Modern Methods of Schedule Risk Analysis using Monte Carlo Simulations

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Agenda

- Modern Methods of risk analysis
- Collecting risk data
- Introducing uncertainty to the model
- Introducing risks as Risk Drivers
- Risk drivers model correlation between activity durations
- Risks may be entered in series or in parallel
- Offshore gas production platform project
- Use Categories to apply risks to multiple activities
- Prioritizing risks for management action
- Risk mitigation actions and Results (simple example)
- Probabilistic branching for test failure possibility



MODERN METHODS OF RISK ANALYSIS



Modern Methods of Schedule Risk Analysis(1)

- Earlier methods of quantifying risk analysis using Monte Carlo Simulation (MCS) placed probability distributions directly on activity durations
 - Did not distinguish risks from uncertainty
 - Could not disentangle the relative impacts of several risks on one activity
 - Could not assess the whole impact of a risk that affects more than one activity
 - Therefore, could not prioritize risks for risk mitigation



Modern Methods of Schedule Risk Analysis (2)

- In the last 10 years we have been able to specify risks and use those to directly drive the MCS
 - Distinguish uncertainty from risks
 - Model specific risks including systemic risks from benchmarking data
 - Represent failing a test with probabilistic branches
- This development allows us to model much more specifically and intelligently
 - Apply risks to multiple activities (categories of activities)
 - Apply risks in series and in parallel
 - Model how duration correlation occurs
 - Prioritize risks for focused risk mitigation



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COLLECTING RISK DATA



Collecting Risk Data Using Confidential Interviews

- Data about risk may start with the Risk Register
- During one-on-one confidential interviews we <u>always</u> discover risks not on even well-developed and maintained Risk Registers
- This omission may be because there are some Unknown Knows that are not talked about in workshops
- Collect descriptions of the risk, probability it will occur, impact (multiplicative factors) on the scheduled durations and activities it will affect if it occurs
- Collect data on uncertainty too 100% likely to occur with some impact



INTRODUCING UNCERTAINTY TO THE MODEL



Add components of Risk - Uncertainty

- Uncertainty is akin to "common cause" variation in the six sigma management
- "Common cause variability is a source of variation caused by unknown factors that result in a steady but random distribution of output around the average of the data. Common cause variation is a measure of the process's potential, or how well the process can perform when special cause variation is removed. ... Common cause variation is also called random variation, noise, non-controllable variation, withingroup variation, or inherent variation."

https://www.isixsigma.com/dictionary/common-cause-variation/



Specifying Uncertainty - Reference

| Tem | plated | Unce | ertainty Editor | | |
|---------|--------|--------------------|-----------------|-----|--|
| Tem | plates | G # | Add Semove | | |
| Priorit | tγ | | Filter | | Schedule Uncertainty |
| | 1 | V | Approval | - 0 | Triangular - Min:0.8 Likely:1 Max:1.3 |
| | 2 | \bigtriangledown | Engineering | - | Triangular - Min:0.9 Likely:1.1 Max:1.4 |
| | 3 | \bigtriangledown | Procurement | · 🗢 | Triangular - Min:0.95 Likely:1 Max:1.2 |
| ۵ | 4 | \bigtriangledown | Fabrication | - 0 | Triangular - Min:0.85 Likely:1.1 Max:1.3 |
| | 5 | \bigtriangledown | Drilling | * 🗢 | Triangular - Min:0.8 Likely:1 Max:1.2 |
| | 6 | \bigtriangledown | Installation | - 0 | Triangular - Min:0.9 Likely:1.05 Max:1.3 |
| | 7 | | HUC | * | Triangular - Min:0.85 Likely:1.1 Max:1.4 |

Uncertainty ranges can be applied to different types of activities "reference ranges" Uncertainty can be correlated, in this case 100% to make overall project uncertainty model what people said during interviews





Schedule Risk with Uncertainty Only



Scheduled completion is April 4, 2019

With Uncertainty Only the P-80 completion is October 19, 2019, an addition of 6 ½ months

With Uncertainty only the likelihood of meeting the scheduled date is 14%

"P-80" means the date that the project will finish on or earlier than in 80% of the iterations



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INTRODUCING RISKS AS RISK DRIVERS



Adding Project-Specific Risks

- Project Specific Risks are like special cause risk in the Six Sigma world
- "... Special cause variation is caused by <u>known</u> <u>factors that result in a non-random</u> <u>distribution of output</u>...Special cause variation is a shift in output <u>caused by a specific factor</u> such as environmental conditions or process input parameters. It can be accounted for directly and <u>potentially removed</u>..."

