activity durations** and **critical sequences** **change**.

Top Prioritized Risks in the House Construction Schedule

Priority	Risk	80th percentile date	Calendar days saved
	All	April 23, 2026	
1.	Design is incomplete	April 1	22
2.	Machines are not available	March 23	9
3.	Material is not available	March 17	6
4.	Efficacy of the general contractor	March 10	7
5.	Materials are late or defective	March 4	6

Source: GAO | GAO-16-89G.

Prioritizing schedule risks – Example

- **Schedule risks are identified in priority in the table below.**
- Their designation of **"S" or "C"** indicates whether they are typically thought of as risks to schedule or cost.

Priority Schedule Risks			
Risk ID	Risks	P-80 Date	Contribution to the P-80 Contingency
	ALL RISKS INCLUDED	27-May-14	(Days)
Risks Removed			
9	S/C - May have Problems during Commissioning	13-Nov-13	195
8	S/C Key Engineering Personnel may be Unavailable	4-Oct-13	40
6	S - Activity Duration Estimates is Inaccurate	18-Aug-13	47
2	S -Site Conditions / Site Access may Slow Logistics	6-Jul-13	43
1	S/C - Design Complexity may Challenge Engineers	19-Jun-13	17
3	S/C-Equipment Suppliers may be busy	30-May-13	20
4	S - Capable Management may not be Assigned	6-May-13	24
5	S -Environmental Agency May be Slow	29-Apr-13	7

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Prioritizing cost risks – Example

- **Cost risks are identified in priority in the table below.**
- Their designation of **"S" or "C"** indicates whether they are typically thought of as risks to schedule or cost.

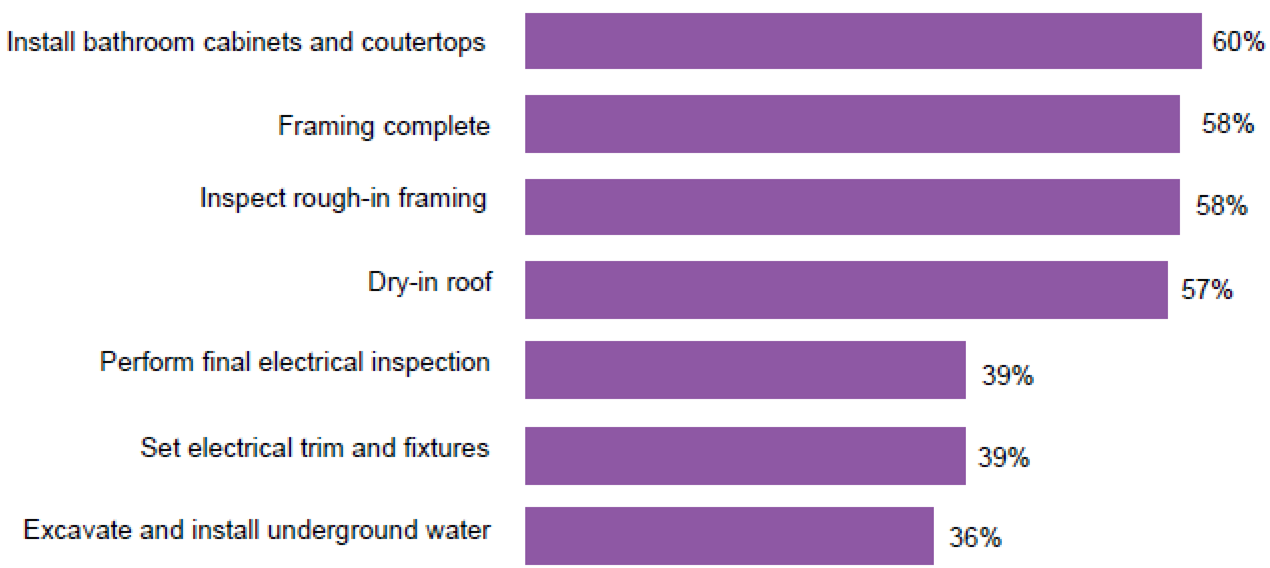
Priority Cost Risks			
Risk ID	Risks	P-80 Cost	Contribution to the P-80 Contingency
	ALL RISKS INCLUDED	829.5	
Risks Removed			
7	C - Cost Estimate is Inaccurate	788.3	41.2
9	S/C - May have Problems during Commissioning	750.4	37.9
8	S/C Key Engineering Personnel may be Unavailable	719.1	31.3
2	S -Site Conditions / Site Access may Slow Logistics	687.7	31.4
6	S - Activity Duration Estimates is Inaccurate	664.6	23.1
3	S/C-Equipment Suppliers may be busy	641.7	22.9
4	S - Capable Management may not be Assigned	632.6	9.1
1	S/C - Design Complexity may Challenge Engineers	625	7.6
5	S -Environmental Agency May be Slow	624.2	0.8

Prioritizing risk criticality of selected activities – Example

- **Risk analysis** should also **identify** the **activities** that **most often** ended up on the **critical path** during the simulation, so that
  near risk-critical path activities can be **identified** and closely **monitored**.
  - **Risk criticality** represents the **percentage of simulation iterations** that an **activity** or **milestone** is on the **critical path**.

