



Cost and Time Performance Analysis Using the Earned Value Concept in the Construction of the Integrated Lecture Building at the State Polytechnic of Shipbuilding Surabaya

Victor Fajar Bahari¹, Muhammad Alvan Rizki¹

¹Civil Engineering Study Program, Muhammadiyah University of Sidoarjo, Indonesia

*Corresponding Author: Muhammad Alvan Rizki

Email: alvanrizki@umsida.ac.id



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Abstract

Time and cost control is an important aspect in the success of construction projects, especially in large-scale projects such as the construction of the Integrated Lecture Building (GKT) of Surabaya State Polytechnic of Shipping. This research aims to analyze the time and cost performance of the project using the earned value concept. With this method, measurement and evaluation of project performance can be done quantitatively based on earned value data. The results of the analysis show that from the evaluation results in the 35th week, the value of ACWP is Rp. 47,741,219,980.93, the BCWP value is Rp. 47,874,478,839.55, and the BCWS value is Rp. 47,721,477,927.80. Based on the ACWP, BCWP, and BCWS values, the Cost Variance (CV) value is Rp. 133,258,858.63 and the Schedule Variance (SV) is Rp. 153,00,911.76. This figure indicates that the costs incurred are more efficient and the implementation time is faster than planned. The values of CPI and SPI equal to 1.00 indicate good cost performance within budget as well as good schedule performance with the schedule on time against the plan. The estimated cost of ETC is Rp. 1,476,532,576.73 and EAC is Rp. 49,217,752,557.66. The estimated time of ETS is Rp. 1.99 weeks and EAS is 36.99 weeks. With the application of this method, deviations from schedule and budget can be identified early so that decision making can be done appropriately to return the project to the predetermined schedule.

Introduction

The implementation of construction projects plays a crucial role in the development of educational infrastructure, particularly within higher education institutions (Xianhe, 2024; Sandanayake et al., 2022; Ruso et al., 2017). The construction project of the Integrated Lecture Building at the State Polytechnic of Shipbuilding Surabaya is a strategic initiative aimed at enhancing the quality of the teaching and learning process. This integrated lecture building is expected to provide facilities that support the academic and practical needs of students, especially in the field of shipbuilding, which requires high-tech equipment and specialized laboratories (Borysenko et al., 2025; Stevens, 2024).

In a project execution process, there are three essential parameters for project stakeholders: the allocated cost or budget, schedule, and quality that must be met (Pandjaitan & Zuhdy, 2023; Dugbarty & Kehinde, 2023). These three parameters are commonly referred to as the “triple constraint” and are interrelated, meaning that improvements in project performance

are generally accompanied by improvements in quality (Pramesthi & Chaullah, 2021). In construction projects, cost and time deviations often occur; therefore, a control mechanism is required to monitor and accurately reflect the project's condition (Arifin et al., 2023; Akpe et al., 2024).

One of the methods for assessing project performance is the Earned Value concept (Yuliana et al., 2019; Choiriyahet al., 2024; Proboretno et al., 2025). This method enables early detection of potential cost overruns or delays that may occur during project execution, allowing stakeholders to anticipate and take corrective actions to ensure project completion on time and within the remaining budget (Li, 2023). The Earned Value Method was initially developed in the late 20th century within the manufacturing industry and subsequently experienced significant growth, becoming widely adopted in various construction projects around the year 2000 in the United States. At that time, the U.S. government mandated the use of this method for all government-funded or publicly financed projects (Sugiyanto & Gondokusumo, 2020; Glavan et al., 2024; Alwan et al., 2024).

Fundamentally, the process of controlling project time and cost aims to ensure optimal performance at each stage of implementation, in accordance with the project planning guidelines (Popoola et al., 2024; Latilo et al., 2024; Al Wahid et al., 2024). A form of project progress reporting is essential so that work productivity relative to the planned schedule and cost can be recorded objectively, documented in detail, and accounted for by each project stakeholder (Ayni et al., 2019; Yilmaz et al., 2025).

Project time or schedule control is a process of monitoring the status of project activities to determine the project's progress. In contrast, project cost control is the process of monitoring the cost status during project implementation (Sri Mahapatni et al., 2022; Pal et al., 2024; Kamila & Marzuq., 2024). The main benefit of these two processes is that they provide a means to identify cost or schedule deviations from the original plan, thereby enabling the implementation of appropriate and preventive measures to minimize potential risks (Soetjipto et al., 2024).

