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An Advanced Technology Performance Measure Method for System

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Abstract: Arming at TRMs only accounts for the achieved performance instead of both the achieved and unmet performance, so it is impossible to reflect the aggregated risk. This paper firstly extends the technology category in TPMs. A new kind of technology is added to the traditional TRMs and the calculating formula is given. Secondly, the proposed TPRM is based on two concepts: the unmet performance and the degree of difficulty with the unmet performance. At last, two applications are given to prove the availability of the method in the paper.

Keywords: Technical performance requirements (TPR), Technical performance measure (TPM), Degree of difficulty(DD), Technology performance risk measure (TPRM), System.

1. INTRODUCTION

Technical Performance Measures (TPMs) are defined and evaluated on how well a system is achieving its performance requirement indicators. The TPM can provide the information that it is achieving the intended target with the development progress of the system performance, but, these TPM are just a response of the system's single performance parameters. Comprehensive individual indicators obtained the technical performance of the integrated metrics which reflects the overall state.

In addition, TPR is a measure of technology to achieve performance requirements. It is a measure of the past, without considering the difficulty of application technology. As TPM does not consider the risk of completion of the remaining performance requirements, TPM needs to be further improved, need to adopt a more reasonable metric to mark the integrated risk [1-4].

Firstly, the original TPM of technical performance indicators is expanded for 3 types, and given the respective TPM formula; Second, Technology performance risk measure (TPRM) is proposed, and the rapid discriminating map is given.

2. THE ESTABLISHMENT OF TECHNICAL PERFORMANCE MEASURE

2.1. Traditional Technical Performance Measure

The classical TPM is to assess the situation of the system's technical performance in one aspect, and then obtains the performance measure of the system through different indicators, to have a global understanding of the progress of the whole system. In order to meet equipment requirements for war, some requirements of the technical performance of the system require its value to be higher and some require its value to be lower. According to this feature, this paper divides technical indicators into two categories [5-8]. The lower value classified as Class A, on the contrary for the Class B. Although some of the indicators required the higher the better or the lower the better, but they can not be infinitely high or infinitely low, so we only require meeting the performance requirements of the tasks. Class A of technical performance may require a threshold to meet the mission requirements. Class A is more than the threshold means it meets the requirements; Similarly, Class B is less than the threshold means it meets the requirements. As shown in Figs. (**1**, **2**).

2.2. Modified Technical Performance Measure

In addition to the two technical measures above, there is another case: technical performances for system meet the performance requirements within the specified range, higher than the upper limit or below the lower limit does not meet the requirements, categorized as Class C. This is similar to the pulse of the body, healthy body requires a certain range in pulse rate, and pulses too fast or too slow per minute are unhealthy signs. Provides Class C to meet the upper threshold and lower threshold for task requirement, which can be given in accordance with task requirements, Class C between the upper threshold and the lower threshold value is described to meet the requirements, shown in Fig. (**3**).

The horizontal axis in Fig. (**3**) the same as Fig. (**1**) and (**2**), $V_{Up-thres}$ means upper threshold, $V_{Low-thres}$ means lower threshold.

Since there is no uniform standard and units of measurement between each TPM, and the original data can not be