***Activities most likely** to be on the **critical path** may **not** be the **most risky** themselves.*

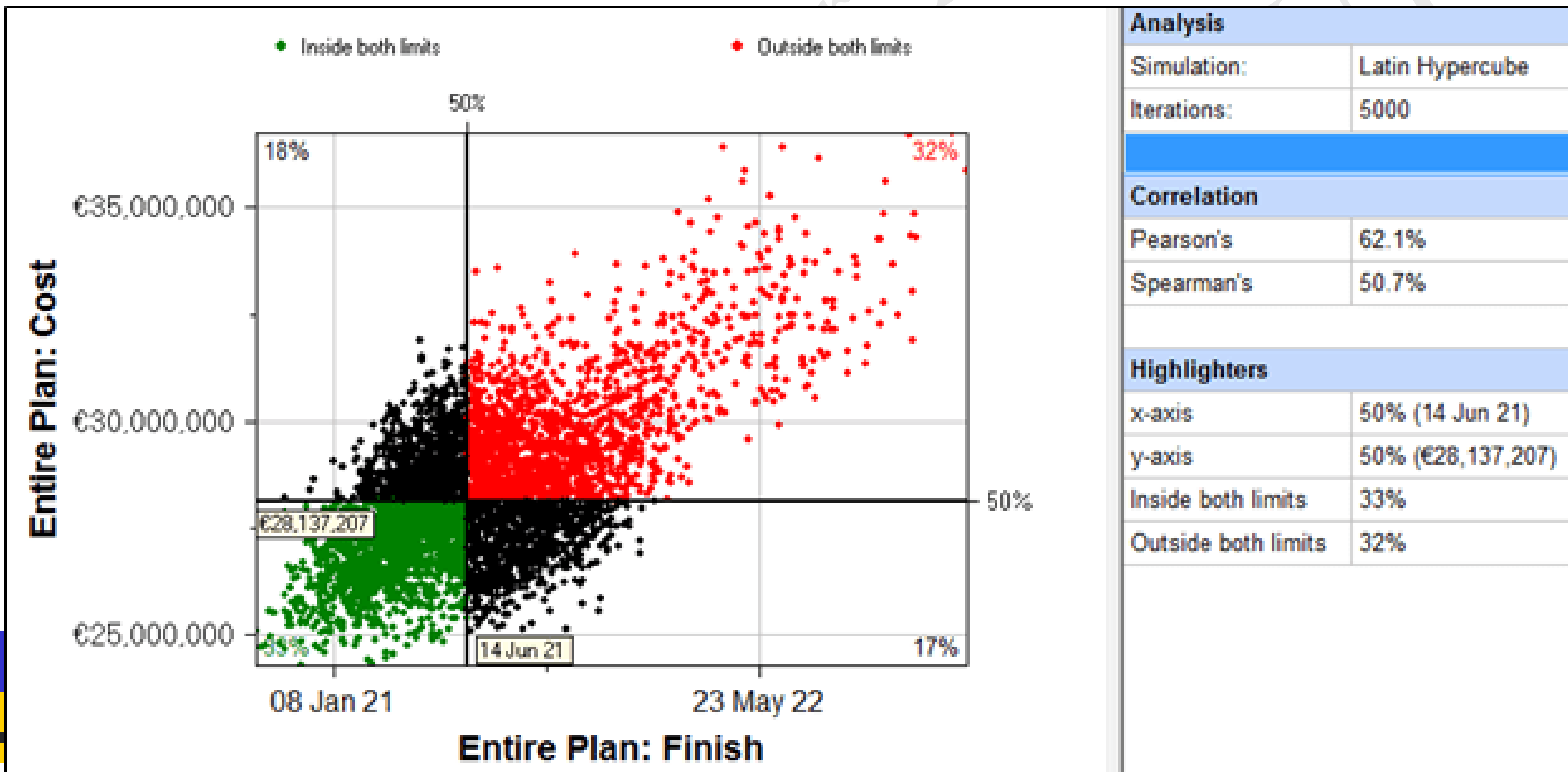
Risk Criticality of Selected Activities in the House Construction Schedule



Source: GAO. | GAO-16-89G

Correlation between time and cost – Example

- **Scatter Plot**
  - How the risks to overall cost and schedule are related.
  - **33% chance** to deliver project **without** cost and time **overrun (green area)**.
  - **67% chance** of cost or time **overrun** (**black and red areas**)



Schedule Risk Analysis

(Probabilistic branching)

Definition

- In addition to **standard schedule risk** and **sensitivity analysis**, **typical events** in programs require **adding** some **new activities** to the schedule.
  - This is called **"probabilistic branching."**
  - *One common event is the completion of a test of an integrated product.*
  - *A schedule often assumes that tests are successful, whereas experience indicates that tests may fail and that their failure will require the activities of root cause analysis, plan for recovery, execution of recovery, and retest.*
  - ***This is a branch that happens only with some probability***

Probabilistic branching analyses may need to be conducted on a copy of the IMS file if the IMS is baselined or represents only required scope.

Probabilistic branching in a schedule – Example

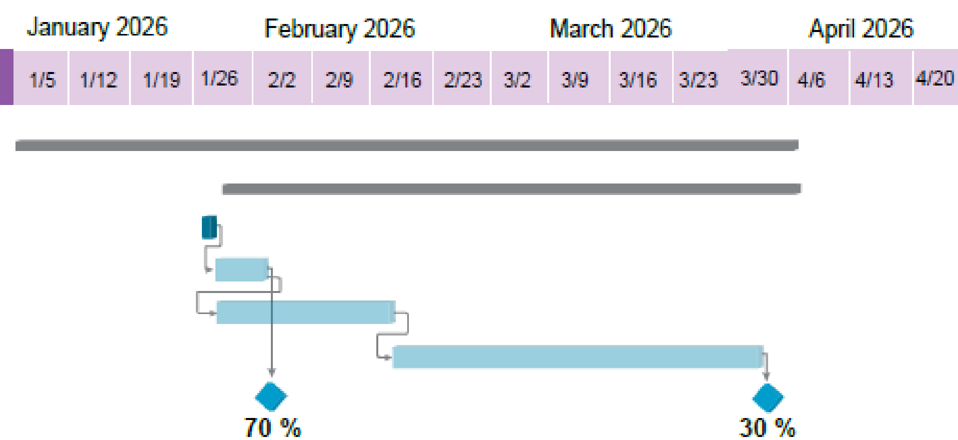
- In the house construction example, the SRA accounts for two scenarios that could occur after owner walkthrough.
  1. The plan assumes that in **70 percent of the cases**, deficiencies identified during walkthrough can be **addressed** by the general contractor **within a work week**.
  2. However, in **30 percent of the cases**, the owner and the general contractor **dispute the deficiencies** for **15 working days**, and, **unable** to **resolve** their differences, enter **mediation for 30 working days**.