Methods

This study employed a case study approach on the construction project of the Integrated Lecture Building at the State Polytechnic of Shipbuilding Surabaya. At this stage, data collection and problem analysis were conducted using the Earned Value concept applied during project implementation. The data collected included the following: 1) Work Plan and Project Implementation Requirements (RKS); 2) Bill of Quantity (BOQ) for the construction of the Integrated Lecture Building at the State Polytechnic of Shipbuilding Surabaya; 3) Project Time Schedule (S-Curve) for the construction of the Integrated Lecture Building; 4) Project design drawings for the Integrated Lecture Building; 5) Weekly progress reports of the construction project

Data Analysis

Several indicators were used to analyze project performance by determining the values of Actual Cost, Earned Value, Planned Value, Cost Variance, Schedule Variance, Cost Performance Index, Schedule Performance Index, Estimate to Complete, Estimate at Completion, Estimate Temporary Schedule, and Estimate All Schedule (Pribadi & Abduh, 2022).

Budget Cost of Work Scheduled (BCWS) or Planned Value (PV)

BCWS refers to the planned budget allocated for completing a task within a specified duration. It can be calculated using Equation 1:

$$\text{BCWS} = \text{Planned \% of work progress} \times \text{BAC} \quad (1)$$

Budgeted Cost of Work Performed (BCWP) or Earned Value (EV)

BCWP represents the actual value of the work performed up to a certain point. It can be determined using Equation 2:

$$\text{BCWP} = \text{BCWP} = \text{\% of completed work} \times \text{BAC} \quad (2)$$

Actual Cost of Work Performed (ACWP) atau Actual Cost (AC)

ACWP is the actual cost incurred for the work that has been completed. It can be calculated using Equation 3:

$$\text{ACWP} = \text{Direct costs} + \text{Indirect costs} \quad (3)$$

Cost Variance (CV)

Cost variance is the difference between the earned value (BCWP) and the actual cost incurred (ACWP). CV is calculated using Equation 4:

$$\text{CV} = \text{BCWP} - \text{ACWP} \quad (4)$$

Schedule Variance (SV)

Schedule variance is the difference between the earned value (BCWP) and the planned value (BCWS) at a given time. It is calculated using Equation 5:

$$\text{SV} = \text{BCWP} - \text{BCWS} \quad (5)$$

Cost Performance Index (CPI)

CPI is a ratio that measures the cost efficiency of the project by comparing the earned value to the actual cost incurred. It is determined using Equation 6:

$$\text{CPI} = \text{BCWP} / \text{ACWP} \quad (6)$$

Schedule Performance Index (SPI)

SPI is a ratio that measures schedule efficiency by comparing the earned value to the planned value. It is calculated using Equation 7:

$$\text{SPI} = \text{BCWP} / \text{BCWS} \quad (7)$$

Estimate to Complete (ETC)

ETC is an estimate of the remaining cost required for the remaining work or work that has not been completed based on the project cost performance at the time of the evaluation with the assumption that the project performance will remain (constant) until the end of the project. To get the ETC value, you can use equation 8:

$$\text{ETC} = (\text{BAC} - \text{BCWP}) / \text{CPI} \quad (8)$$

Estimate at Completion (EAC)

EAC is an estimate of the total cost that will be required to complete all project work activities based on the project cost performance at the time of the evaluation with the assumption that the project performance will remain (constant) until the end of the project. To get the EAC value, it is calculated using equation 9:

$$\text{EAC} = \text{ACWP} + \text{ETC} \quad (9)$$

Estimate Temporary Schedule (ETS)

ETS is an estimate of the time required to complete the remaining work or work that has not been completed based on the performance of the project schedule at the time of the evaluation with the assumption that the project performance will remain (constant) until the end of the project. To get the ETS value, it can be calculated using equation 10:

$$\text{ETS} = \text{Remaining planned project time} / \text{SPI} \quad (10)$$

Estimate All Schedule (EAS)

EAS is an estimate of the total time it will take to complete all project work activities based on the performance of the project schedule at the time of the evaluation with the assumption that the project performance will remain (constant) until the end of the project. To get the EAS value, it is determined using equation 11:

$$\text{EAS} = \text{Time already spent} + \text{ETS} \quad (11)$$

Results and Discussion

The calculation of Budget Cost of works Scheduled (BCWS) or Planed Value (PV) in week 23 to week 37 can be seen in Table 1.