https://www.isixsigma.com/dictionary/special-cause-variation/



Root Cause of Variation – Risk Drivers

- Risk Drivers came about nearly 10 years ago as the author and a colleague asked Pertmaster, on behalf of a client, to develop this method
- Risk Drivers' impacts on scheduled durations are in ranges of multiplicative factors translated into probability distributions
- Risk Drivers can be assigned to many activities so it models how a strategic risk influences the project
- Some activities can have several risk drivers



Introducing the Risk Driver Method for Causing Additional Variation in the Simulation

| Risk Driv | ver Ed | litor | | | | | |
|---------------------------|--------|--|-------------|-------------|--------|--|-----------------|
| Enabled 🗹 | UID | Risk Driver Name | Probability | Description | Notes | | |
| V | 1 | Engineering company productivity may differ from planned | 100% | | 0 | | |
| \checkmark | 2 | Construction Contractor may or may not be familiar with the technology | 40% | | 0 | | |
| \checkmark | 3 | Testing may reveal issues that need to be resolved | 65% | | | | |
| | 4 | Organization's quality controls may not be sufficient to avoid issues in Delivered Product | 50% | | | | |
| l isk Driv Task | ver Im | npact Editor | | Tasks 🙆 Add | Remove | Triangular - Min:0.9 Likely:1.05 Max:1.3 | Duration Factor |
| B1000 - Desig | in 1 | | | | | | Cost Factor |
| 1000 Deci | 10.2 | | | | No | ne - Original Value: 1 | |

Four risk drivers are specified. The first is a general risk about engineering productivity, which may be under- or over-estimated, with 100% probability. It is applied to the two Design activities



100% Likely Risk Driver's Effect on Design Duration



With a 100% likely risk the probability distribution of the activity's duration looks like a triangle. Not any different from placing a triangle directly on the activity



Risk Driver with Risk at < 100% likelihood

| Risk Drive | er Ed | litor | | | | | |
|-----------------|-------|--|-------------|-------------|-------------|--|----------------|
| Enabled 🗹 | UID | Risk Driver Name | Probability | Description | Notes | | |
| 2 | 1 | Engineering company productivity may differ from planned | 100% | | 0 | | |
| I | 2 | Construction Contractor may or may not be familiar with the technology | 40% | | | | |
| 1 | 3 | Testing may reveal issues that need to be resolved | 65% | | 0 | | |
| | 4 | Organization's quality controls may not be sufficient to avoid issues in Delivered Product | 50% | | 0 | | |
| Risk Drive | er In | npact Editor | | Tasks 👔 | Add Semove | Triangular - Min: 0.9 Likely: 1.1 May: 1.4 | Duration Facto |
| Task | 1 | | | | In Parallel | | Cost Factor |
| C1010 - Build 2 | 2 | | | | | None - Original Value: 1 | |

With this risk, the Construction Contractor may or may not be familiar with the technology, the probability is 40% and the risk impact if it happens is .9, 1.1 and 1.4. It is applied to the two Build activities



With a 40% Likelihood, the "Spike" in the Distribution Contains 60% of the Probability



Here is where the Risk Driver method gets interesting. It can create distributions that reflect:

- Probability of occurring
- Impact if it does occur

Cannot represent these two factors with simple triangular distributions applied to the durations directly



RISK DRIVERS MODEL CORRELATION BETWEEN ACTIVITY DURATIONS



Model Correlation of Activity Durations

- A common question with schedule (or cost) risk analysis is; "Have you considered correlation?"
- Correlation is defined between pairs of durations. A matrix of correlation coefficients is created
 - Example Tasks may be long because subcontractor may not be able to provide high productivity
 - Example Tasks may be long because technology may not be well understood (low TRL)
- People do not do well guessing coefficients
- Using Risk Drivers removes this problem since it models how correlation occurs in projects



Risk Drivers Model How Correlation Occurs



Correlation arises when two activities' durations are influenced by the same external, variable and influential force, a risk



Correlation of 100% Scatterplot





Introduce Two Confounding Risks



Two risks that affect only one but not the other activity duration drives down the correlation substantially



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Scatterplot with 2 Confounding Risks





RISKS MAY BE ENTERED IN SERIES OR IN PARALLEL



Risks in Series or Parallel

- Some risks, if they happen, will stop progress until the impact is recovered
- Other risks are not that important and their recovery can occur simultaneously with other risks' recovery
- This matters only on the iterations when the two risks both occur
- An activity can be influenced by both series and parallel risks



