Problem Chosen	2022 MCM/ICM Summary Sheet	Team Control Number
D		2219711

Wonder the Maturity of D&A? We Help You!

Summary

Nowadays, data is playing an increasingly important role in our life, especially for companies. Undoubtedly, a company with superb data and analytics(D&A) system tends to remain competitive. The purpose of this paper is to create a model to quantify the level of D&A system and generalize the model to other domains.

In TASK 1, in order to assess the factors affecting the maturity of D&A system, we propose a model termed PTP, which is composed of Analytic Hierarchy Process (AHP) and Grey Clustering. First, we choose four indicators from the level of people, four indicators from the level of technology and six indicators from the level of process. Then, we obtain their relative weights with AHP. After passing the consistency test, we get three eigenvectors of judgment matrix in the criteria layer (i.e. the corresponding weight of the alternatives layer). Moreover, with the establishment of level model and improved trigonometric whitening weight function which constitute Gray Clustering, we make it possible to quantify the maturity.

In TASK 2, we present our model PTP with specific data that we assume and demonstrate a promising direction of upgrading the D&A system based on the results of PTP. In addition, with reference to the indicators we identify for the system, we come up with some other ideas to maximize the potential of ICM's data assets.

In TASK 3, we adopt System Effectiveness Analysis (SEA) to measure the effectiveness of D&A system. We select five original parameters according to ICM's business and map them into three attributes which form the Euclidean space. By geometric relationships in space between the practical and the ideal, we define a formula to calculate the effectiveness of D&A.

In TASK 4, our model PTP is generalized to more systems with different scales or in different industries. It is worth mentioning that different indicators should be used in different systems so as to obtain a more accurate maturity level in a targeted way. What's more, we are convinced that ICM and its customers can reach a win-win situation using our PTP and present an example to prove it.

Finally, we write a letter to the customers of ICM to instill their confidence. Also, we conclude the strengths and weaknesses of our models and make suggestions for promotion.

Key words: PTP, AHP, Grey Clustering, SEA.

Contents

1 Introduction

1.1 Background

Since the era of big data has already befallen, ones who process information properly win a competitive edge. Systems which extract and integrate information are more generally utilized by companies in order to increase both efficiency and quality in decision-making. With such surging trend, the importance of constructing a sound data and analytics (D&A) system should be highlighted. In this paper, we propose a model termed People, Technology and Process (PTP) which evaluates a system from the literal three angles and adopt System Effectiveness Analysis (SEA) to further assists ICM company in advancing the original system.

1.2 Problem Restatement

To develop a scientific and effective evaluation model for ICM's D&A system, we need to solve following problems:

Firstly, we should measure several key performance indicators concerning people, technology and process to evaluate the maturity level of ICM current D&A system.

Secondly, we should demonstrate how to use the given models above to improve the system, maximizing the potential of original data assets.

Thirdly, in terms of the effectiveness of D&A system measured by our model, we should develop relevant protocols.

Furthermore, we examine whether our analytical model is applicable to ports of different sizes or even other industries with discussing the applicability of trucking companies in detail.

Finally, write a letter to targeted customers to introduce our optimization and strengthen their confidence in ICM.

2 Preparations of our models

2.1 Assumptions and Justifications

1) The maturity of subsystems: People, Technology and Process has an independent impact on the maturity of D&A system.

2) ICM Corporation operates normally without disturbance of emergencies or special circumstances.

3) All expert panel ratings are accurate and objective, reflecting the reality of the D&A system.

2.2 Notations

The main notations adopted in this paper are shown in the following table:

Notations	***Descriptions***
C_i	Evaluation indicators for people, technology and process, 1≤i≤14
x_i	Expert rating of indicators in percentage, 1≤i≤14
ω_j	The corresponding weight of the alternatives layer, 1≤j≤3
PEOM	D&A people maturity
TECM	D&A technology maturity
PROM	D&A process maturity
M_j	Evaluation matrix of PEOM, TECM, PROM respectively, 1≤j≤3
σ_j	Maturity level membership degree of PEOM, TECM, PROM respectively, 1≤j≤3
PEOL	The grey class level of PEOM
TECL	The grey class level of TECM
PROL	The grey class level of PROM
DASL	The grey class level of D&A system maturity
L_s	The actual state trajectory of the system
L_m	The ideal state trajectory of the system

(Table 1: Notations)

Other notations if used will be described later.

3 TASK1: Construction of D&A Maturity Measurement Model PTP

PTP consists of Hierarchical Structure Model with AHP, System Maturity Evaluation Framework, Level Model and Improved Trigonometric Whitening Weight Function Model.

3. 1 Application of AHP in Establishment

In this part, we use Analytic Hierarchy Process (AHP) to form a set of scoring rules.