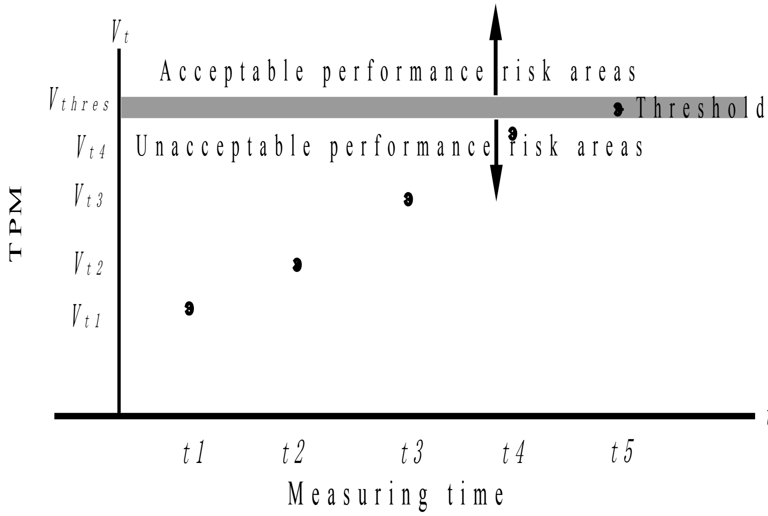

Fig. (1). Class A specifications.

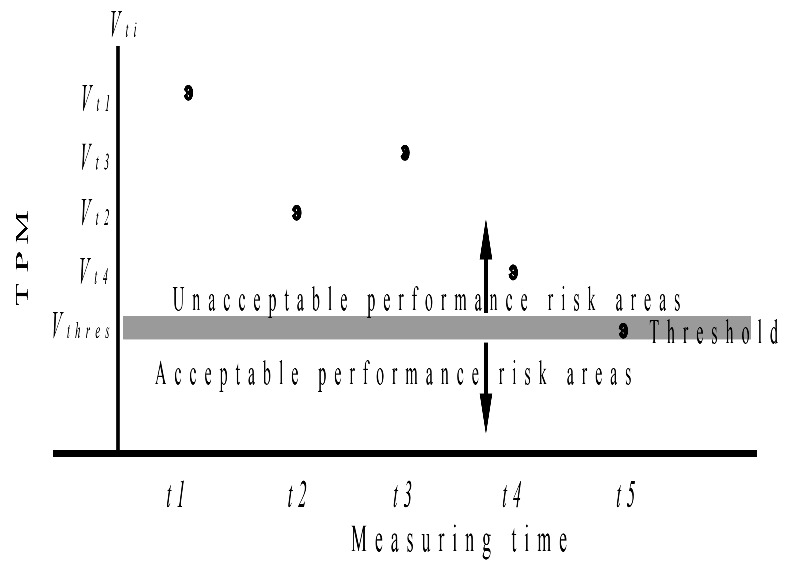

Fig. (2). Class B specifications.

compared with each other directly, the original data needs to be normalized. For the 3' specifications of the classes, we proposed the following normalization methods in this paper.

$V_{ti,Aj}$ means Class A's TPM with item j in ti measuring time, $V_{thres,Aj}$ means the threshold for Class A's TPM with item j, $v_{ti,Aj}$ means Class A's TPM with item j in ti measuring time which after normalization of.

$$\begin{aligned} v_{ti,Aj} &= \max\{V_{ti,Aj}, V_{thres,Aj}\} / V_{thres,Aj} \\ &= \max\{V_{ti,Aj} / V_{thres,Aj}, \quad 1\} \\ &= \max\{(V_{thres,Aj} - V_{thres,Aj} + V_{ti,Aj}) / V_{thres,Aj}, \quad 1\} \\ &= \max\{[1 + (V_{ti,Aj} - V_{thres,Aj}) / V_{thres,Aj}], \quad 1\} \quad (\geq 1) \end{aligned} \tag{1}$$

For Class B, $V_{ti,Bk}$ means Class B's TPM with item k in ti measuring time, $V_{thres,Bk}$ means the threshold for Class B's TPM with item k, $v_{ti,Bk}$ means Class B's TPM with item k in ti measuring time which after normalization of.

$$\begin{aligned} v_{ti,Bk} &= \min\{V_{ti,Bk}, V_{thres,Bk}\} / V_{thres,Bk} \\ &= \min\{V_{ti,Bk} / V_{thres,Bk}, \quad 1\} \\ &= \min\{[1 - (V_{thres,Bk} - V_{ti,Bk}) / V_{thres,Bk}], \quad 1\} \quad (\leq 1) \end{aligned} \tag{2}$$