Probabilistic branching in a schedule – Example

- The **Gantt chart** in figure shows the **probabilistic branch** associated with **owner walkthrough** for this example.
- If **deficiencies are disputed**, results in a **40-working day delay** to owner occupation.
- The **resulting probability distribution** of dates for the **entire project** can be depicted in a **figure** as **when 3-point duration risk simulation** or **risk driver method** applied.

Probabilistic Branching in a Schedule

Activity	Start	Finish	Duration
Close-out	**11/25**	**4/7**	**91 days**
Acceptance	**1/28**	**4/7**	**49 days**
Conduct owner walkthrough	1/28	1/28	1 day
Deficiencies are corrected	1/29	2/3	4 days
Deficiencies are disputed	1/29	2/19	15 days
Dispute is mediated	2/20	4/2	30 days
Owner acceptance	4/2	4/2	0 days



Source: GAO. | GAO-16-89G

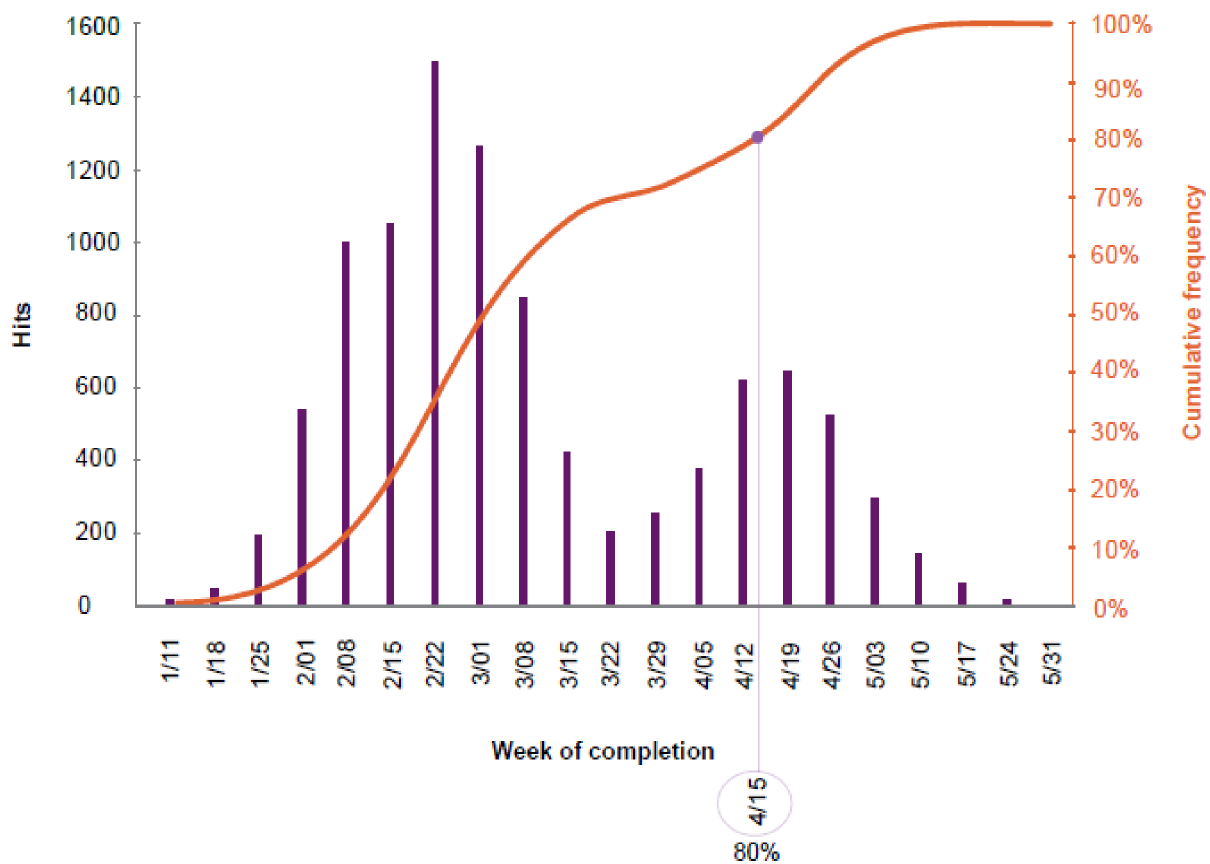
Probabilistic branching in a schedule

- **Probabilistic branching** is used to **model** the **random choice** between **two alternatives**.
- An **advanced technique** known as **"conditional branching"** is also available in **certain SRA software packages**.
  - With **conditional branching**, an action is **determined** by **some scheduled event rather than** by **randomness**.
    - ✓ That is, it is **modeled** as an **"If…then…else"** statement **rather than** a **probability of occurrence**.
      - *For example, if a design activity takes 2 weeks, then execute Plan A, otherwise (else) execute Plan B.*

Probabilistic branching in a schedule

- The **resulting probability distribution** of dates for the **entire project** shown in the figure, as applied to the **3-point duration risk simulation**.
- **Bimodal distribution** with the **corrected deficiencies scenario** on the **left of figure** and the **dispute scenario** on the **right**.
- In this case, **if** the **homeowner demanded** an **80th percentile** schedule, it would be **April 15.**

Probability Distribution Results for Probabilistic Branching



Source: GAO. | GAO-16-89G

Schedule Risk Analysis

(Schedule contingency)

Definition

- The **contingency** represents a **gap** in **time** **between**
  - **Finish date** of the **last activity** (the **planned date**)
  - **Finish milestone** (the **committed date**).

- When schedule contingency is **depicted this way**, a **delay** in the **finish date** of the **predecessor activity** results in a **reduction** of the **contingency activity's duration**.
  - **This reduction** translates into the **consumption** of **schedule contingency**.

How to calculate?

We use AACE 70R-12, 40R-08, and GAO instructions at this section!

Definition – Schedule management reserve

- **Schedule Management Reserve *(SMR)*** is a
  1. Designated **amount of time** to account for risks that **cannot be quantified** and/or **managed** with **contingency**,

     or

  2. **Time for management** purposes.