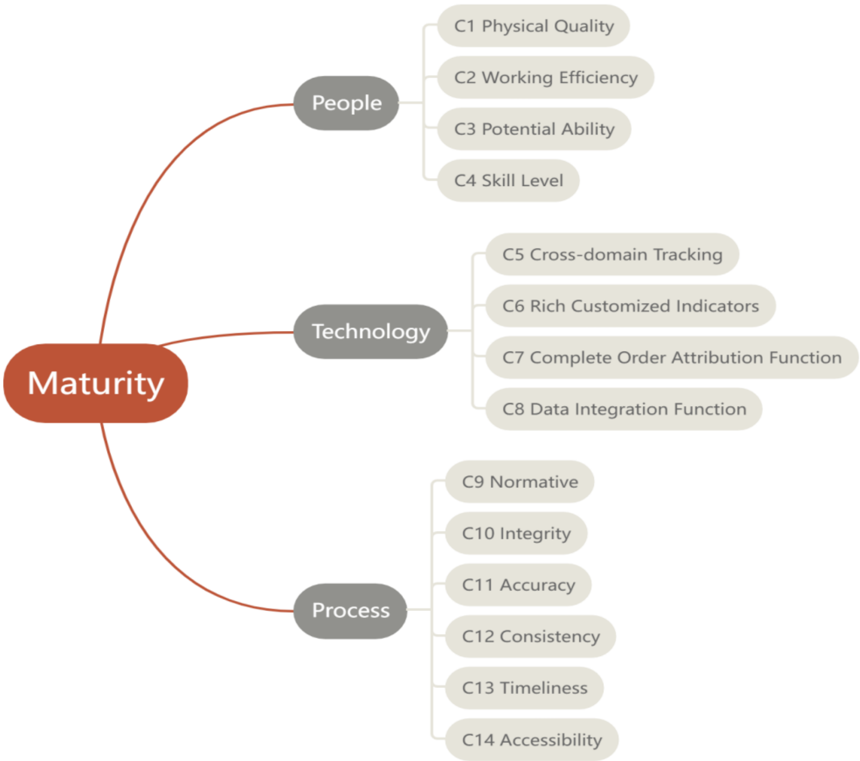
3.1.1 Construction of Hierarchical Structure Model

We determine the factors affecting the maturity of D&A system, and obtain the evaluation indicators (C1~C14) from the three aspects: People, Technology and Process as Figure 1 shows. Here are some reasons.

We hold the belief that as a data analyst, he or she should be in good physical condition to handle the work. Also, working efficiency and potential ability are important factors to consider. And technical level is a dispensable part of data analysis. Thus we give C1~C4.

Advanced technology like a good data analysis tool is capable of real-time processing and analysis of a large amount of data. Cross-domain tracking is a common situation in data processing and customized indicators can make our process personalized. What’s more, order attribution function can help us have access to data more conveniently. Thus we give C5~C8.

For data governance process, especially in the case of high requirements for real-time data, the system should ensure that each group of metadata adopts a unified standard and data transmission process is consistent and accurate so that visitors can quickly get real-time data. Thus we give C9~C14.



(Figure 1: Hierarchical Structure Model)

3.1.2 Construction of Marking Scale and Definition

For multiple indicators, we can compare and evaluate them two by two, and judge the weight according to the results of pairwise comparison. In order to quantify, AHP uses nine levels of eighteen numbers to compare the importance (satisfaction) between the two indicators, as shown in the table below.

Scale	Definition
1	Referring to two factors of equal importance.
3	Referring to two factors in which one is slightly more important than the other.
5	Referring to two factors in which one factor is significantly more important than the other.
7	Referring to two factors in which one is more strongly important than the other.
9	Referring to two factors in which one is more important than the other.
2, 4, 6, 8	The median of the two adjacent judgments above.

Reciprocal	**If A is on the scale of 3, then B is on the scale of $\frac{1}{3}$ compared to A.**

(Table 2: Marking Scale and Definition)

3.2 Construction of Judgment Matrix and Checking Consistency at Three Levels

3.2.1 Using AHP to score respective indicators, we obtain the judgment matrix.

	C1	C2	C3	C4
C1	1	1/3	1/5	1/7
C2	3	1	1/3	1/5
C3	5	3	1	1/3
C4	7	5	3	1

(Table 3: Judgment Matrix at the Level of People)

	C5	C6	C7	C8
C5	1	1	1/5	1/5
C6	1	1	1/5	1/5
C7	5	5	1	3
C8	5	5	1/3	1

(Table 4: Judgment Matrix at the Level of Technology)

	C9	C10	C11	C12	C13	C14
C9	1	1/2	1/2	1/2	1/3	1/3
C10	2	1	1/2	1/2	1/2	1/2
C11	2	2	1	1	2	2
C12	2	2	1	1	2	2
C13	3	2	1/2	1/2	1	1/2
C14	3	2	1/2	1/2	2	1

(Table 5: Judgment Matrix at the Level of Process)

3.2.2 Checking Consistency

Then, we need to conduct a consistency test.