Entering Risks in Series or in Parallel





Results with Risks in Parallel or in Series





OFFSHORE GAS PRODUCTION PLATFORM PROJECT



Summary Schedule of a Megaproject

| | | CI-1 D 1 | E I D I | D | 6 I. | 2015 | 2016 | line t | | | 2017 | | | | 2018 | | (acetae) | | 2019 | 121 | | | 2020 | | |
|--------------|--|-----------------|------------|----------|-------------|------|------|-----------|-----|------------|------------|--------|-----|------|--------|----------|-----------------|-----------|------------|-----------|------------|---------|-------------|-----------|----------|
| UID | Task — | Start Date | End Date | Duration | Cost | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 0 | 22 | Q3 Q |
| Gas Platform | Offshore Gas Production Platfori | 01/01/2016 | 04/04/2019 | 1,190 | \$1.717M | | - | | | | | | | | | | | | | Off | shore Gas | Produc | tion Platfo | rm | |
| Gas Platform | ▼ Milestones and Hammocks | 01/01/2016 | 04/04/2019 | 1,190 | \$400,000 | | - | | - | | | | | | - | - | | | | Mile | estones ar | nd Hami | mocks | | |
| A1000 | Project Start | 01/01/2016 | | 0 | \$0 | | Pro | oject Sta | art | | | | | | | | | | | | | | | | |
| A1010 | Project Sanction | | 07/18/2016 | 0 | \$ 0 | | | | • | Project S | Sanction | | | | | | | | | | | | | | |
| A1020 | First Gas | | 04/04/2019 | 0 | \$0 | | | | | | | | | | | | | | | First | st Gas | | | | |
| A1030 | Project Management Ham | 01/01/2016 | 04/04/2019 | 1,190 | \$400,000 | | -000 | 1111 | | 11/1 | //// | | 111 | //// | //// | //// | //// | 111 | 111 | Pro | ject Mana | gement | Hammocl | ¢ | |
| Gas Platform | ▼ Decision Making | 04/10/2016 | 07/18/2016 | 100 | \$8,000 | | | - | - | Decision | n Making | | | | | | | | | | | | | | |
| B1000 | Approval Process | 04/10/2016 | 07/18/2016 | 100 | \$8,000 | | | - | | 🔣 Appro | oval Proce | ess | | | | | | | | | | | | | |
| Gas Platform | ▼ Engineering | 01/01/2016 | 11/30/2017 | 700 | \$256,000 | 1 | | | | | | | - | | Engine | ering | | | | | | | | | |
| C950 | FEED | 07/19/2016 | 02/03/2017 | 200 | \$80,000 | | | | | | <u> </u> | K FEED | | | | | | | | | | | | | |
| C1010 | Detailed Engineering | 02/04/2017 | 11/30/2017 | 300 | \$160,000 | | | | | | | | | | 🔣 Det | ailed En | gineering | | | | | | | | |
| C900 | Concept Engineering | 01/01/2016 | 04/09/2016 | 100 | \$16,000 | | - | | Con | cept Engir | neering | | | | | | | | | | | | | | |
| Gas Platform | ▼ Procurement | 02/04/2017 | 09/06/2018 | 580 | \$350,000 | | | | | | - | | | | | | | Procur | rement | | | | | | |
| D1000 | Procurement of LLE | 02/04/2017 | 09/06/2018 | 580 | \$250,000 | | | | | | - | | - | | | | <u> </u> | E Pro | cureme | nt of LLI | E | | | | |
| D1010 | Procurement of Other Equ | 12/01/2017 | 08/07/2018 | 250 | \$100,000 | | | | | | | | | | | - | -6 | Procu | rement | of Othe | r Equipme | nt | | | |
| Gas Platform | ▼ Fabrication | 12/01/2017 | 11/05/2018 | 340 | \$536,000 | | | | | | | | | - | - | | 1.1 | F | abricatio | on | | | | | |
| E1000 | Fabricate Drilling Topsides | 12/01/2017 | 06/18/2018 | 200 | \$80,000 | | | | | | | | | | | | - 🔣 Fat | oricate (| Drilling T | Topside: | s | | | | |
| E1010 | Fabricate Drilling Jacket | 12/01/2017 | 06/18/2018 | 200 | \$80,000 | | | | | | | | | | | | — 🔣 Fal | oricate I | Drilling J | Jacket | | | | | |
| E1020 | Fabricate CPP Topsides | 12/01/2017 | 09/26/2018 | 300 | \$240,000 | | | | | | | | | | | | | F | abricate | CPP To | psides | | | | |
| E1030 | Fabricate CPP Jacket | 12/01/2017 | 08/07/2018 | 250 | \$104,000 | | | | | | | | | - | | | | Fabric | ate CPP | Jacket | | | | | |
| E1025 | Install LLE Equipment | 09/27/2018 | 11/05/2018 | 40 | \$32,000 | | | | | | | | | | | | - 4 | | Instal | I LLE Eq | uipment | | | | |
| Gas Platform | ▼ Drilling | 08/03/2018 | 11/10/2018 | 100 | \$80,000 | | | | | | | | | | | | - | | Drilling | | | | | | |
| F1000 | Drilling for First Gas Only | 08/03/2018 | 11/10/2018 | 100 | \$80,000 | | | | | | | | | | | | - | | K Drillin | ng for Fi | rst Gas O | nly | | | |
| Gas Platform | ▼ Installation | 06/19/2018 | 12/05/2018 | 170 | \$47,200 | | | | | | | | | | | | | | Install | ation | | | | | |
| G1000 | Install Drilling Platform Ja | 06/19/2018 | 07/08/2018 | 20 | \$8,000 | | | | | | | | | | | Ģ | O - 🗰 II | nstall D | rilling Pl | atform | Jacket | | | | |
| G1010 | Install Drilling Topsides | 07/09/2018 | 08/02/2018 | 25 | \$13,600 | | | | | | | | | | | - | | Install | Drilling | Topside | BS | | | | |
| G1020 | Install CPP Jacket | 08/08/2018 | 08/27/2018 | 20 | \$9,600 | | | | | | | | | | | | -0 | 🔣 Inst | all CPP | Jacket | | | | | |
| G1030 | Install CPP Topsides | 11/06/2018 | 12/05/2018 | 30 | \$16,000 | | | | | | | | | | | | | -0- | Ins 🕅 | tall CPF | Topsides | | | | |
| Gas Platform | ▼ HUC | 12/06/2018 | 04/04/2019 | 120 | \$40,000 | | | | | | | | | | | | | | - | HU | С | | | | |
| H1000 | Hook UP and Commission | 12/06/2018 | 04/04/2019 | 120 | \$40,000 | | | | | | | | | | | | | 냐 | 1 | | Hook UP a | and Cor | nmissionin | ig for Fi | irst Gas |