The same as Class C, $V_{ti,Cl}$ means Class C's TPM with item 1 in ti measuring time, $V_{Up-thres,Cl}$ means the upper

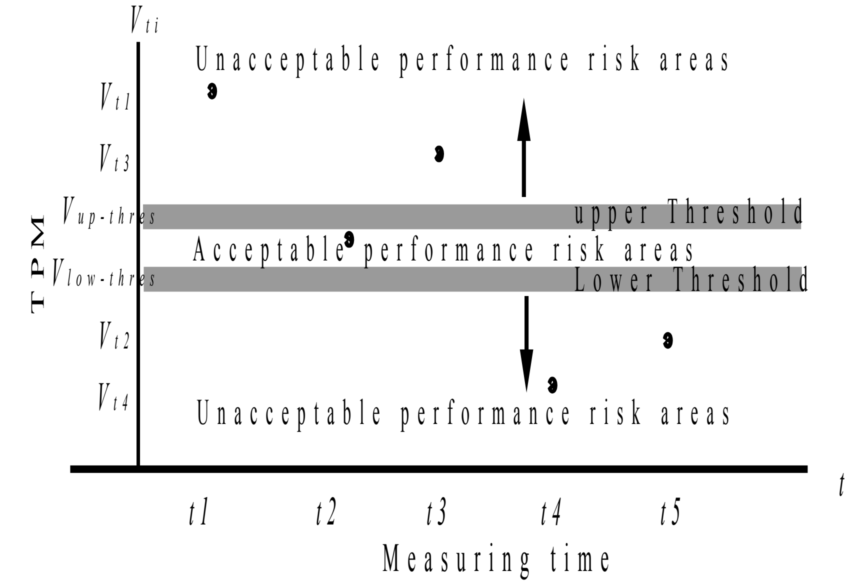

Fig. (3). Class C specifications.

threshold for Class C's TPM with item l, $V_{Low-thres,Cl}$ means the lower threshold for Class C's TPM with item l, $v_{ti,Cl}$ means Class C's TPM with item l in *ti* measuring time which after normalization of.

$$v_{ti,Cj}=\begin{cases}\max\{V_{ti,Cj},V_{Up-thres,Cj}\}/V_{Up-thres,Cj} & V_{ti,Cj}>V_{Up-thres,Cj}\\ 1 & V_{Low-thres,Cj}\le V_{ti,Cj}\le V_{Up-thres,Cj}\\ \min\{V_{ti,Cj},V_{Low-thres,Cj}\}/V_{Low-thres,Cj} & V_{ti,Cj}<V_{Low-thres,Cj}\end{cases} \quad (3)$$

For combinations of all normalized TPM to unity values reflect the different techniques, Class A and C will be normalized to range [0, 1]

$$\begin{aligned}u_{ti,Aj}&=1/[\max\{V_{ti,Aj},V_{thres,Aj}\}/V_{thres,Aj}]\\&=1/v_{ti,Aj}\quad(\le 1)\end{aligned} \quad (4)$$

$$u_{ti,Cj}=\begin{cases}1/[\max\{V_{ti,Cj},V_{Up-thres,Cj}\}/V_{Up-thres,Cj}] & V_{ti,Cj}>V_{Up-thres,Cj}\\ 1 & V_{Low-thres,Cj}\le V_{ti,Cj}\le V_{Up-thres,Cj}\\ \min\{V_{ti,Cj},V_{Low-thres,Cj}\}/V_{Low-thres,Cj} & V_{ti,Cj}<V_{Low-thres,Cj}\end{cases} \quad (5)$$

In index comprehensive, using the regular systematic reviews modeling, according to the importance of each TPM in system requirements, combined weight coefficients such as expert ratings and AHP methods for determining the weight of each indicator, then comprehensive. The result as the comprehensive technical performance metrics $TPM_{ti,all}$.