Table 1. BCWS calculation results

Week	Cumulative Plan Weight (%)	BAC (Rp)	BCWS (Rp)
23	45,57%	49.355.132.824,28	22.491.134.028,02
24	49,65%		24.504.823.447,26
25	53,99%		26.646.836.211,83
26	58,33%		28.788.848.976,40
27	64,22%		31.695.866.299,75
28	66,44%		32.791.550.248,45
29	71,48%		35.279.048.942,80
30	76,39%		37.702.385.964,47
31	81,01%		39.982.593.100,95
32	85,53%		42.213.445.104,61
33	89,59%		44.217.263.497,27
34	93,40%		46.097.694.057,88
35	96,69%		47.721.477.927,80
36	99,30%		49.009.646.894,51
37	100%		49.355.132.824,28

BCWS calculations can use equation (1). The following example of calculating the BCWS or Planed Value value obtained in week 35 is as follows:

$$\begin{aligned} \text{BCWS} &= \% \text{ Progress of work planned} \times \text{BAC} \\ &= 96,69\% \times \text{Rp. } 49.355.132.824,28 \\ &= \text{Rp. } 47.721.477.927,80 \end{aligned}$$

While the cumulative plan weight value of BCWS is calculated based on the plan progress on the S curve in week 37 of Rp. 49.355.132.824,28

In the calculation of Budgeted Cost of Work Performed (BCWP) or Earned Value (EV) in week 23 to week 35 in full can be seen in Table 2.

Table 2. Results of BCWP Calculation

Week	Cumulative Plan Weight (%)	BAC (Rp)	BCWP (Rp)
23	46,00%	49.355.132.824,28	22.703.361.099,17
24	50,00%		24.677.566.412,14
25	54,00%		26.651.771.725,11
26	58,00%		28.625.977.038,08
27	64,00%		31.587.285.007,54
28	66,00%		32.574.387.664,02
29	71,00%		35.042.144.305,24
30	76,00%		37.509.900.946,45
31	81,00%		39.977.657.587,67
32	86,00%		42.445.414.228,88
33	90,00%		44.419.619.541,85
34	93,00%		45.900.273.526,58
35	97,00%		47.874.478.839,55
36	Belum		-
37	Belum		-

The calculation of the BCWP value can use equation (2). The following example of calculating the BCWP value in week 35 is as follows:

BCWP = % Progress of work that has been completed x BAC

$$= 97,00\% \times \text{Rp. } 49.355.132.824,28$$

$$= \text{Rp. } 47.874.478.839,55$$

The calculation of Actual Cost in week 23 to week 35 consists of all project expenditures for a certain duration of time. These expenses consist of wages, materials, tools, and other costs incurred for project activities can be seen in equation (3). The results of project cost expenditures can be seen in Table 3.

Table 3. Actual Cost from Week 23 to Week 35

Week	Weekly Expenses (Rp)	Cumulative Expenditure Cost (Rp)
23	1.979.140.826,25	22.505.940.567,87
24	2.013.689.419,23	24.519.629.987,10
25	2.142.012.764,57	26.661.642.751,68
26	2.142.012.764,57	28.803.655.516,25
27	2.018.624.932,51	30.822.280.448,76
28	1.984.076.339,54	32.806.356.788,30
29	2.487.498.694,34	35.293.855.482,64
30	2.428.272.534,95	37.722.128.017,60
31	2.280.207.136,48	40.002.335.154,08
32	2.230.852.003,66	42.233.187.157,74
33	2.003.818.392,67	44.237.005.550,40
34	1.880.430.560,61	46.117.436.111,01
35	1.623.783.869,92	47.741.219.980,93
36	-	-
37	-	-

Table 4. Project Cost and Schedule Evaluation Based on BCWS, BCWP, and ACWP Parameters