Offshore Gas Production Platform Project summarized from real projects 39 months duration, \$1.7 billion cost Developed in Primavera Risk Analysis[®] Simulated in Booz Allen Hamilton Polaris[®]



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Project-Specific Risks as Risk Drivers

| Risk Driv | ver E | ditor | | | | | \sim | Risk D |
|---------------|------------|-----------------------|---|-------------------------|--------------|---------------|-----------------------|-------------|
| Enabled 🗹 | UID | Risk Driver Name | | | | | Probability | Notes |
| • | 1 | Bids may be Abusiv | e leading to delayed approval | | | | 60% | |
| | 2 | Engineering may be | e complicated by using offshore design | firm | | | 40% | |
| ~ | 3 | Suppliers of installe | d equipment may be busy | | | | 30% | |
| | 4 | Fabrication yards m | ay experience different Productivity th | an planned | | | 55% | |
| | 5 | The subsea geologi | cal conditions may be different than ex | pected | | Probabilities | 45% | |
| | 6 | The organization ha | is other priority projects so personnel a | and funding may be unav | ailable | | 45% | |
| | 7 | Fabrication and inst | allation problems may be revealed dur | ring HUC | | | 40% | |
| | 9 | Megaproject may h | ave interdependency problems | | | | 10% | |
| 1 | 10 | Megaproject may h | ave coordination problems offshore so | urcing | | | 10% | |
| | 11 | Megaproject may h | ave excessive schedule pressure | | | | 10% | |
| | 12 | Installation may be | more complex than planned | | | | 60% | |
| ask | | | | | Parallel | Triangular - | Min:1.4 Likely:1.5 Ma | x:1.7 |
| 1000 - Appr | oval Pro | cess | | | | | | Cost Factor |
| 21010 - Detai | iled Engi | neering | | | | Triangular - | Min:1 Likely:1.1 Max: | 1.3 |
| 900 - Conce | pt Engin | eering | Activities | | | | | |
| 950 - FEED | | | offerstead by | | | | | |
| 1000 - Proc | urement | of LLE | affected by | | | | | |
| 1010 - Proci | urement | of Other Equipment | the selected | | | Duration a | ad Cast Im | nacto |
| 1000 - Fabri | cate Drill | ing Topsides | the selected | | \mathbf{N} | Duration a | iu cost ini | pacts |
| 1010 - Fabri | cate Drill | ing Jacket | systemic risk | | | | | |
| 1020 - Fabri | cate CPP | Topsider | | | | | | |
| 1025 - Insta | II LLE Eq | uipment | | | | | | |
| 1030 Fabrie | cate Cre | Jacket | | | \checkmark | T | | |

