Appendix D Illustrative example

In order to illustrate the use of the Hotelling's T^2 and SPE metrics for top-down project schedule control, we simulate the project network depicted in figure D1 [1, 2]. This project consists of 10 non-dummy activities, with the predefined baseline duration estimate ($\hat{d}_i | i \in 1..10$, in days) and the Budget At Completion ($\text{BAC}_i | i \in 1..10$, in euros) denoted respectively above and below the nodes in the network of figure D1. The project has a Planned Duration (PD) of 16 days and a BAC of €456. It should be noted that the calculations presented for this example may be subject to rounding errors. For the sake of readability, rounding to two digits has been performed in the matrix calculations presented in this appendix.

To illustrate the mechanisms presented in this paper, we define the state of activity level schedule control from the 10 fictitious project executions presented in table D1. For each of these simulated execution runs of the project, the activity durations ($d_i | i \in 1..10$), the real duration (RD) of the project and the K-S statistic are displayed. Given a level of significance $\eta = 0.001$ and a corresponding critical value $\text{K-S}_\eta = 0.65$ [3], we allow all 10 fictitious project executions to be included in the schedule control reference, since all K-S values are lower than this critical value $\text{K-S}_\eta = 0.65$.

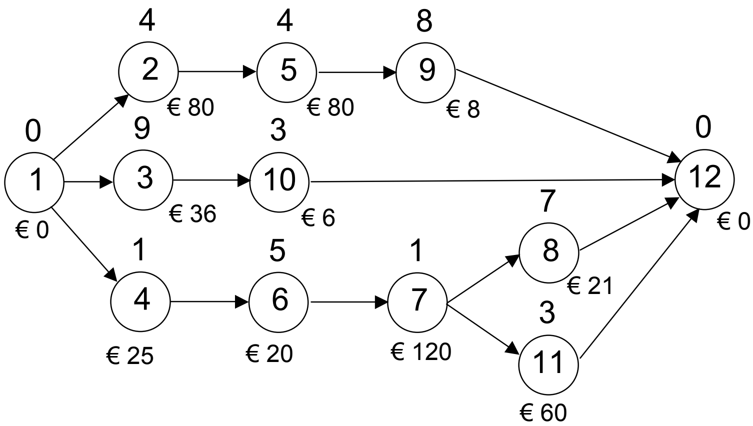

Figure D1: An illustrative project network (Source: [1])

Table D1: 10 fictitious project executions to represent the first phase of the Monte Carlo experiment

	Activity										RD	K-S
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**		
Run 1	3	8	1	5	4	1	9	6	2	4	15	0.18
Run 2	5	6	1	5	6	1	7	6	3	3	16	0.12
Run 3	4	7	1	4	5	1	6	7	2	3	15	0.22
Run 4	4	12	1	3	5	1	9	8	4	2	16	0.21
Run 5	3	11	1	3	4	1	8	10	2	4	16	0.19
Run 6	**5**	**8**	**1**	**3**	**5**	**1**	**6**	**9**	**3**	**3**	**17**	**0.16**
Run 7	3	6	1	4	6	1	7	7	2	4	15	0.10
Run 8	4	6	1	5	5	1	8	8	2	3	17	0.12
Run 9	5	9	1	3	4	1	7	8	3	2	16	0.12
Run 10	4	12	1	4	4	1	7	6	4	2	16	0.13

Table D2 displays the Planned Value (PV) of the project and the Earned Value (EV) along the project duration for each fictitious project execution. Each activity is assumed to follow a linear EV accrue. Hence, the EV for each individual activity starts at 0 at its actual start time and progresses linearly towards its Budget At Completion (BAC_i) when the activity is finished. The metrics designed for schedule control in the Earned Value and Earned Schedule methodology (SV, SPI, SV(t), SPI(t)) can all be calculated from the EV and PV time series displayed in this table. For more details regarding their calculations, the reader is referred to the detailed works of [4] and [5].