Definition – Schedule contingency

- **Schedule contingency** should be calculated by
  1. **Performing** a **schedule risk analysis**
  2. **Comparing** the **schedule date** with that of the **simulation result** at a **desired level of certainty**.

For example, an organization may want to adopt an 80 percent chance that its program will finish on time or earlier.

The amount of contingency necessary would be the difference in time between the 80th percentile date from the cumulative distribution and the date of the deterministic finish date in the schedule.

Schedule contingency can be quantified by using risk modeling software

Definition – Schedule contingency

- **Schedule contingency** should cover
  - Incomplete designs
  - Construction disturbances (accidents or breakdowns)
  - Changes in market conditions
  - Regulatory risk
  - Technological complexities
  - Unidentified testing and start-up problems
  - Unforeseen regulatory and safety requirements
  - Unusual Schedule Risks including:
    - Unavailable Labor, Materials, Equipment
    - Uncertainties in Contractor Stability
    - Unavailable Facilities

Definition – Cost contingency

- **Cost Contingency** is "an amount added to an estimate to allow for items, conditions or events for which the occurrence is **uncertain** and will likely result in **additional costs.**"
  - Incomplete designs
  - Construction disturbances (accidents or breakdowns)
  - Changes in market conditions
  - Regulatory risk
  - Estimating inaccuracies
  - Technological changes
  - Omissions
  - Abnormal construction and start-up problems
  - Unforeseen safety requirements
  - Unanticipated price changes

Schedule and Cost contingency

- Contingency usually **excludes** **major scope changes** such as changes in end product specification, capacities, facility sizes, errors and omissions.

- Contingency time for **construction rework** is **not** normally **included** in construction schedules.

- Contingency also **excludes** **extraordinary events** such as natural disasters.

What should be done? There should be an agreement between parties!

Contingency estimating methods that "link risk drivers and cost/schedule outcomes" are described in AACE 40R-08

Schedule contingency – Management

- **Schedule contingency** or reserve is held by the **program manager** but can be **allocated** to **contractors**, **subcontractors**, **partners**, and others as necessary for their **scope of work**.

- **When** contingency needs to be **allocated**, a **formal change process** should be **followed**.
  - **Variances** should be **tracked** and **monitored**
  - **Use of contingency** should be **transparent** and **traceable**

What are the most common schedule contingency?

Schedule contingency – Management

- **Project** **contract** (terms and conditions) will determine whether or not **schedule contingency** can be **jointly established** and managed in the project schedule.

- **Schedule contingency** should be managed **consistent** with the project **specifications**.

- ***Scheduling specifications*** require modification to include the **definitions** and **guidelines** for the **management** and **use of schedule contingency**.

Schedule contingency – Management

Schedule contingency will not be included in the individual project work activities as “duration padding”

But rather

Should be established as a separate “buffer” activity for the associated tasks!

i. If **not visible** then it **cannot be managed**

ii. **Critical path** may **change** during project execution

iii. Activities are likely to **experience lower production rates**

- ✓ If the contractor achieves **less progress** due to **lower productivity**, it may be considered as a contingency.

Schedule contingency – Management

Schedule contingency:

- ***Is not float***
- ***Is not lag/lead***
- ***Is not a non-work period in calendar***
- ***Is not hidden***

When considered as above items, cannot be visible and managed

- ***Is not management reserve***

IT IS A SCHEDULE ACTIVITY

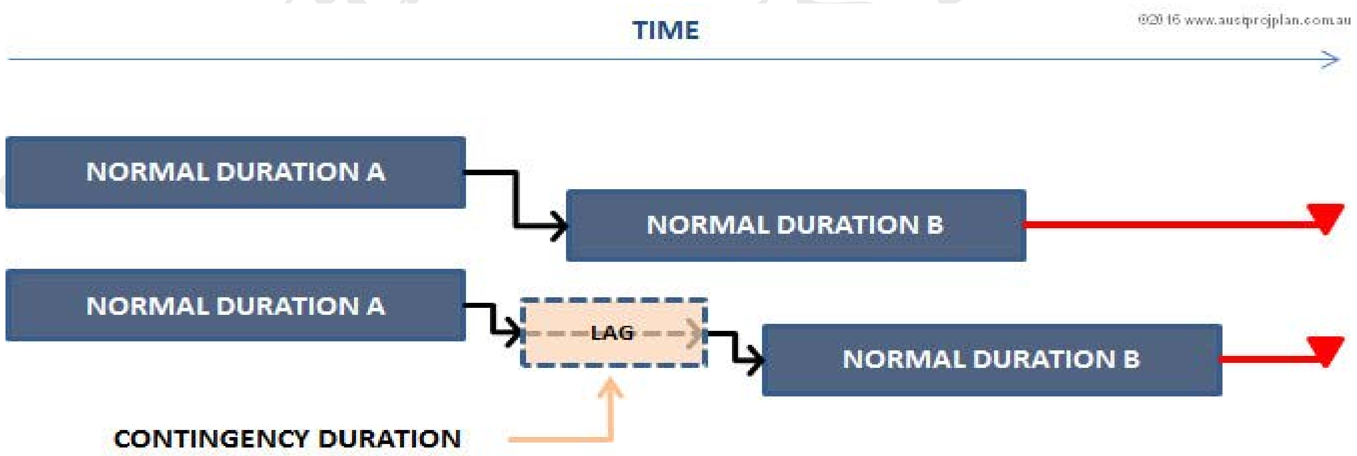
Schedule contingency – Management

Schedule contingency:

- ***Must be visible in the schedule***
- ***It is time only and does not contain scope, resources or costs***
- ***It is only established based on schedule risk analysis***

Schedule contingency – Management

- **Schedule contingency** should **not be represented** as a **lag** between two activities.
  - **Lags** have **no descriptive name** in schedules
  - **Associated contingency** may become **lost** within the **network logic**.
  - This lag may **change the critical path** and may result in **complicated case** due to **float ownership**.
  - Lag **cannot be managed** **unless manually**.
    - This results in **changing the schedule** all the time