Here are 8 project-specific and 3 systemic risks assigned to activities Most risks are assigned to several activities defined as a "category" for ease of application. Some activities have several risks assigned The risks are specified by probability and impact, a distribution of multiplicative factors and are called "Risk Drivers." If they happen on an iteration a factor is chosen at random and multiplies the duration of all activities to which the risk is assigned

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USE CATEGORIES TO APPLY RISKS TO MULTIPLE ACTIVITIES



Use Categories to Enable Assigning Risks to Multiple Activities

| - | | | | | | |
|---|----------|--|-------|---------------|--|--|
| Name | | | Logic | Field | Test | Criteria |
| Approva | 1 | A | | Category | contains | Fabrication |
| Engineer | ring | | | | | |
| Procurer | ment | | | | | |
| Fabricati | on | | L | | | |
| Drilling | | | | | | |
| | | | | | | |
| | | | | | | |
| 7 Tasks | Filter A | Applied: Fabrication | | | | |
| Vame: | Filter / | Applied: Fabrication | 2 | | Displaying 1 of 30 1 | Fasks |
| V Tasks | Filter A | Applied: Fabrication | 2 | | Displaying 1 of 30 1 Task | īasks |
| Vame: UID | Filter A | Fabricate Drilling Topsides | | | Displaying 4 of 30 T Task | Tasks |
| Vame: UID E1000 E1010 | Filter / | Fabricate Drilling Topsides Fabricate Drilling Jacket | 2 | Seve | Displaying 1 of 30 T Task ral Filters are | created so a risk may be |
| Vame: UID E1000 E1020 | Filter A | Fabricate Drilling Topsides Fabricate Drilling Jacket Fabricate CPP Topsides | 2 | Seve | Displaying 1 of 30 T Task | rasks created so a risk may be |
| P Tasks Name: UID E1000 E1010 E1020 E1030 | Filter / | Fabricate Drilling Topsides Fabricate Drilling Jacket Fabricate CPP Topsides Fabricate CPP Jacket | | Seve assig | Displaying 1 of 30 T Task ral Filters are ned to multip | rasks created so a risk may be ole activities in one |



Add Project Specific Risks



Adding Project-Specific risks brings the P-80 to 7/15/20, 15+ months after the schedule date

The scheduled date is now only 2% likely



Adding 3 Systemic Risks





Three systemic risks often associated with large, complex projects:

- Interdependency
- Coordination
- Excessive schedule
 pressure

Adding these make the P-80 = 5/15/21 or about 25 + months late



Comparing Results with Uncertainty and Risks





PRIORITIZING RISKS FOR MANAGEMENT ACTION



Typical Risk Prioritization Method

- Typical tornado diagrams have limitations:
 - Report correlation coefficients, but management does not know how to turn these into actionable metrics
 - Correlation centers on the means of the distributions, but management cares about other targets, e.g., P-80
 - Usually report on activities, not risks, whereas management looks to mitigate risks
 - Even when they show correlation of risks with the finish date, the algorithm can show incorrect correlation leading to incorrect conclusions



Preferred Prioritization Method

| | Itera | tive Approa | ach to Prior | ritizing Risks | (Days Sa | aved at P-8 | 30) | |
|------------------------------------|-----------------|----------------------------|-------------------|---------------------|--------------------|---|--------------------|--|
| Risk # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Priority Level (Iteration #) | Abusive Bids | Offshore design firm | Suppliers Busy | Fab productivity | Geology unknown | Coordinati on during Installatio n | Problems at HUC | Resource s may go to other projects |
| 1 | Х | Х | Х | Х | Х | Х | Х | 1 |
| 2 | Х | Х | Х | 2 | Х | Х | Х | |
| 3 | Х | 3 | Х | | Х | Х | Х | |
| 4 | Х | | Х | | Х | Х | 4 | |
| 5 | Х | | 5 | | Х | Х | | |
| 6 | Х | | | | Х | 6 | | |
| 7 | 7 | | | | Х | | | |
| 8 | | | | | 8 | | | |



Iterative prioritization method requires many simulations to order the risks correctly @ P-80 in Days Saved