Table D2: The Earned Value (EV) and Planned Value (PV) along the project duration

		Actual Time (in days)																
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
PV		49	77	105	133	161	189	333	380	408	434	440	446	450	454	455	456	
	Run 1	56	92	128	154	180	320	358	396	417	439	443	446	450	454	456		
	Run 2	47	72	98	123	148	174	195	333	374	413	437	442	446	450	455	456	
	Run 3	50	79	108	138	167	196	341	388	392	416	441	446	450	455	456		
	Run 4	48	75	102	129	163	196	346	382	419	425	431	438	442	447	452	456	
EV	**Run 5**	55	90	125	160	195	345	366	388	410	431	438	445	451	454	455	456	
	Run 6	**46**	**70**	**95**	**119**	**144**	**179**	**330**	**385**	**411**	**437**	**444**	**448**	**452**	**453**	**454**	**455**	**456**
	Run 7	58	94	130	159	188	218	244	368	387	406	426	445	449	453	456		
	Run 8	51	81	111	141	167	193	332	374	412	436	440	443	447	450	454	455	456
	Run 9	45	70	95	120	145	296	359	423	431	437	443	449	453	454	455	456	
	Run 10	48	76	104	132	160	303	359	415	422	430	437	444	450	453	455	456	

In order to structure the matrix X to be used in a PCA decomposition, the measurements taken after each day need to be transformed to measurements equally spaced along a Percentage Complete (PC) axis. For the sake of the readability of this example and to keep the data in a presentable format, we will only use two metrics (SPI and SPI(t)) at four ($K = 4$) distinct PC instances of the project, resulting in eight variables that will be monitored. The transformed data can be found in table D3. The two bottom rows of table D3 present the sample mean and sample standard deviation for each of the columns. If the data of table D3 are normalized column-wise, using the sample estimates for the mean and standard deviation, they can be restructured into the matrix X in equation (D1). The matrix unfolding using $\mathrm{X}_{\kappa,j}$ with $\kappa \in \Big\{1, 2, 3, 4\Big\}$ and $j \in \Big\{\mathrm{SPI}, \mathrm{SPI(t)}\Big\}$ was introduced in section 3.2 of the paper.

Table D3: The SPI and SPI(t) for PC intervals after interpolation

PC	Periodic Measurements							
	20%		**40%**		**60%**		**80%**	
Metric	**SPI**	**SPI(t)**	**SPI**	**SPI(t)**	**SPI**	**SPI(t)**	**SPI**	**SPI(t)**
Run 1	1.197	1.273	1.127	1.133	1.502	1.145	1.068	1.074
Run 2	0.933	0.914	0.782	0.89	0.751	0.87	0.908	0.875
Run 3	1.031	1.041	1.036	1.023	1.03	1.017	1.022	1.029
Run 4	0.972	0.964	1.027	1.01	1.039	1.025	1.022	1.024
Run 5	1.168	1.23	1.206	1.219	1.532	1.208	1.151	1.109
Run 6	**0.901**	**0.875**	**0.946**	**0.94**	**0.974**	**0.975**	**1.004**	**1.012**
Run 7	1.214	1.298	1.175	1.203	0.789	0.925	0.962	0.967
Run 8	1.054	1.071	1.028	1.02	1.007	1.001	0.986	0.986
Run 9	0.905	0.88	1.065	0.945	1.467	1.089	1.082	1.09
Run 10	0.989	0.985	1.089	1.015	1.478	1.103	1.08	1.087
$\bar{\mathbf{x}}_{\kappa,j}$	1.036	1.053	1.048	1.04	1.157	1.036	1.028	1.025
$s_{\mathbf{x}_{\kappa,j}}$	0.119	0.161	0.121	0.111	0.306	0.102	0.07	0.071

The PCA in equation (D1) was performed in the statistical programming language R [6] using singular value decomposition (SVD). Both the matrix of scores T and the matrix of loadings P were obtained directly. This example handles only a restricted number of variables and its purpose is foremost to provide the reader with a hands-on illustration. Therefore, in order to be able to display our calculations in a presentable format, we retain only two ($k = 2$) principal components in the further analysis.