Schedule contingency – Management

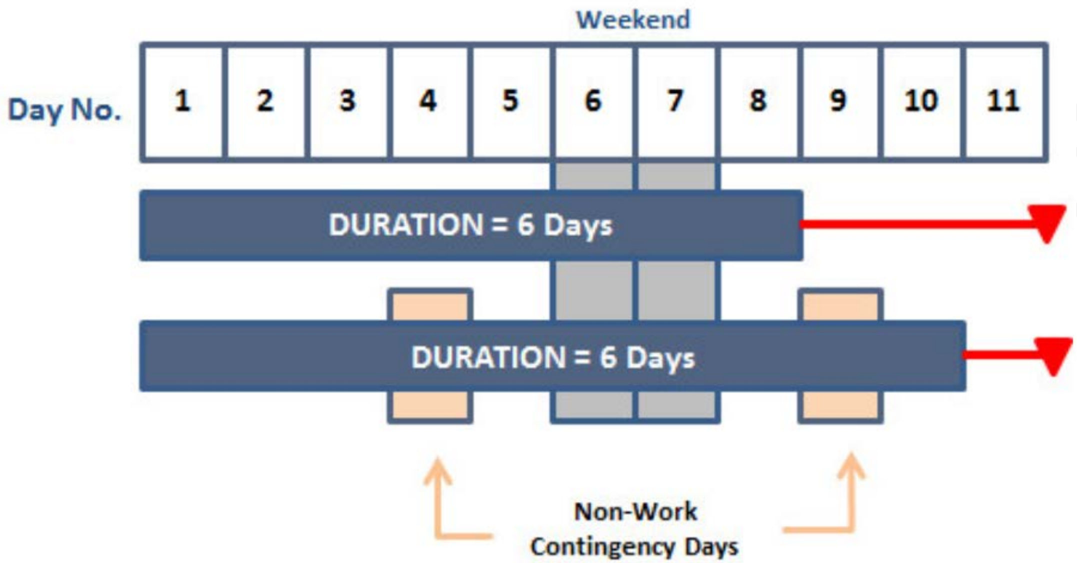
Contingency is not the same as total float!

WHY?

- **Total float** is **directly** related to **network logic** and is **calculated** from **early and late activity dates**.
- **Schedule contingency**, in contrast, is **determined** by a **schedule risk analysis**.

Schedule contingency – Management

- **Schedule contingency is not a non-work period in calendar.**



- **No explicit indication of contingency** at activity or project level
- Will be **complicated by activity control**

Schedule contingency – Management

Establishing schedule contingency

- Schedule contingency may be **established** by **either** the **owner** or the **contractor (or both)** and is only established based upon a **schedule risk analysis**.
- The project **may** include **more than one schedule contingency** (or buffer) element linked to
  1. **Key performance milestones**
  2. Completion of a **specific group of related tasks** where unforeseen events could put the project schedule performance at risk

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Schedule contingency – Management

- **How to insert contingency?**

1. Schedule contingency may appear as a **single activity** just **before** the **finish milestone** **(project completion date)**

or

2. It may be **dispersed throughout** the schedule as **multiple activities** before **key milestones**.

Which one is preferable?

Schedule contingency – Management

- It is **preferable** that **contingency** be held as **one activity** just **before** the **finish milestone** for several reasons.
  1. In general, **apportioning contingency** in advance to specific activities is **not recommended** because risks that **will** actually occur and the **magnitude** of their effects are **not known** in **advance**.
  2. In addition, **dispersing contingency** to specific **key milestones** may be harder to track and monitor.
  3. **Dispersion** may also **encourage team** members to work toward **late dates rather than** the **expected early dates** in **each milestones**.

Schedule contingency – Management

- **What if we have to disperse contingency?**
  - ✓ **Everyone** on the project will be working to **protect** the schedule contingency as a **whole**, **not simply their own portions**.
  - ✓ **Care** must be taken that the contingency activities do **not affect total float** and, therefore, **critical path calculations**.
  - ✓ **Contingency activities** should **not become critical** because **no resources** or **scope** are associated with them and they **cannot practically delay** a **successor activity**.

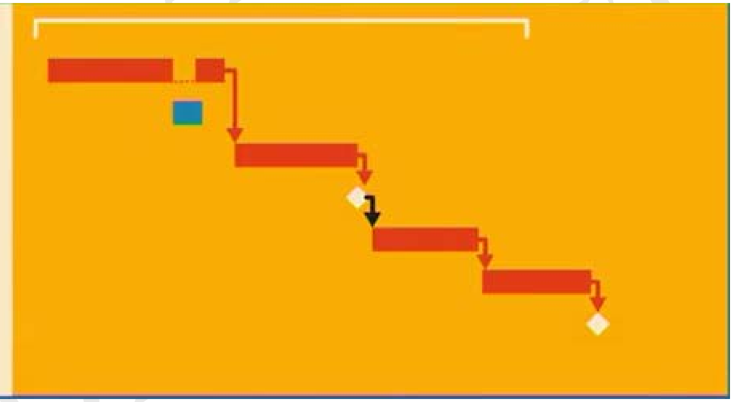
How to insert contingency if we have to disperse it?

Schedule contingency – Management

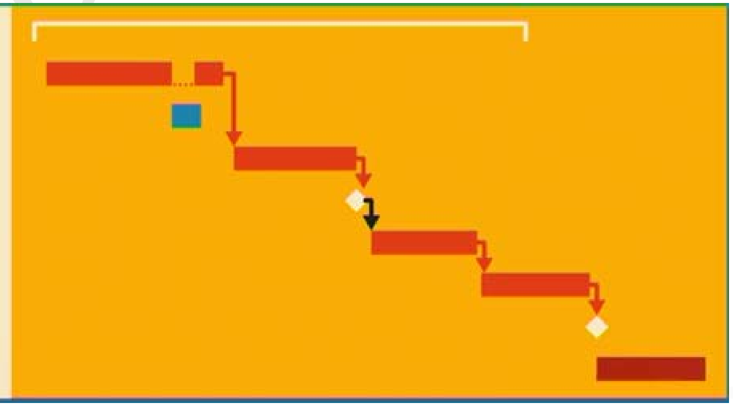
❑ What if we have to disperse contingency?