Risk Prioritization Results





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Risk Prioritization Table for Risk Mitigation Workshop

| | Risks Prioritized by their Contribution to P-80 Finish Date | |
|-----|--|-------|
| | | Days |
| UID | Name | Saved |
| 11 | Megaproject may have excessive schedule pressure | 133 |
| | The organization has other priority projects so personnel and funding may be | |
| 6 | unavailable | 129 |
| 9 | Megaproject may have interdependency problems | 117 |
| 2 | Engineering may be complicated by using offshore design firm | 77 |
| 10 | Megaproject may have coordination problems offshore sourcing | 42 |
| 4 | Fabrication yards may experience different Productivity than planned | 31 |
| 7 | Fabrication and installation problems may be revealed during HUC | 17 |
| 12 | Installation may be more complex than planned | 10 |
| 1 | Bids may be Abusive leading to delayed approval | 9 |
| 3 | Suppliers of installed equipment may be busy | 9 |
| 5 | The subsea geological conditions may be different than expected | 0 |
| | Days saved by Completely Mitigating the Risks | 574 |
| | Days Contributed to the Schedule Margin by Uncertainty | 198 |
| | Total Pre-Mitigated Schedule Contingency | 772 |



RISK MITIGATION ACTIONS AND RESULTS (SIMPLE EXAMPLE)



Mitigation Workshop

- Owner and Contractor meet separately with the same prioritized list of risks
- Propose their own risk mitigations with cost of the actions, owners of the actions and improvement in the risk parameters
- Mitigation must be new, not continued practices from before
- Joint Owner / Contractor meeting to agree
- Must commit to the mitigations to get credit



Risk Mitigation Workshop Forms

| | | | Sc | hedule Impa | act | (| Cost Impact | | |
|---------|---|-----------------------|--------------------------------|------------------------------------|----------------------------------|--------------------------------|---------------------------------|-------------------------------------|--|
| Risk ID | Risk Description: | Probability | Optimistic Impact Factor | Most Likely Impact Factor | Pessimisti c Impact Factor | Optimistic Impact Factor | Most Likely Impact Factor | Pessimis tic Impact Factor | Activities Affected |
| 26 b | Given the quantity of piping in the project, scope may be underestimated | 30% | 110% | 130% | 170% | 110% | 120% | 130% | Name Contains Piping |
| | Mitigations Proposed | | | | | | | | Cost Estimate, total all mitigations proposed |
| 26b.1 | | | | | | | | | \$20 million |
| 26b.2 | Fill out mit (ROM) for | tigation all actio | actions | propose proun ri | d, cost sk owne | ars | | | Responsible person/persons |
| 26b.3 | | | 115 US U 8 | 51000,11 | | .13, | | | Smith |
| 26b.4 | and param | leters at | ter mitig | gation | | | | | Jones |
| 26b.5 | | | | | | | | | |
| | | | 1 | Paramete | ers After Mi | tigation | | | |
| 26 b | Given the quantity of piping in the project, scope may be underestimated | 15% | 100% | 115% | 140% | | | | \bigcup |



Risk Mitigation Simple Example

- Probability reduced by half for each risk
- Duration impact ranges reduced mostly schedule risk mitigation
- No change for cost impact ranges
- Cost of mitigation actions range from \$10 million to \$40 million in Cash (resource) paid at front end
- Mitigation costs in this example total \$220 million



Schedule and Cost Risk Post-Mitigated





PROBABILISTIC BRANCHING FOR TEST FAILURE POSSIBILITY



Probabilistic Branch with Test Failure

- Projects have many tests. Each of these is done because the system may fail, with consequences
- Seldom does the schedule include recovery activities, but is usually "success oriented"
- There is a probability of failure with consequences of added activities:
 - Root Cause Analysis of the Failure
 - Determining what to do
 - Doing what is planned
 - Retesting



Failing the Test may lead to Multiple Activities that are Not In the Schedule

- If fail the test all of these activities are needed
- If pass the test none is needed
- These 4 activities constitute a probabilistic branch, since the possibility of doing them is probabilistic
- There is a probability that the instrument or system will not pass the test
 - This probability is often underestimated



Set up the Probabilistic Branch



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Using Booz Allen Hamilton Polaris®