$$
\mathrm{X} = \begin{bmatrix}
1.4 & 1.4 & 0.7 & 0.8 & 1.1 & 1.1 & 0.6 & 0.7 \\
-0.9 & -0.9 & -2.2 & -1.4 & -1.3 & -1.6 & -1.7 & -2.1 \\
0 & -0.1 & -0.1 & -0.2 & -0.4 & -0.2 & -0.1 & 0.1 \\
-0.5 & -0.6 & -0.2 & -0.3 & -0.4 & -0.1 & -0.1 & 0 \\
1.1 & 1.1 & 1.3 & 1.6 & 1.2 & 1.7 & 1.8 & 1.2 \\
\mathbf{-1.1} & \mathbf{-1.1} & \mathbf{-0.8} & \mathbf{-0.9} & \mathbf{-0.6} & \mathbf{-0.6} & \mathbf{-0.3} & \mathbf{-0.2} \\
1.5 & 1.5 & 1 & 1.5 & -1.2 & -1.1 & -0.9 & -0.8 \\
0.2 & 0.1 & -0.2 & -0.2 & -0.5 & -0.3 & -0.6 & -0.5 \\
-1.1 & -1.1 & 0.1 & -0.9 & 1 & 0.5 & 0.8 & 0.9 \\
-0.4 & -0.4 & 0.3 & -0.2 & 1 & 0.7 & 0.7 & 0.9
\end{bmatrix}
$$

$$
= \begin{bmatrix}
-2.7 & -0.6 & -0.8 & -0.2 & -0.2 & 0.1 & 0 & 0.1 \\
4.5 & -0.5 & -0.9 & 0.2 & 0.2 & 0 & 0 & -0.3 \\
0.4 & -0.1 & 0.2 & 0 & -0.3 & 0.1 & 0.1 & 0 \\
0.7 & 0.5 & 0.3 & 0.1 & -0.1 & -0.2 & 0 & 0 \\
-4.1 & 0 & 0 & 0.6 & -0.1 & 0.1 & 0.1 & 0.3 \\
\mathbf{2} & \mathbf{1} & 0.3 & 0.1 & 0 & 0 & 0 & -0.1 \\
-0.4 & -3.5 & 0.5 & 0 & 0.1 & 0.2 & -0.1 & -0.2 \\
0.8 & -0.7 & -0.2 & -0.1 & -0.2 & -0.2 & 0 & -0.1 \\
-0.2 & 2.5 & 0.3 & -0.4 & 0.2 & 0 & 0.2 & 0.2 \\
-1 & 1.5 & 0.1 & -0.3 & 0.1 & 0 & 0 & 0.2
\end{bmatrix}
\times
\begin{bmatrix}
-0.3 & -0.5 & -0.3 & -0.1 & -0.3 & 0.1 & 0.3 & 0.6 \\
-0.3 & -0.5 & -0.3 & -0.1 & -0.1 & 0.3 & 0 & -0.7 \\
-0.4 & -0.1 & 0.6 & -0.4 & 0.2 & -0.4 & 0.3 & -0.1 \\
-0.4 & -0.4 & 0.2 & 0.5 & 0.3 & 0 & -0.6 & 0.2 \\
-0.3 & 0.4 & -0.4 & -0.4 & 0.6 & 0.1 & -0.1 & 0.2 \\
-0.4 & 0.3 & -0.3 & 0.3 & -0.4 & -0.7 & -0.1 & -0.1 \\
-0.4 & 0.3 & 0.1 & 0.5 & 0.1 & 0.4 & 0.6 & 0 \\
-0.4 & 0.3 & 0.3 & -0.3 & -0.5 & 0.4 & -0.4 & 0.1
\end{bmatrix}^{T}
= \mathrm{TP}^{T} \tag{D1}
$$

Equation (D2) presents the calculations needed to derive the T^2 and SPE value for the sixth fictitious project execution presented (and displayed in bold) in table D1. If this is done for all the fictitious executions in the schedule control reference, the values presented in table D8 are found. For execution run 6, the T^2 and SPE values are 1.2 and 0.4 respectively.

