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|---|--|-------------------|------------------------------|--|
|  OR-AS Operations Research Applications and Solutions | Case Name: Signalisation work Peru | Sector | Construction (Civil) | |
| | OR-AS Operations Research - Applications and Solutions www.or-as.be info@or-as.be | Baseline Schedule | Schedule with resources | |
| | | | Schedule with costs | |
| | | Risk Analysis | Random simulation | |
| Submitted by | Eder Vilca | | One of nine std. scenarios | |
| Date | March, 2024 | Project Control | User defined distributions | |
| File Name | Signalisation work peru.p2x | | Automatic tracking | |
| | | | Tracking based on user input | |

1. Project description

Project authenticity

Installation of signalization for road safety in Peru, consisting of both light signalization and road control systems.

2. Project properties

2.1. Baseline Schedule

| General | |
|----------------------------|--------------|
| # Activities | 66 |
| Planned Duration (PD) | 84 days* |
| Budget At Completion (BAC) | 201,312.14 € |
| Renewable Resources | 6 |
| Consumable Resources | - |

* standard eight-hour working days

| Network topology | |
|----------------------------|-----|
| Serial/Parallel (SP) | 57% |
| Activity Distribution (AD) | 52% |
| Length of Arcs (LA) | 0% |
| Topological Float (TF) | 43% |

2.2. Risk Analysis

Random simulation by ProTrack was performed using the default symmetric triangular risk distribution profiles.

| | Cost sensitivity | | |
|---------|------------------|-------------|----------|
| | avg [%] | std dev [%] | skew [-] |
| CRI-r | 3.8 | 0.1 | 3.9 |
| CRI-rho | 0.12 | 0.1 | -2.2 |
| CRI-tau | 3.92 | 0.3 | -2.0 |

| | Resource sensitivity | | |
|---------|----------------------|-------------|----------|
| | avg [%] | std dev [%] | skew [-] |
| CRI-r | N/A | N/A | N/A |
| CRI-rho | N/A | N/A | N/A |
| CRI-tau | N/A | N/A | N/A |

| | Time sensitivity | | |
|---------|------------------|-------------|----------|
| | avg [%] | std dev [%] | skew [-] |
| CI | 55.2 | 0.5 | -0.2 |
| SI | 9.2 | 0.2 | 2.0 |
| SSI | 1.9 | 0.1 | 7.8 |
| CRI-r | 2.2 | 0.1 | 8.0 |
| CRI-rho | 38.3 | 0.2 | -0.7 |
| CRI-tau | 77.0 | 0.4 | -1.2 |

2.3. Project Control

2.3.1. Simulated forecasting accuracy

The accuracy of time and cost forecasting methods has been evaluated based on Monte Carlo simulation runs using the risk profiles described in section “2.2. Risk Analysis”. Based on these risk profiles, the Mean Absolute Percentage Error (MAPE) and Mean Percentage Error (MPE) has been calculated to evaluate the expected accuracy of the time and cost predictions, EAC(t) and EAC, respectively.

| Simulated EAC(t) accuracy | | | Simulated EAC accuracy | | |
|---------------------------|----------|---------|------------------------|----------|---------|
| method - PF | MAPE [%] | MPE [%] | method (PF) | MAPE [%] | MPE [%] |
| PV - 1 | 4 | 0 | 1 | 0 | 0 |
| PV - SPI | 8 | 0 | CPI | 0 | 0 |
| PV - SCI | 8 | 0 | SPI | 5 | 0 |
| ED - 1 | 6 | 1 | SPI(t) | 243 | -221 |
| ED - SPI | 8 | 0 | SCI | 5 | 0 |
| ED - SCI | 8 | 0 | SCI(t) | 243 | -221 |
| ES - 1 | 9 | -4 | 0.8 CPI + 0.2 SPI | 2.0 | 0 |
| ES - SPI(t) | 245 | -242 | 0.8 CPI + 0.2 SPI(t) | 7.5 | 7 |
| ES - SCI(t) | 245 | -242 | | | |

According to the MAPE values¹ the best performance for time forecasting can be expected from the unweighted Earned Schedule method. For cost forecasting the unweighted and CPI-weighted methods should yield the best results.