Make the Probabilistic Branch Activities, Fix Calendars and Durations

| 🌮 Polaris - Or | ne Path Project Discrete Risks on all activities.polaris | | - | | Sec. 1 | - | Berki I | Rosard Int | | A | | | | | _ 0 X |
|----------------------------|--|------------|--------------------|--------------|--------------------------------|--------------|------------|------------|------------|-----------------|-------------|------------------|-----------------|------------------------|----------------------|
| File | 💌 🔁 📳 Export 💌 🍌 Run Simulatio | n Details. | 🔻 🚮 Hon | ie 📄 Risk Pr | ioritization | ∬ Scenario I | Modeling 👍 | Health | 🕗 Task Det | ails 📗 Cost Pha | ising | r: Standard 🛛 🔻 | | | 0 |
| Task Details: | 3 - New Task 3 X | UTD | Task | 1 | Controls | Start Date | End Date | Duration | Cost | Predecessors | H1, 2017 | H2, 2017 | H1, 2018 | H2, 2018 | H1, 2019 |
| | ncertainty Risks Budget Schedule | | 103K | | controls | Diant Date | End Dute | Durution | con | Tracessory | 01 02 03 04 | 05 06 07 08 09 1 | 0 11 12 01 02 0 | 3 04 05 06 07 08 09 10 | 11 12 01 02 03 04 05 |
| | | 88426 | ▼ One Path Project | | | 06/01/2017 | 03/27/2018 | 214 | \$0 | | | | | One Path Project | \$\$ Q Q |
| | Task Editor | 136330 | A1000 - START | | | 06/01/2017 | | 0 | \$0 | | | A1000 - START | | | |
| Task Name | New Task 3 | 136331 | A1010 - Design | 1 | | 06/01/2017 | 09/08/2017 | 100 | \$0 | 136330 | | | 1010 - Design 1 | | |
| Tusk Hulle. | | 136333 | A1020 - Build 1 | | | 09/09/2017 | 03/27/2018 | 200 | \$0 | 136331 | | 4 | | A1020 - Build 1 | |
| Unique ID: | 3 | 136333 | A1030 - Test 1 | | | 03/28/2018 | | 0 | \$0 | 136332 | | | | A1030 - Test 1 | |
| Start: | 03/28/2018 Finish: N/A | 2 | New Task 2 | | | 00/20/2010 | | 0 | \$0 | | | | | New Task 2 | |
| | | 1 | New Task 1 | | | 03/28/2018 | | 0 | \$0 | | | | | New Task 1 | |
| Duration: | 0 | 4 | New Task 4 | | | 03/28/2018 | | 0 | \$0 | | | | | New Task 4 | |
| Base Calend | ar: 7 Day 👻 | 3 | New Task 3 | | $\land \land \bigtriangledown$ | 03/28/2018 | | 0 | \$0 | | | | | 🔶 New Task 3 | |
| Constraint T | ype: 5 Day 7 Day | 136334 | A1040 - FINISH | | | 03/28/2018 | | 0 | \$0 | 136333 | | | | A1040 - FINISH | |
| Task Type: | Milestone | | | | | | | | | | | | | | |
| | 🕜 Add Subtask 🔵 Remove Task | | | | | | | | | | | | | | |
| Task: 88428 Start: 06/0 | Summary Task One Path Project 01/2017 | | | | | | | | | | | | | | |
| Finish: 03 | /27/2018 | | | | | | | | | | | | | | |

Activity A1030 Test 1 is the node from which the project either finishes or fails and goes down the branch



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Set the Test Failure Branch as Probabilistic

LLC

| | Task Editor |
|---|--|
| Task Name: | A1030 - Test 1 |
| Unique ID: | 136333 |
| Start: | 03/28/2018 Finish: N/A |
| Duration: | 0 |
| Base Calendar: | 7 Day |
| Constraint Type: | As Soon As Possible 👻 |
| Task Type: | Milestone |
| | 🙆 Add Subtask 🛛 🥌 Remove Task |
| | Summary Task |
| Task: 88426 - One | Path Project |
| Start: 06/01/20 | 117 |
| Start: 06/01/20 Finish: 03/27/2 | 017 2018 |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta | 017 2018 Predecessors 🚱 .020 - Build 1 art |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta | Predecessors (2) 0200 - Build 1 art |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta | Predecessors (2) 020 - Build 1 ort Successors (2) |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta Task: 136334 - A1 Type: Finish to Sta | Successors C Successors C 0400 - FINISH 1040 - FINISH 1040 - FINISH |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta Task: 136334 - A1 Type: Finish to Sta Task: 2 - Root Ca | Successors C Successors C 040 - FINISH art Probability: 60% use Analysis of Failure |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta Type: Finish to Sta Task: 136334 - A1 Type: Finish to Sta Task: 2 - Root Ca Type | Predecessors (2) 0.020 - Build 1 art Successors (2) 0.040 - FINISH mt Probability: 60% use Analysis of Failure Edit Successor |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta Type: Finish to Sta Task: 136334 - A1 Type: Finish to Sta Task: 2 - Root Ca Type Successo | Predecessors Predecessors Successors Successors Successors Successors Successors Successor Successor |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta Type: Finish to Sta Task: 136334 - A1 Type: Finish to Sta Task: 2 - Root Ca Type Successo Type: | Successors C Successors C 020 - Build 1 art Successors C 040 - FINISH art Probability: 60% use Analysis of Failure Edit Successor r task: 2 - Root Cause Analysis of Fail T Finish to Start T |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta Type: Finish to Sta Task: 136334 - A1 Type: Finish to Sta Task: 2 - Root Ca Type: Lag: | Successors C Successors C 020 - Build 1 art 040 - FINISH mt Probability: 60% use Analysis of Failure Edit Successor r task: 2 - Root Cause Analysis of Failv Finish to Start v 0 0 0 0 0 0 0 0 0 0 0 0 0 |
| Start: 06/01/20 Finish: 03/27/2 Task: 136332 - A1 Type: Finish to Sta Type: Finish to Sta Task: 136334 - A1 Type: Finish to Sta Task: 2 - Root Ca Type: Lag: ↓ Probal | Successors C Successors C 020 - Build 1 art 040 - FINISH art Probability: 60% use Analysis of Failure Edit Successor ir task: 2 - Root Cause Analysis of Faile Finish to Start 0 0 0 0 0 0 0 0 0 0 0 0 0 |