$$
\hat{\mathbf{x}} = \mathbf{t}\mathrm{P}^{\mathrm{T}} = \begin{bmatrix} 2 & 1 \end{bmatrix} \times
\begin{bmatrix}
-0.3 & -0.5 \\
-0.3 & -0.5 \\
-0.4 & -0.1 \\
-0.4 & -0.4 \\
-0.3 & 0.4 \\
-0.4 & 0.3 \\
-0.4 & 0.3 \\
-0.4 & 0.3
\end{bmatrix}^{T}
= \begin{bmatrix} \mathbf{-1.1} & \mathbf{-1.1} & \mathbf{-0.9} & \mathbf{-1.2} & \mathbf{-0.2} & \mathbf{-0.5} & \mathbf{-0.5} & \mathbf{-0.5} \end{bmatrix}
$$

$$
\begin{aligned}
T^2 &= \sum_{i=1}^{k=2} \left(\frac{\begin{bmatrix} 2 & 1 \end{bmatrix}_i}{\begin{bmatrix} 2.3 & 1.5 \end{bmatrix}_i} \right)^2 = 1.2 \\
\implies SPE &= \|\mathbf{e}\|^2 = \|\mathbf{x} - \hat{\mathbf{x}}\|^2 \\
&= \left\| \mathbf{0} \quad \mathbf{0} \quad \mathbf{0.1} \quad \mathbf{0.3} \quad \mathbf{-0.4} \quad \mathbf{-0.1} \quad \mathbf{0.2} \quad \mathbf{0.3} \right\|^2 \\
&= 0.4
\end{aligned} \tag{D2}
$$

Figures D2 and D3 present the histograms for the calculated values of respectively the T^2 and the SPE metric. These histograms (or alternatively, the empirical cumulative distribution functions) allow us to derive the tolerance limit by using the α^{th} quantiles. In the literature on batch process control, the tolerance limits are often derived from theoretical distribution functions (see Appendix C). We present the scaled F distribution and weighted Chi-squared distribution along with the histograms of respectively the T^2 and SPE schedule control metric. We have chosen not to incorporate these theoretical tolerance limits in our approach, since we do not want to impose restrictions with respect to the multivariate normality of $\mathbf{x}$ onto our project control procedure.

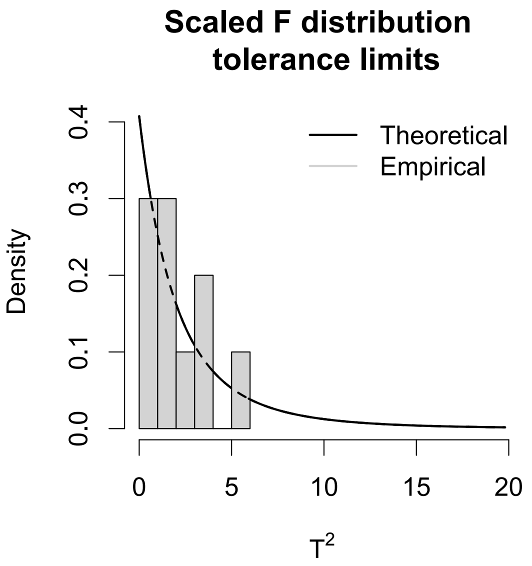

Figure D2: Finding tolerance limits for the T^2 schedule control metric

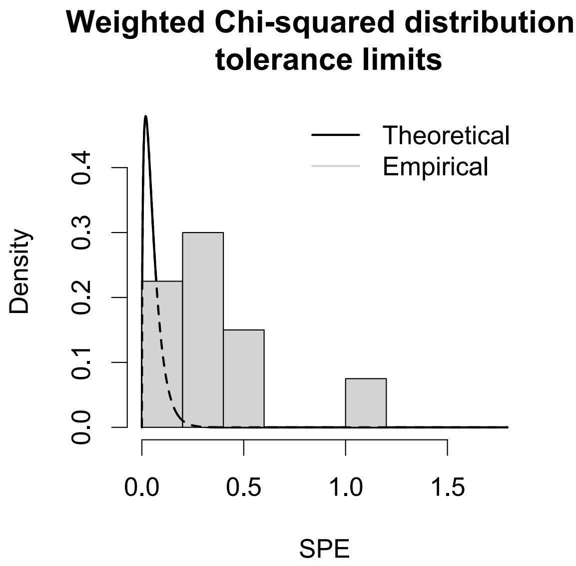

Figure D3: Finding tolerance limits for the SPE schedule control metric

Figure D3 shows how the sample of observed SPE values is not likely to have come from the theoretically predicted weighted Chi-squared distribution. The proposed empirical tolerance limits are also presented in table D8, with $\alpha = 0.95$. The theoretical tolerances are included between brackets for the sake of completeness.