1. Add contingency activity to the end of sequence activities
   - ❖ All activities in the sequence share one buffer

Written Manuscript	45 days	3/10/17
Write chapters 1–4	3 weeks	3/10/17
Review progress	2 days	3/27/17
Write chapters 5–6	2 weeks	3/31/17
Manuscript 50% complete	0 days	4/13/17
Write chapters 7–8	2 weeks	4/14/17
Write chapters 9–12	2 weeks	4/28/17
Manuscript written	0 days	5/11/17



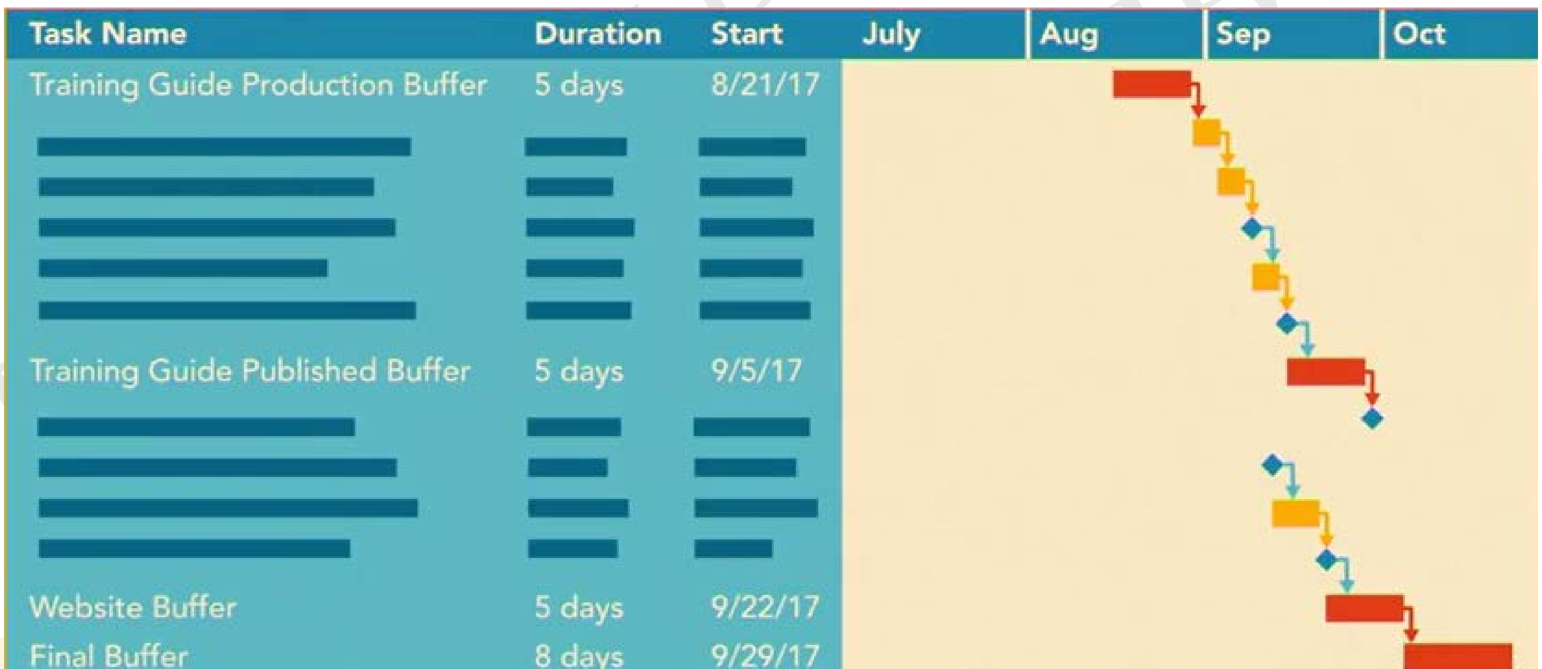
Written Manuscript	**50 days**	3/10/17
Write chapters 1–4	3 weeks	3/10/17
Review progress	2 days	3/27/17
Write chapters 5–6	2 weeks	3/31/17
Manuscript 50% complete	0 days	4/13/17
Write chapters 7–8	2 weeks	4/14/17
Write chapters 9–12	2 weeks	4/28/17
Manuscript written	0 days	5/11/17
Manuscript buffer	**5 days**	**5/12/17**



Schedule contingency – Management

What if we have to disperse contingency?

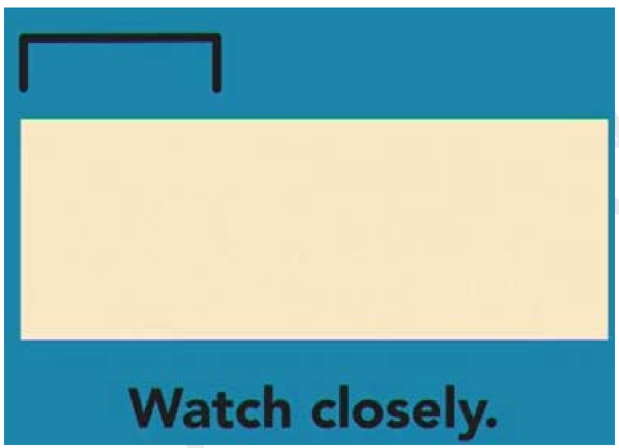
2. Add buffers at the end of each phase and end of the project
   - Helps when multiple paths merge in a schedule
   - Four buffers in this example at the end of each phase



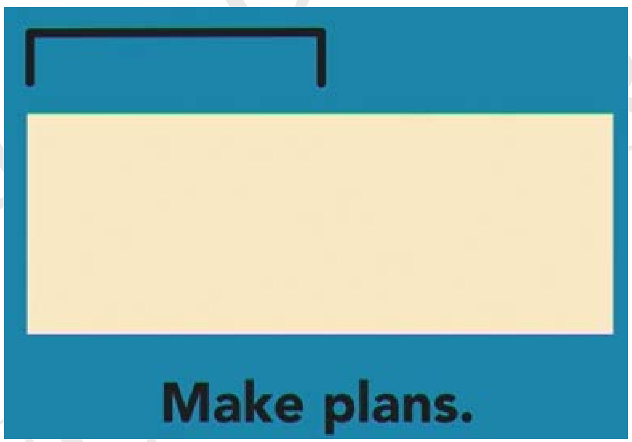
Schedule contingency – Management

What are the advantages of the method mentioned?