2.3.2. Tracking description

Tracking authenticity

Manual tracking was performed over 28 tracking periods with a length of approximately one week. The Real Duration and Real Cost mentioned in section “2.3.3. Earned Value Management” are based on manual user input.

The tracking information obtained from the project owner and introduced in ProTrack includes actual activity start dates, durations and costs.

¹ The MAPE gives the best indication for the forecast accuracy (the lower the MAPE, the more accurate the method) since all deviations from the targeted real duration (real cost) are cumulated, whereas for the MPE underestimates can be compensated by overestimates and vice versa, possibly leading to an overly positive evaluation of a certain method. However, the MPE can provide useful information about the nature of the deviations, i.e. does the method rather underestimate or overestimate the real duration (real cost)?

2.3.3. Earned Value Management

2.3.3.1. Performance metrics

| | CV [€] | SV [€] | SV(t) [d] | CPI [-] | SPI [-] | SPI(t) [-] | p-factor [-] |
|---------|----------|----------|-----------|---------|---------|------------|--------------|
| avg | 11,824.6 | -4,774.5 | -0.1 | 1.2 | 1 | 1 | 0.7 |
| std dev | 10,952.4 | 39,902.5 | 14.2 | 0.1 | 0.5 | 0.6 | 0.3 |
| final | 26,495.9 | 40,589.4 | 11 | 1.15 | 1.25 | 1.18 | 1 |

2.3.3.2. Time forecasting

| | | | | | |
|----|-----------|---------------|-----------|-------|-----|
| PD | 84.0 days | Real Duration | 36.2 days | Early | 57% |
|----|-----------|---------------|-----------|-------|-----|

| EAC(t) | | | Real Accuracy | |
|-------------|---------|-------------|---------------|---------|
| method - PF | avg [d] | std dev [d] | MAPE [%] | MPE [%] |
| PV - 1 | 43.77 | 8.54 | 22.86 | -20.86 |
| PV - SPI | 61.23 | 49.47 | 79.13 | -69.05 |
| PV - SCI | 49.23 | 37.09 | 63.31 | -35.92 |
| ED - 1 | 43.56 | 12.03 | 25.79 | -20.26 |
| ED - SPI | 61.23 | 49.47 | 79.13 | -69.05 |
| ED - SCI | 53.62 | 38.20 | 62.15 | -48.04 |
| ES - 1 | 42.51 | 7.69 | 20.04 | -17.38 |
| ES - SPI(t) | 42.58 | 14.89 | 30.05 | -17.56 |
| ES - SCI(t) | 39.42 | 13.29 | 27.24 | -8.83 |

2.3.3.3. Cost forecasting

| | | | | | |
|-----|--------------|-----------|-------------|--------------|-----|
| BAC | 201,312.14 € | Real Cost | 174,816.3 € | Under Budget | 13% |
|-----|--------------|-----------|-------------|--------------|-----|

| EAC | | | Real Accuracy | |
|----------------------|------------|-------------|---------------|---------|
| method (PF) | avg [€] | std dev [€] | MAPE [%] | MPE [%] |
| 1 | 189,847.56 | 10952.39 | 8.39 | -8.39 |
| CPI | 163,772.75 | 15620.20 | 9.04 | 6.32 |
| SPI | 271,208.93 | 198190.39 | 63.60 | -55.14 |
| SPI(t) | 188,445.19 | 58944.94 | 19.85 | -7.80 |
| SCI | 228,510.20 | 146673.40 | 51.86 | -30.71 |
| SCI(t) | 162,914.73 | 47178.62 | 19.31 | 6.81 |
| 0.8 CPI + 0.2 SPI | 170,925.39 | 19647.71 | 8.04 | 2.23 |
| 0.8 CPI + 0.2 SPI(t) | 165,893.74 | 16867.4 | 8.24 | 5.10 |