Table D4: T^2 and SPE for the control reference

	Fictitious project executions										Tolerance limits	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	$\alpha = 0.95$	
T^2	1.54	3.94	0.03	0.2	3.18	**1.2**	5.47	0.34	2.79	1.19	4.78	(11.03)*
SPE	1.08	0.59	0.16	0.24	0.37	**0.4**	0.58	0.1	0.21	0.06	0.85	(0.98)**

* α^{th} quantile from a weighted (2.457) F distribution, d.f. 2 and 8

** α^{th} quantile from a weighted (0.125) Chi-squared distribution, d.f. 3.033

In the remainder of this section, we will introduce an additional project execution that has a value for the K-S statistic that is higher than the critical value. In other words, the new project execution does not conform to our specified state of schedule control. We will illustrate how the T^2 and the SPE metric can be used to detect this at the highest level of the WBS.

D.1 Post-project schedule control inference

Table D5 presents the activity durations for an additional fictitious project execution. Note that the K-S statistic for this fictitious execution (0.9) is much higher than the critical value established in our schedule control reference (0.65). The measurements of the project EV after each day are given in table D6. In order to be used as a new vector of observations $\mathbf{x}_{new}$, the SPI and SPI(t) values have to be calculated and transformed to the PC-dependent format. This results in the values found in table D7. The two bottom rows of table D7 are copied from the schedule control reference data of table D3. We re-use these sample estimates to normalize the data from the additional fictitious project execution that is under study. This results in the $\mathbf{x}_{new}$ vector in equation (D3). Using $\mathbf{x}_{new}$ and the matrix of loadings P (with $k = 2$), we can calculate the scores for this new vector of observations and its corresponding T^2 and SPE values.

$$\left.\begin{aligned}
\mathbf{x}_{new} &= \begin{bmatrix} -1.7 & -1.6 & 0 & -1.1 & 1 & 0.6 & -1.1 & -1 \end{bmatrix} \\
\mathbf{t}_{new} = \mathbf{x}_{new}\mathrm{P} &= \begin{bmatrix} -1.7 & -1.6 & 0 & -1.1 & 1 & 0.6 & -1.1 & -1 \end{bmatrix} \times \begin{bmatrix} -0.3 & -0.5 \\ -0.3 & -0.5 \\ -0.4 & -0.1 \\ -0.4 & -0.4 \\ -0.3 & 0.4 \\ -0.4 & 0.3 \\ -0.4 & 0.3 \\ -0.4 & 0.3 \end{bmatrix} \\
&= \begin{bmatrix} 1.7 & 2 \end{bmatrix} \\
\hat{\mathbf{x}}_{new} = \mathbf{t}_{new}\mathrm{P}^T &= \begin{bmatrix} 1.7 & 2 \end{bmatrix} \times \begin{bmatrix} -0.3 & -0.5 \\ -0.3 & -0.5 \\ -0.4 & -0.1 \\ -0.4 & -0.4 \\ -0.3 & 0.4 \\ -0.4 & 0.3 \\ -0.4 & 0.3 \\ -0.4 & 0.3 \end{bmatrix}^T \\
&= \begin{bmatrix} -1.5 & -1.5 & -0.9 & -1.5 & 0.3 & -0.1 & -0.1 & -0.1 \end{bmatrix}
\end{aligned}\right\} \Longrightarrow \begin{aligned} T^2_{new} &= 2.3 \\ SPE_{new} &= 3.8 \end{aligned} \tag{D3}$$