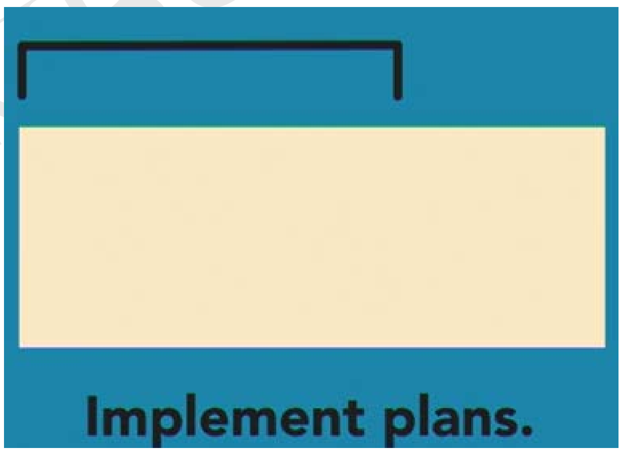
- **You don't need to take action at the first sign of the problem because buffers absorb delay.**



Don't need to take action



Put plans in place to correct if the delays continue

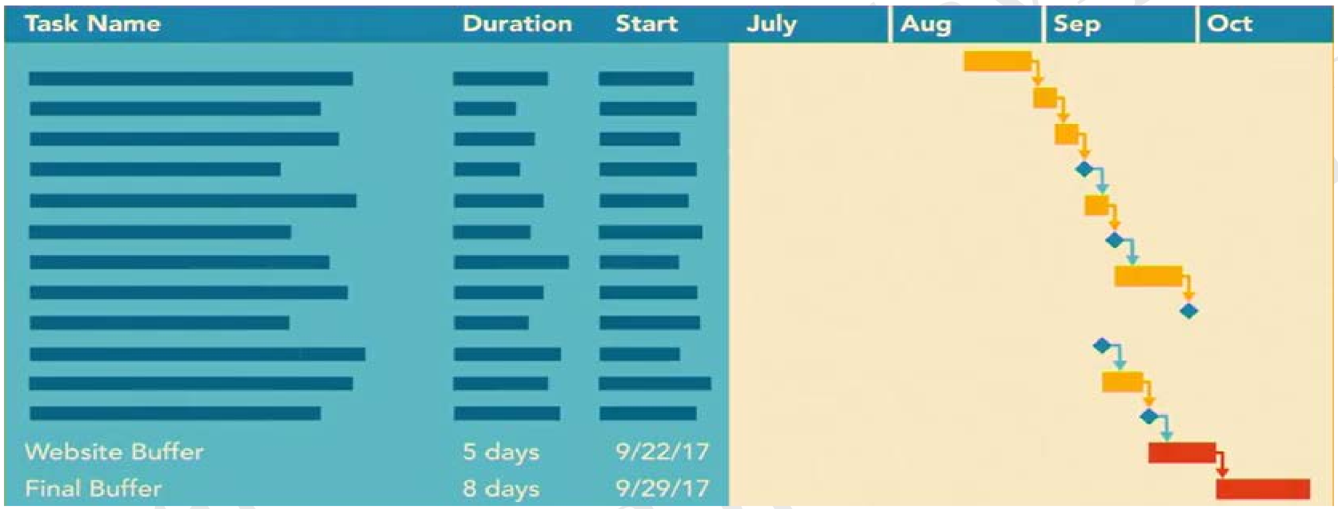


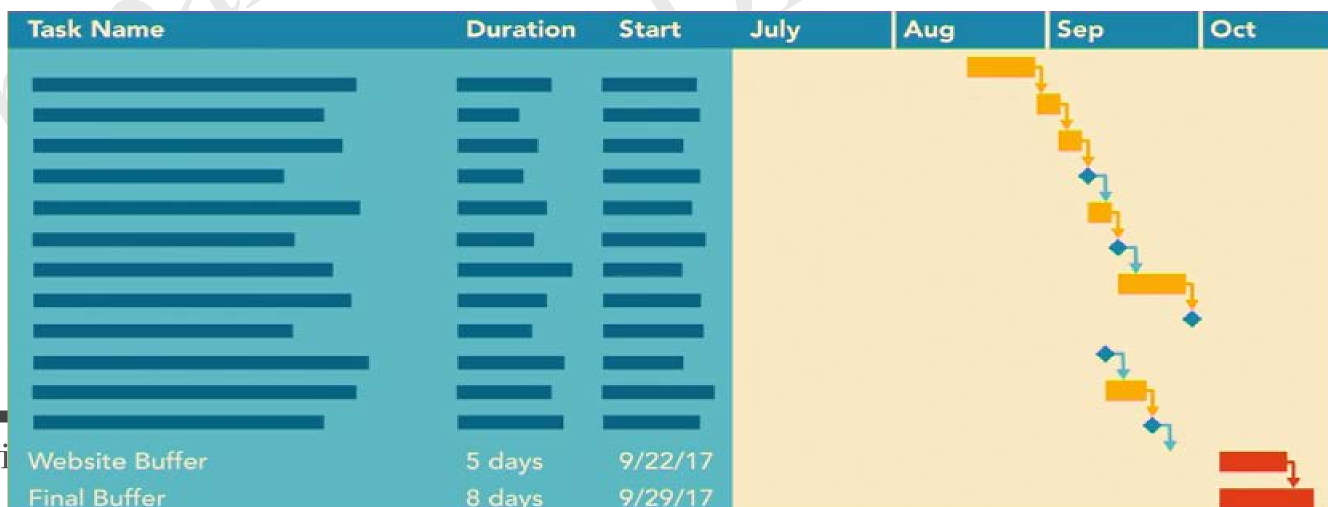
Implement the plans you made

Schedule contingency – Management

What if activity sequence extends beyond its buffer?