Assumed $j=1,2,\cdots,m$, $k=1,2,\cdots,n$, $l=1,2,\cdots,p$, for Class A, comprehensive technical performance metric is calculated as follows:

$$TPM_{ti,A}=(w_{A1}u_{tj,A1}+w_{A2}u_{tj,A2}+\cdots+w_{Am}u_{tj,Am})/W_A \quad (6)$$

$w_{Aj}(j=1,2,\ldots,m)$ means the weight of A_j, and $W_A=w_{A1}+w_{A2}+\cdots+w_{Am}$.

Similarly:

$$TPM_{tj,B}=(w_{B1}v_{tj,B1}+w_{B2}v_{tj,B2}+\cdots+w_{Bm}v_{tj,Bn})/W_B \quad (7)$$

$$W_B=w_{B1}+w_{B2}+\cdots+w_{Bm} \quad (8)$$

$$TPM_{tj,C}=(w_{C1}u_{tj,C1}+w_{C2}u_{tj,C2}+\cdots+w_{Cm}u_{tj,Cn})/W_C \quad (9)$$

$$W_C=w_{C1}+w_{C2}+\cdots+w_{Cm} \quad (10)$$

Considered the weights W_A、W_B、W_C of Class A、B、C，there are:

$$TPM_{tj,All}=(W_A TPM_{tj,A}+W_B TPM_{tj,B}+W_C TPM_{tj,C})/W \quad (11)$$

$$W=W_A+W_B+W_C \quad (12)$$

3. THE ESTABISHIMENT OF TECHNICAL PERFORMANCE RISK MEASURE

3.1. Degree of Difficulty

In considering the technology to achieve performance requirements, we must pay attention to the degree of difficulty which is to complete the remaining technical performance requirements. It is proposed that the concept of degree of difficulty that is expected for risk measurement from low-risk to high-risk, can be considered a failure probability to achieve performance goals, the degree of difficulty ranges from [0,1]. DD expressed degree of difficulty, means, the

Table 1. The concept of technical difficulties index.

Degree of Difficulty	Risk Level	DD Value
Minimum degree of difficulty	Success	0.0
1	Very low risk	0.1
2	Low risk	0.3
3	Medium risk	0.5
4	High risk	0.7
5	Very high risk, need basic technological breakthroughs	0.9
Maximum degree of difficulty	Failure	1.0

degree of difficulty that the system is able to complete the remaining requirements. Reference Mankins's [9] concept of R & D difficulty, Following Table **1** shows the division of DD.

Technical difficulties index expressed the failure probability of completing the remaining performance requirements, High degree of difficulty expressed to complete the unfinished performance requirements have high risk and high probability of failure; Low degree of difficulty expressed to complete the unfinished performance requirements have low risk and low probability of failure. The minimum level of technical difficulties expressed have no risk, the maximum level expressed technical solutions can not achieve the remaining performance requirements.

3.2. Technical Performance Risk Measure

Technical performance risk measure is the function of technical performance measure and degree of difficulty, it can be expressed with the following formula as follow:

$$TPRM = f(TPM, DD) \tag{13}$$

According to the limit of TPM and DD, the boundary conditions for TPRM can be given:

1) The degree of difficulty complete the remaining performance requirement to 0, TPRM can represent the remaining performance requirements;
2) The degree of difficulty complete the remaining performance requirement to 1, that is impossible to complete the remaining performance requirements, the performance requirements system is absolutely unrealizable, TPRM = 1;
3) When the TPM fully meets all performance requirements, TPRM = 0, is almost totally without any risk at this time;
4) Does not implement any TPM, that is, when TPM is 0, does not meet any performance requirements, clearly, technical performance is definitely the highest risk at this time: TPRM = 1;

According to the four conditions above, the following formulas can be obtained:

$$\lim_{DD \to 0} TPRM = 1 - TPM \tag{14}$$

$$\lim_{DD \to 1} TPRM = 1 \tag{15}$$

$$\lim_{TPM \to 1} TPRM = 0 \tag{16}$$

$$\lim_{TPM \to 0} TPRM = 1 \tag{17}$$

According to the above four conditions can be calculated for TPRM:

$$TPRM = \frac{1 - TPM}{1 - TPM \times DD^n} \tag{18}$$

Where n can take rational numbers, the general calculations take n = 1.