Table D5: An additional out-of-control fictitious project execution

	Activity										RD	K-S
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**		
Project Run	5	15	2	5	3	1	5	11	2	3	21	0.9

Table D6: The Earned Value (EV) along the project duration (in days) for the additional fictitious execution

	Actual Time (in days)																				
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
EV	31	62	87	112	137	275	318	361	403	426	433	436	439	443	446	449	453	454	455	455	456

Table D7: The SPI and SPI(t) at PC for the additional fictitious execution

	Periodic Measurements							
PC	**20%**		**40%**		**60%**		**80%**	
Metric	**SPI**	**SPI(t)**	**SPI**	**SPI(t)**	**SPI**	**SPI(t)**	**SPI**	**SPI(t)**
Value	0.83	0.789	1.05	0.918	1.449	1.096	0.953	0.952
$\bar{\mathbf{x}}_{\kappa,j}$	1.036	1.053	1.048	1.04	1.157	1.036	1.028	1.025
$s_{\mathbf{x}_{\kappa,j}}$	0.119	0.161	0.121	0.111	0.306	0.102	0.07	0.071

The values calculated in equation (D3) for the T^2 and SPE metric of the additional fictitious execution, T^2_{new} and SPE_{new}, are 2.3 and 3.8 respectively. Only the value calculated for the SPE metric exceeds the $\alpha = 0.95$ tolerance limit. For this illustrative example, after completion of the project, we can correctly deduce from the measured SPE that the underlying activity level performance does not conform to the pre-defined state of schedule control.

D.2 Dynamic schedule control inference

We now investigate whether this conclusion could have been drawn when the project was not yet fully completed (PC=0.6). The vector of observations $\mathbf{x}_{new,\kappa}$ has 1/4 of its values missing at that point ($\kappa = 3$), as illustrated at the top of equation (D4). For this dynamic monitoring of project performance, we use the estimation procedure outlined in section 4.2. Conditional

Mean Replacement (CMR) provides us with an estimate for the scores, from which the T^2 and SPE values can be derived.

It is important to note that these values for the T^2 and the SPE metrics cannot be referenced directly to the schedule control reference values shown in figure D2 and D3. Instead, we need to calculate a reference for the estimated T^2 and SPE, handling the 10 fictitious project executions from the matrix X as if they would also have the same missing measurements. This reference (at $\kappa = 3$) is presented in table **??**. The T^2 and SPE metrics of the reference set at $\kappa = 3$ have a value of 4.87 and 0.86 respectively.

Table D8: T^2 and SPE for the control reference at $\kappa = 3$

	Fictitious project executions										Tolerance limits	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	$\alpha = 0.95$	
T^2	1.86	3.51	0.07	0.2	3.38	1.21	6	0.18	2.35	1.14	4.87	(11.03)*
SPE	1.4	0.58	0.21	0.24	0.46	0.54	0.73	0.12	0.26	0.06	0.86	(1.24)**

* α^{th} quantile from a weighted (2.457) F distribution, d.f. 2 and 8

** α^{th} quantile from a weighted (0.125) Chi-squared distribution, d.f. 3.033

In equation (D4), the values for the T^2 and the SPE metric for the additional fictitious project execution at $\kappa = 3$, $T^2_{new,\kappa=3}$ and $SPE_{new,\kappa=3}$, are calculated. Based on these values (4 and 6.5, respectively), we can once more conclude that the SPE metric allows a correct inference to be made of the activity level performance, even when the project is only 60% completed.

$$\mathbf{x}_{new,\kappa} = \begin{bmatrix} -1.7 & -1.6 & 0 & -1.1 & 1 & 0.6 & - & - \end{bmatrix}$$