- You can start using a phase buffer in the same way to protect project finish date





Schedule contingency – Management

How to insert contingency if we have to disperse it?

- **Technique** for **inserting contingency activities** within the network is to **insert an activity** as a **predecessor** to a **"reference milestone."**
  - The **reference milestone** is a **copy of the original key milestone** but has **no successor**.

This method allows the reference milestone to

- **Shift** in **response to**
  1. **Depletion** of **contingency without affecting total float values** in the schedule
  2. **Accumulation** of **contingency without affecting total float values** in the schedule

Schedule contingency – Management

- The **practice for assessing and managing the contingency activities** is sometimes called the **contingency drawdown method**.

Contingency change management requires a disciplined, well documented and controlled process.

References: AACE *TCM Framework* (Chapter 10.3)
"Developing the Project Controls Plan" ~ RP 60R-10
"Documenting the Schedule Basis" ~ RP 38R-06

Schedule contingency – Management

- **Regardless** of whether contingency is **captured at the end** of the schedule or just **before key milestones**,

  representing it as activities will help ensure that the schedule is **not hiding potential problems**.

  - **If contingency represented as activities**,

    it can be quickly **identified and zeroed out before**

    1. **Schedule health measures** are **calculated** or
    2. **SRA** is **conducted**

If activities representing schedule contingency are not removed before an update to the SRA is conducted, they will adversely affect the results.

Schedule Risk Analysis

(Updating and documenting a schedule risk analysis)

Definition

- **Risk management planning** is usually done once, at the **beginning** of the project **planning phase**,

  although mid-course corrections may be made (for instance, to add personnel if more risks arise than originally anticipated).

- A **schedule risk analysis** should be performed **periodically** as the schedule is **updated**.

- **Schedule contingency** should be **reassessed periodically**.

- **As the program progresses:**
  - **Risks** **retire or change**
  - **New risks** that were previously categorized as **"unknown unknowns" may appear**.

Updating SRA

- The **time** between **SRA updates** will **vary** according to **project**.
  - An **SRA** might occur **more regularly**, for instance, to support **annual budget request submissions**
  - Preferably, an **SRA** is also performed **before key decision points.**
  - A **contractor** should perform an **SRA** **during the formulation** of the **performance measurement baseline.**
  - **SRAs** should also be performed **when** schedule contingency is **consumed**
    - ✓ at a higher-than-expected rate
    - ✓ by the materialization of risks not included in the risk register

Checklist For a Scheduler For Conducting Schedule Risk Analysis

Checklist

- A schedule risk analysis was conducted to determine
  - the likelihood that the program completion date will occur,
  - how much schedule risk contingency is needed to provide the acceptable
  - certainty of completion by a specific date,
  - risks most likely to delay the project, and
  - the paths or activities that are most likely to delay the program.
- The schedule was assessed against best practices before the simulation was conducted. The schedule network clearly identifies work to be done and the relationships between detailed activities and includes a minimum number of justified date constraints.
- The SRA has optimistic, most likely, and pessimistic duration data fields.
- The SRA accounts for correlation in the uncertainty of activity durations.

Checklist

- Risks are prioritized by probability and magnitude of effect.
- The risk register was used in identifying the discrete risks potentially driving the schedule before the SRA was conducted.
- The SRA data and methodology are available and documented.
- The SRA identifies the activities in the simulation that most often ended up on the critical path, so that near-critical path activities can be closely monitored.
- The risk inputs have been validated. The probabilities and impact ranges are reasonable and based on information gathered from knowledgeable sources, and there is no evidence of bias in the risk data.
- The baseline schedule includes schedule contingency to account for the occurrence of risks. Schedule contingency is calculated by performing an SRA and comparing the schedule date with that of the simulation result at a preferred level of certainty.

Checklist

- Schedule contingency is held by the program manager and allocated to contractors, subcontractors, partners, and others as necessary for their scope of work.
- The program documents the derivation and amount of contingency management has set aside for risk mitigation and unforeseen problems. An assessment of schedule risk is performed to determine whether the contingency is sufficient.
- A contractor performs an SRA during the formulation of the performance measurement baseline to provide the basis for contractor schedule reserve at the preferred confidence level.
- An SRA is performed on the schedule periodically as the schedule is updated to reflect actual progress on activity durations and sequences, as well as new risks.

An Auditor’s Key Questions and Documents For Conducting Schedule Risk Analysis

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Key questions

1. Was an SRA performed to determine the confidence level in achieving the program schedule and other key dates?
   a. Was the schedule checked to ensure that it meets best practices before the simulation was conducted?
   b. Are there data fields within the schedule for risk analysis such as optimistic, most likely, and pessimistic durations?
   c. Were uncertainties in activity durations statistically correlated to one another?
   d. How much schedule contingency was selected and what is the probability of meeting the completion date?
   e. Did the SRA identify activities during the simulation that most often ended up on the critical path, so that near-critical path activities can be closely monitored?

Key questions

2. Was a risk register used as an input to schedule development?
   a. Was the risk register used in identifying the risk factors potentially driving the schedule before the SRA was conducted?
   b. Once the SRA was conducted, were risks prioritized by probability and magnitude of effect?
3. Are the SRA data, assumptions, and methodology available and documented?
4. Are the probabilities and impact ranges reasonable and based on information gathered from knowledgeable sources? Is there evidence of bias in the risk data?
5. How is the use of schedule contingency controlled and authorized?
6. Is an SRA performed periodically to reflect actual progress and changes in risks?

Key Documents

1. A risk register with prioritized risks.
2. SRA documentation that includes assumptions, methodology, data, data normalization techniques, and findings.
3. A listing of people interviewed or included in risk interviews along with their organizations, positions, and expertise.
4. The schedule risk analysis file.

موسسه مهندسی و مدیریت ساخت علوی پور (ACEMI)

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