For different DD, correspondence between TPM and TPRM is shown in Fig. (**4**). Only when DD is 0, there exist a linear relation between TPM and TPRM, TPM is just TPRM's special form.

For different TPM, correspondence between DD and TPM is shown in Fig. (**5**). When TPM is small, the impact of DD is less. When TPM is large, with DD increasing, TPRM increases.

Calculated the contour TPRM between the different degree of difficulty and technical performance measure through the formula 18, as shown in Fig. (**6**), thus the method of rapid assessment by technical performance risk measurement is given in different combinations of DD and TPM, as shown in Fig. (**7**).

Under combination of different type of technology the technical performance risk measure can be calculated, we get technical performance risk measurement formula as:

$$TPRM_{tj,All} = (W_A TPRM_{tj,A} + W_B TPRM_{tj,B} + W_C TPRM_{tj,C}) / W \tag{19}$$

$$W = W_A + W_B + W_C \tag{20}$$

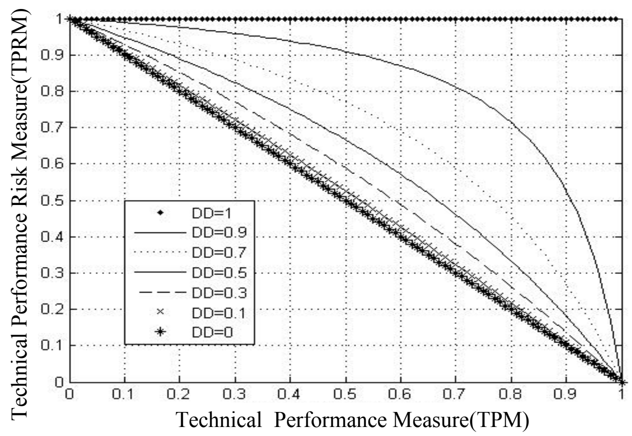

Fig. (4). Relation between TPM and TPRM for different DD.

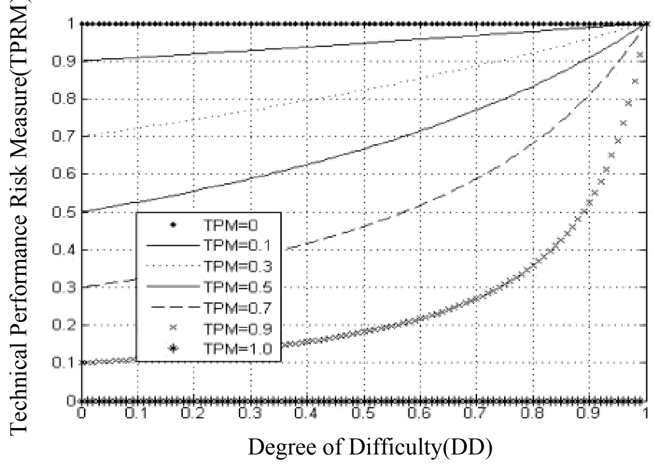

Fig. (5). Relation between DD and TPRM for different TPM.