Week	BCWS (Rp)	BCWP (Rp)	ACWP (Rp)
23	22.491.134.028,02	22.703.361.099,17	22.505.940.567,87
24	24.504.823.447,26	24.677.566.412,14	24.519.629.987,10
25	26.646.836.211,83	26.651.771.725,11	26.661.642.751,68
26	28.788.848.976,40	28.625.977.038,08	28.803.655.516,25
27	31.695.866.299m75	31.587.285.007,54	30.822.280.448,76
28	32,791,550,248.45	32.574.387.664,02	32.806.356.788,30
29	35.279.048.942,80	35.042.144.305,24	35.293.855.482,64
30	37.702.385.964,47	37.509.900.946,45	37.722.128.017,60
31	39.982.593.100,95	39.977.657.587,67	40.002.335.154,08
32	42.213.445.104,61	42.445.414.228,88	42.233.187.157,74
33	44.217.263.497,27	44.419.619.541,85	44.237.005.550,40
34	46.097.694.057,88	45.900.273.526,58	46.117.436.111,01
35	47.721.477.927,80	47.874.478.839,55	47.741.219.980,93
36	49.009.646.894,51	-	-
37	49.355.132.824,28	-	-

In Table 4 and Figure 1 shows the entire relationship between cost and schedule so that it can predict linearly regarding the saving or wasteful expenditure of project costs and also the speed or slowness of the actual implementation schedule against the plan and the prediction of the amount of costs that will be incurred on the length of time required until the completion of the project. While the calculation of Cost Variance and Schedule Variance from week 23 to week 35 is described in Table 5 and Table 6.

Calculation of Cost Variance and Schedule Variance values can use equations (4-5). The following example of the calculation of Cost Variance and Schedule Variance in week 35 is as follows:

$$\begin{aligned}
 CV &= BCWP - ACWP \\
 &= 47.874.478.839,55 - 47.741.219.980,93 \\
 &= \text{Rp. } 133.258.858,63 \\
 SV &= BCWP - BCWS \\
 &= 47.874.478.839,55 - 47.721.477.927,80 \\
 &= \text{Rp. } 153.000.911,76
 \end{aligned}$$

Based on Table 5, it can be concluded that in Week 35 of the project implementation, the Cost Variance is positive, this indicates that the costs incurred are less than the planned costs, while the Schedule Variance is positive, indicating that the project implementation time is faster than the initial planning which can be seen in Table 6.

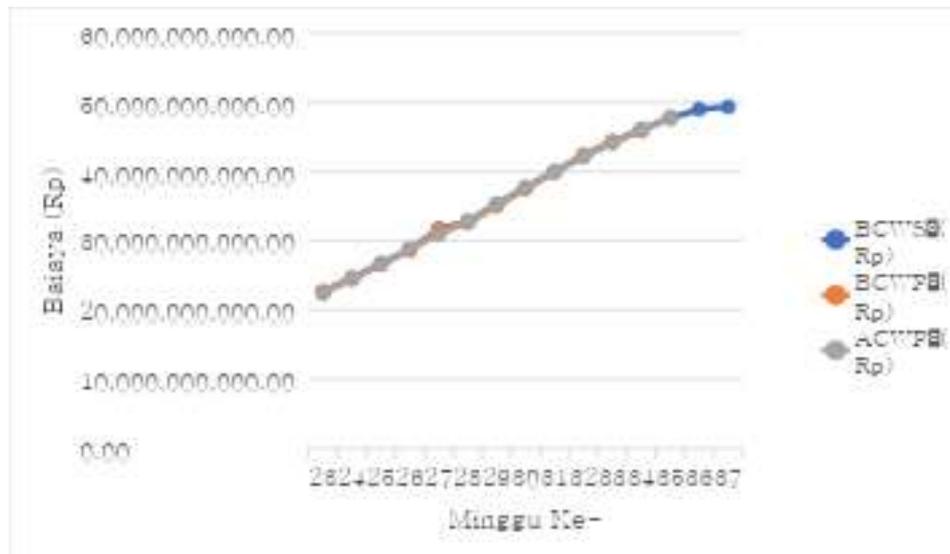


Figure 1. Graph of ACWP, BCWP, and BCWS Values

For the calculation of Cost Performance Index and Schedule Performance Index in week 23 to week 35, it can be seen from the results of the analysis as described in Table 7 and Figure 2.