Make the branch 40% if it is 40% likely to Fail the Test first time

Give the New Activities Ranges of Impact, if they Happen

| Task Details: 2 - Root Cause Analysis of Failure X | UID | Task | Controls | Start Date | End Date | Duration | Cost | Predecessors | A H1, 2017 | H2, 2017 | H1, 2018 | H2, 2018 |
|--|--------|---------------------------|-------------|--------------|-----------|----------|------|--------------|-------------|-------------------|----------------|-------------------------|
| Incertainty Disks Budget Schedule | 010 | TUSK | Controls | Start Date | chu bute | Durution | con | Treaccessors | 01 02 03 04 | 05 06 07 08 09 10 | 11 12 01 02 03 | 04 05 06 07 08 09 |
| | 88426 | ▼ One Path Project | | 06/01/2017 0 | 3/27/2018 | 214 | \$0 | | | | | One Path Project |
| Duration Uncertainty | 136330 | A1000 - START | | 06/01/2017 | | 0 | \$0 | | | A1000 - START | | |
| Triangular - Min-20 Likely:40 May:50 | 136331 | A1010 - Design 1 | | 06/01/2017 0 | 9/08/2017 | 100 | \$0 | 136330 | | A101 | 9 - Design 1 | |
| | 130332 | A1020 - Build 1 | | 09/09/2017 | 3/27/2018 | 200 | \$0 | 136331 | | | | A1020 - Build 1 |
| | 1363.3 | A1030 - Test 1 | | 03/28/2018 | | 0 | \$0 | 136332 | | | C | A1030 - Test 1 |
| Planned 0 | 2 | Root Cause Analysis of Fa | iilur 🜔 🛆 💎 | 03/28/2018 | | 0 | \$0 | 136333 | | | C | 🔶 🗵 Root Cause Analysis |
| Uncertainty Type Triangular | 1 | Design the Fix | | 03/28/2018 | | 0 | \$0 | 2 | | | t | 🔶 🛐 Design the Fix |
| Min: 20 | 4 | Fix the Product | | 03/28/2018 | | 0 | \$0 | 1 | | | [| Fix the Product |
| 10 III | 3 | Retest the Product | | 03/28/2018 | | 0 | \$0 | 4 | | | C. | 🔶 🗵 Retest the Product |
| 40 | 136334 | A1040 - FINISH | | 03/28/2018 | | 0 | \$0 | 136333, 3 | | | ļ | 🄶 🔣 A1040 - FINISH |
| Max: bu | | | | | | | | | | | | |

> Highlight the new activities in turn and give them uncertainties:

- Root Cause Analysis 20d 40d 60d
- Design the Fix 10d 20d 40d
- Fix the Product 10d- 30d- 50d
- Retest the Product 20d 30d 50d



With the Probabilistic Branch in Place, Results may show Bi-modal Distribution



Probabilistic branch develops a shoulder at 60%

There can be more than one probabilistic outcome from a node. The probabilities need to sum to (40% + 60%) 100%.

Probabilistic branch can represent more planning than can be shown with a single probabilistic activity



Review

- Modern Methods of risk analysis
- Collecting risk data
- Introducing uncertainty to the model
- Introducing risks as Risk Drivers
- Risk drivers model correlation between activity durations
- Risks may be entered in series or in parallel
- Offshore gas production platform project
- Use Categories to apply risks to multiple activities
- Prioritizing risks for management action
- Risk mitigation actions and Results (simple example)
- Probabilistic branching for test failure possibility



Modern Methods of Schedule Risk Analysis using Monte Carlo Simulations

Presented to the 2017 Large Facilities Workshop Baton Rouge, LA

David T. Hulett, Ph.D., FAACE Hulett & Associates, LLC Los Angeles, CA