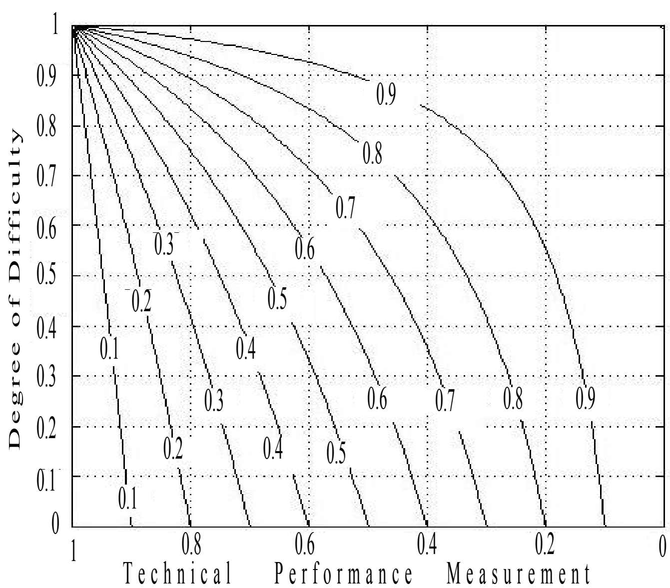

Fig. (6). TPRM contour between DD and TPM.

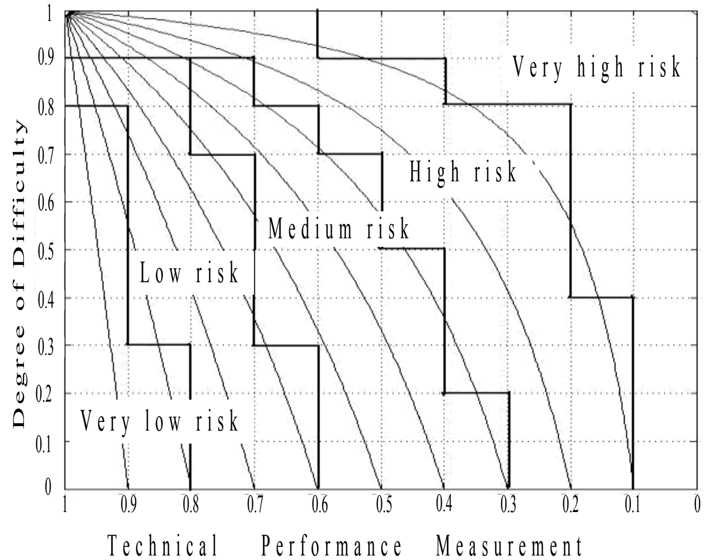

Fig. (7). TPRM allocation of risk between DD and TPM.

Table 2. TPM index calculation for class A technology.

Metric Time		MTBF	Reaction Time	Interval	$TPM_{A,all}$
	Weights	1.0	1.0	3.0	
	Threshold	0.5	5	10	
t1	Vt1,A、vt1,A	1、0.5	11、0.456	30、0.33	0.371
t2	Vt2,A、vt2,A	0.9、0.56	10、0.5	25、0.4	0.452
t3	Vt3,A、vt3,A	0.8、0.625	8.5、0.588	21、0.476	0.528
t4	Vt4,A、vt4,A	0.7、0.71	7、0.714	15、0.667	0.685
t5	Vt5,A、vt5,A	0.6、0.83	6.5、0.769	12、0.833	0.82
t6	Vt6,A、vt6,A	0.5、1	5, 1	9、1	1

Determining the results of the TPRM by the risk determines matrix for TPRM in Fig. (**4**), we get the degree of system technical performance risk measures.

4. APPLICATION EXAMPLE

4.1. One Example: the Application of Modify Technical Performance Measure

From literature [10], combining with wireless sensor networks and applying the above methods to assess technical performance risk, measures the TPM indicators of the system which can be concluded into the following categories:

Class A index: MTBF (hours), reaction time (minutes), interval (seconds)

Class B index: MTTR (hours), precision (%)

Class C index: Firing frequency (HZ)

Various types of indicators are defined by the respective threshold, the original data and the corresponding results are in Table **2-4**.

From the formula, obtain the value of the technical performance measure for different times, as shown in Fig. (**8**), which shows the extent required to achieve the desired system performance for different time stages.