Table 5. Results of CV and SV Calculations

Week	CV (Rp)	SV (Rp)
23	197.420.531,30	212.227.071,14
24	157.936.425,04	172.742.964,88
25	-9.871.026,56	4.935.513,28
26	-177.678.478,17	-162.871.938,32
27	765.004.558,78	-108.581.292,21
28	-231.969.124,27	-217.162.584,43
29	-251.711.177,40	-236.904.637,56
30	-212.227.071,14	-192.485.018,01
31	-24.677.566,41	-4.935.513,28
32	212.227.071,14	231.969.124,27
33	182.613.991,45	202.356.044,58
34	-217.162.584,43	-197.420.531,30
35	133.258.858,63	153.000.911,76
36	-	-
37	-	-

Table 6. Indicators of CV and SV Integration

CV	SV	Description
+	+	Cost Save and Implementation Time Over Plan
-	+	Cost Waste and Implementation Time Over Plan
0	+	Cost On Plan and Implementation Time Over Plan
+	-	Cost Save and Implementation Time Over Plan
-	-	Cost Waste and Implementation Time Over Plan
0	-	Cost On Plan and Implementation Time Over Plan
+	0	Cost Save and Implementation Time Over Plan

-	0	Cost Waste and Implementation Time On Time Over Plan
0	0	Cost On Plan and Implementation Time On Time Over Plan

The following calculation of Cost Performance Index and Schedule Performance Index in week 35 can use equations (6-7) is as follows:

$$CPI = BCWP / ACWP$$

$$= 47.874.478.839,55 / 47.741.219.980,93$$

$$= 1,00$$

$$SPI = BCWP / BCWS$$

$$= 47.874.478.839,55 / 47.721.477.927,80$$

$$= 1,00$$

Table 7. Results of CPI and SPI Calculations

Week	CPI	SPI
23	1,01	1,01
24	1,01	1,01
25	1,00	1,00
26	0,99	0,99
27	1,02	1,00
28	0,99	0,99
29	0,99	0,99
30	0,99	0,99
31	1,00	1,00
32	1,01	1,01
33	1,00	1,00
34	1,00	1,00
35	1,00	1,00
36	-	-
37	-	-

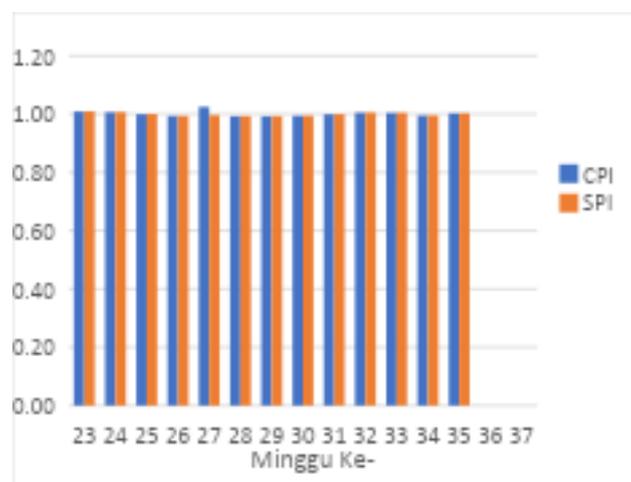


Figure 2. CPI and SPI Value Graph

Based on Table 7, it can be concluded that the 35th week of the project implementation Cost Performance Index is worth 1, this indicates that the cost performance is good and within budget, while the Schedule Performance Index is worth 1, this indicates good schedule performance with the schedule on time against the plan as can be seen in Table 8.

Estimation of the time and cost of completing the project using the earned value concept can be used to estimate the completion time and cost requirements at the time of project implementation from the beginning to the end of the project completion.

Tabel 8. Indikator Perpaduan CPI dan SPI

CPI	SPI	Description
> 1	> 1	Good and Frugal Performance and Good Schedule Performance with Schedule Faster than Plan
0	> 1	Good and on-budget Cost Performance and Good Schedule Performance with Schedule Faster than Plan
> 1	> 1	Poor and Wasteful Cost Performance and Good Schedule Performance with Schedule Faster than Plan
> 1	0	Good and Frugal Cost Performance and Good Schedule Performance with Timely Schedule against Plan
0	0	Kinerja Biaya yang Baik dan sesuai anggaran serta Kinerja Jadwal yang Baik dengan Jadwal Tepat Waktu terhadap Rencana Good and on-budget Cost Performance and Good Schedule Performance with Timely Schedule against Plan
< 1	0	Poor and Wasteful Cost Performance and Good Schedule Performance with Timely Schedule against Plan
> 1	< 1	Good and Frugal Cost Performance and Poor Schedule Performance with Late Schedule against Plan
0	< 1	Good and on-budget Cost Performance and Poor Schedule Performance with Late Schedule against Plan
< 1	< 1	Poor and Wasteful Cost Performance and Poor Schedule Performance with Late Schedule against Plan