$$\Longrightarrow \left.\begin{aligned}
&\mathbf{x}^{*} = \begin{bmatrix} -1.7 & -1.6 & 0 & -1.1 & 1 & 0.6 \end{bmatrix} \\
&\mathrm{P} = \begin{bmatrix} \mathrm{P}^{*} = \begin{bmatrix} -0.3 & -0.5 \\ -0.3 & -0.5 \\ -0.4 & -0.1 \\ -0.4 & -0.4 \\ -0.3 & 0.4 \\ -0.4 & 0.3 \end{bmatrix} \\ \mathrm{P}^{\#} = \begin{bmatrix} -0.4 & 0.3 \\ -0.4 & 0.3 \end{bmatrix} \end{bmatrix} \\
&\Theta = \frac{1}{n-1}\mathrm{T}^{T}\mathrm{T} = \begin{bmatrix} s^2_{\mathbf{t}_1} & 0 \\ 0 & s^2_{\mathbf{t}_2} \end{bmatrix} = \begin{bmatrix} 5.3 \\ 2.2 \end{bmatrix} \\
&\mathrm{S} = \begin{bmatrix} \mathrm{S}_{11} & \mathrm{S}_{12} \\ \mathrm{S}_{21} & \mathrm{S}_{22} \end{bmatrix} \Longrightarrow
\begin{aligned}
\mathrm{S}_{21} &= \begin{bmatrix} 0.3 & 0.3 \\ 0.3 & 0.3 \\ 0.8 & 0.8 \\ 0.6 & 0.6 \\ 0.9 & 0.9 \\ 1 & 1 \end{bmatrix} \\
\mathrm{S}_{22} &= \begin{bmatrix} 1 & 1 & 0.7 & 1.1 & 0 & 0.3 \\ 1 & 1 & 0.7 & 1.1 & 0 & 0.3 \\ 0.7 & 0.7 & 0.9 & 0.9 & 0.5 & 0.8 \\ 1.1 & 1.1 & 0.9 & 1.2 & 0.3 & 0.6 \\ 0 & 0 & 0.5 & 0.3 & 0.8 & 0.9 \\ 0.3 & 0.3 & 0.8 & 0.6 & 0.9 & 1 \end{bmatrix}
\end{aligned}
\end{aligned}\right\} \Longrightarrow
\begin{aligned}
\hat{\boldsymbol{\tau}} &= \mathbf{x}^{*}\mathrm{S}_{22}^{-1}\mathrm{S}_{21}\mathrm{P}^{\#} + \mathbf{x}^{*}\mathrm{P}^{*} \\
&= \begin{bmatrix} 0.4 & 0.3 \end{bmatrix} \\
\hat{\mathbf{x}^{*}} &= \hat{\boldsymbol{\tau}}\mathrm{P}^{*T} \\
&= \begin{bmatrix} -1.6 & -1.6 & -0.5 & -1.4 & 1.1 & 0.7 & 0.7 & 0.7 \end{bmatrix} \\
T^2_{new,\kappa=3} &= 4 \\
SPE_{new,\kappa=3} &= \|\mathbf{x}^{*} - \hat{\mathbf{x}^{*}}\|^2 \\
&= \left\| \begin{bmatrix} -0.1 & 0 & 0.5 & 0.3 & -0.1 & -0.1 & -1.8 & -1.7 \end{bmatrix} \right\|^2 \\
&= 6.5
\end{aligned} \tag{D4}$$

D.3 Using the T^2 and SPE metrics in practice

Before the execution of a project begins, the project manager can construct a schedule control reference by using Monte Carlo simulations. During the project execution, T^2 and SPE metrics can be calculated and compared to the threshold values at distinct time intervals.

In order to construct a schedule control reference, the project manager needs information on the project network of the project and estimates on the activity durations and costs. Monte Carlo simulations are then executed in order to implement uncertainty (in terms of variation and risk) experienced at the activity level. The schedule control reference matrix X will consist of those simulated project executions for which the sample of activity durations is likely to have been drawn from the empirical distribution applied on the activity durations. Subsequently, for each review period tolerance limits can be calculated based on this reference matrix.

During the project execution, the project manager is provided with EVM/ES performance measures on a regular basis. When these measures are transformed to the same PC-dependent format as the schedule control reference matrix, the T^2 and SPE metrics can be calculated and compared with this reference.

When the calculated metrics exceed the tolerance limit, the project manager receives a warning signal which indicates that the actual project execution does not conform to the defined state of schedule control. He/she can then drill down the WBS to investigate which activity or activities are problematic and take corrective action.

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