4.2. Second Example: the Application of Technical Performance Risk Measure

In a system, with two alternative technologies (technology A and technology B) to choose from, decision makers need to choose which of the two can be applied in the system. Both technology A and technology B can achieve

Table 3. TPM index calculation for class B technology.

Metric Time		MTTR	Accuracy	$TPM_{B,all}$
	Weights	1.0	2.0	
	Threshold	60	85%	
t1	Vt1,B、vt1,B	25、0.417	50%、0.589	0.531
t2	Vt2,B、vt2,B	30、0.5	56%、0.659	0.606
t3	Vt3,B、vt3,B	33、0.55	65%、0.765	0.693
t4	Vt4,B、vt4,B	45、0.75	75%、0.882	0.838
t5	Vt5,B、vt5,B	55、0.917	80%、0.941	0.933
t6	Vt6,B、vt6,B	63、1	88%、1	1

Table 4. TPM index calculation for class C technology.

Metric Time		Engine Shock Frequency	$TPM_{C,all}$
	Weights	0.5	
	Threshold	60-66	
t1	Vt1,C、vt1,C	90、0.733	0.733
t2	Vt2,C、vt2,C	81、0.815	0.815
t3	Vt3,C、vt3,C	50、0.833	0.833
t4	Vt4,C、vt4,C	55、0.917	0.917
t5	Vt5,C、vt5,C	68、0.97	0.97
t6	Vt6,C、vt6,C	62、1	1

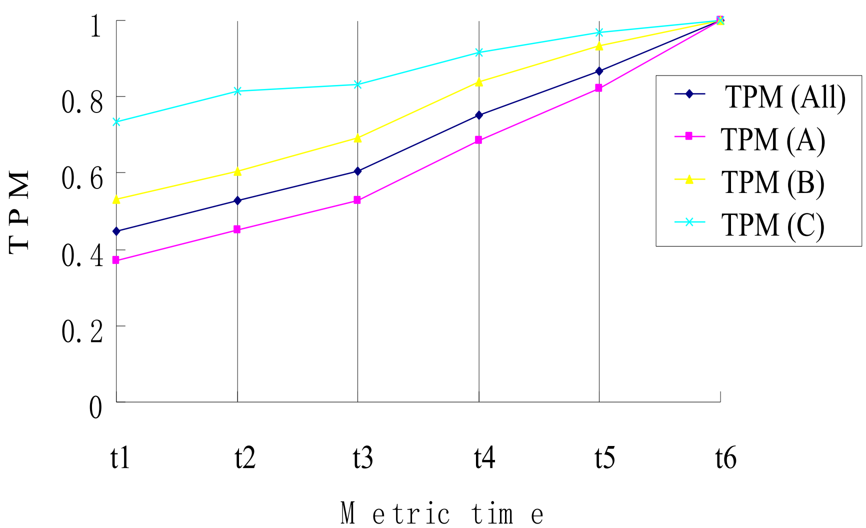

Fig. (8). The TPM value of different measurement time.

technical performance measure of 60%, and technology B's TPM is slightly higher than technology A's. The different applications of technology A and technology B are: technology A, use of Commercial-off-the-shelf components, mainly in the 70's to 80's technology; Technology B is a new technology that requires accurate processing and sophisticated test system. The degree of difficulty (DD) of the technology A is much less than technology B, as shown in Table **5**.

Table 5. TPRM computation of a certain system alternative technologies.

Technical Program	TPM Value has been Reached	DD of Remaining TPM	TPRM
A	0.61	0.2	0.44
B	0.73	0.7	0.55

Although the technology B can achieve a higher TPM value, because of the high degree of difficulty in completing the remaining TPM, so the technical performance risk is also higher than A, in other words, the failure rate of technical B is more than technical A.

CONCLUSION

This paper presents a method to improve the technical performance measurement, through two examples, the results show that the measure system can fully reflect the system's overall risk, can assist decision-making, and is reasonable and scientific in the practical application.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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