The following calculation of the estimated time of the remaining work and the entire project can use equations (8-11).

Cost Estimation

$$\begin{aligned}
 ETC &= (BAC - BCWP) / CPI \\
 &= 49.355.132.824,28 - 47.874.478.839,55 \\
 &\quad / 1,00 \\
 &= \text{Rp. } 1.476.532.576,73
 \end{aligned}$$

$$\begin{aligned}
 EAC &= ACWP + ETC \\
 &= 47.741.219.980,93 + 1.476.532.576,73 \\
 &= \text{Rp. } 49.217.752.557,66
 \end{aligned}$$

Estimated Time

$$\begin{aligned}
 ETS &= \text{remaining time to complete the project according to plan} / SPI \\
 &= (37 - 35) / 1,00 \\
 &= 1,99 \text{ Weeks}
 \end{aligned}$$

EAS = total time already used + ETS

= 35 + 1,99

= 36.99 Weeks

Cost difference until the end of project implementation

= total plan cost – EAC

= 49.355.132.824,28 - 49.217.752.557,66

= Rp. 137.380.266,62

Schedule difference until the end of project implementation

= total plan schedule – EAS

= 37 – 36,99

= 0,01 minutes or 0,07 days

Based on the performance evaluation until the 35th week of project implementation, it is predicted that the project will spend a total cost of Rp. 49,217,752,557.66 and will be able to save costs of Rp. 137,380,266.62 from the total plan cost that has been budgeted at the beginning. In addition, the total schedule for the implementation of the work is 36.99 weeks, where the project completion schedule is only 0.01 weeks or 0.07 days late. When viewed from the planning of the running of the angkaka project it is almost perfect or according to the planned trajectory.



Figure 4. S-curve of MC-1

The table shown is a construction work implementation schedule organized in S-Curve format, which is generally used as a project management control tool. This table contains structured job descriptions, including preparatory work, earthwork, structural, architectural, mechanical electrical and plumbing (MEP), and infrastructure work. Each work item is accompanied by a total budget value (total price) and a percentage weight against the total project cost, which represents the relative contribution of each work to the total construction output.

The time column is organized chronologically by weeks of project implementation, starting from week 1 (early April 2024) to week 40+ (late December 2025), indicating the overall project implementation duration. Within the table cells are percentage figures describing the weekly progress targets for each work item, which cumulatively form a project progress growth curve. This curve is visualized in the form of an S-Curve graph at the bottom of the table, which represents the temporal accumulation of work progress. This curve is important for monitoring project performance, as it can be used to compare planned and actual progress on the ground and identify potential delays.

In addition, this table also marks long holiday periods such as Eid al-Fitr with special colors, as a consideration in schedule planning. Overall, this document has a strategic function in the implementation of time management and performance evaluation of construction projects in a systematic and measurable manner.

Conclusion

Based on the results of the data analysis that has been carried out, this study aims to estimate the estimated time and cost of the construction of the Integrated Lecture Building of Surabaya State Polytechnic of Shipping. The results of this study indicate the value of ACWP is Rp. 47,741,219,980.93, the BCWP value is Rp. 47,874,478,839.55, and the BCWS value is Rp. 47,721,477,927.80. The value of the Cost Variance (CV) is Rp. 133,258,858.63 and the Schedule Variance (SV) is Rp. 153,000,911.76, indicating that the cost savings and implementation time are faster than planned. The value of CPI and SPI is equal to 1, indicating good cost performance within budget and good schedule performance with the schedule on time against the plan. The estimated cost of ETC is Rp. 1,476,532,576.73 and EAC is Rp. 49,217,752,557.66. The estimated time of ETS is 1.99 weeks and EAS is 36.99 weeks.

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