3.2.2.1. Calculate the Consistency Indicator (CI)

When λ_{max} refers to the largest eigenvalue of the judgment matrix (if there is an imaginary number in the eigenvalue, the modulus of the eigenvalue is compared), and n is the dimension of the judgment matrix, the calculation formula of CI is as follows:

$$\mathbf{CI} = \frac{\lambda\max - n}{n-1}$$

3.2.2.2. Find the corresponding Mean Random Consistency index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49

(Table 6: RI of AHP)

3.2.2.3. Calculate the Consistency Ratio (CR)

$$\mathbf{CR}=\frac{CI}{RI}$$

If CR<0.1, the consistency of the judgment matrix is acceptable; otherwise, the judgment matrix needs to be modified.

Based on calculation, at the level of people, λ_{max}=4.117, CI=0.039, CR=0.0442, the consistency test passed. The eigenvector of the matrix ω_1 =[0.055, 0.1178, 0.2634, 0.5638] correspond to the weights of C1~C4 respectively.

At the level of technology, λ_{max}=4.1545, CI=0.0515, CR=0.0579, the consistency test passed. The eigenvector of the matrix ω_2 = [0.0783, 0.0783, 0.5383, 0.3051] correspond to the weights of C5~C8 respectively.

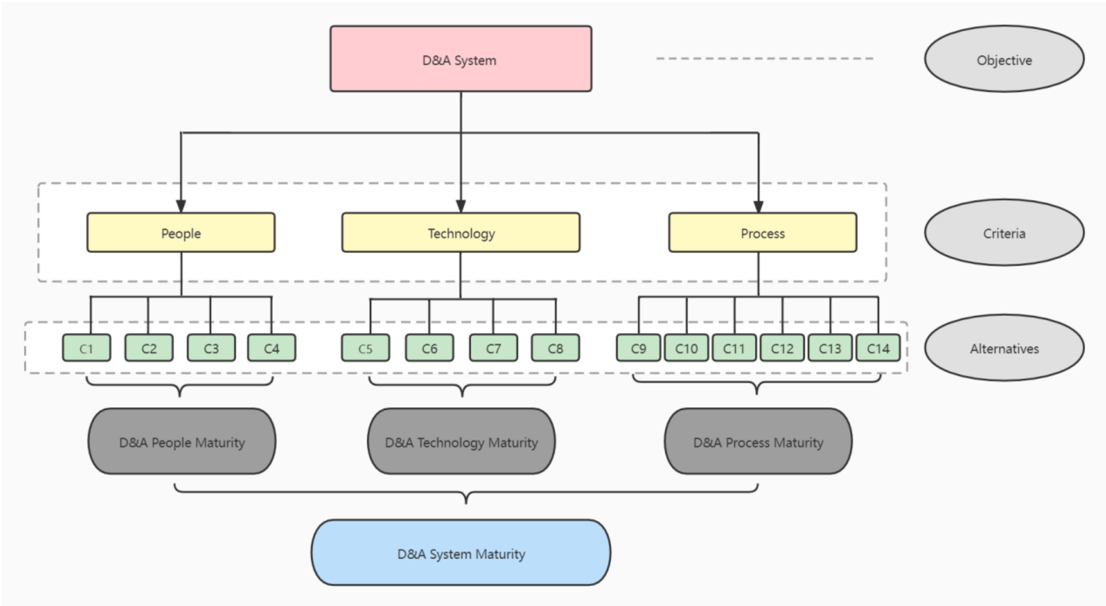
At the level of process, λ_{max}=6.2772, CI=0.0554, CR=0.0440, the consistency test passed too. The eigenvector of the matrix ω_3 =[0.0769, 0.1065, 0.2416, 0.2416, 0.1475, 0.1858] correspond to the weights of C9~C14 respectively.

3.3 Grey Clustering Approach of System Maturity of D&A System under Confidence Level

The system maturity evaluation framework based on People, Technology and Process maturity is constructed, and the hierarchical model of D&A system maturity and the trigonometric whitening weight function model of six grey classes are proposed. Then, the grey clustering evaluation procedure of system maturity based on the trigonometric whitening weight function of the center point is given. Finally, the validity and feasibility of the proposed system maturity evaluation method is verified by an example.

3.3.1 Establishment of the System Maturity Evaluation Framework

We evaluate D&A system from three aspects: People Maturity, Technology Maturity and Process Maturit.



(Figure 2: Establishment of the System Maturity Evaluation Framework)

3.3.2 Establishment of Level Model

By referring to ITIL proficiency model in the field of operations management, INTERNATIONAL ITSS model and 3CMM model of operators' cloud capability maturity, we conclude that defining capability maturity level as 5 levels is relatively the most effective way to show capability maturity. This five-level model further refines the level of D&A capability, making the final maturity result more accurate. The five levels of D&A capability maturity are defined in the following table:

Level	Definition
L1 Initial Level **Highly unskilled**	D&A ability is low, division of labor is chaotic, employees are not competent to process data. Useful and effective data are ignored and the technology level is not developed. The company's earnings are not optimistic.
L2 Growing Level **Less skilled**	D&A ability is less qualified, the division of labor is inchoate with not a little shortcomings and a small number of employees are capable of handling data analysis and processing. The utilization rate of effective data is still low and needs to be improved and technology level is underdeveloped. Overall, the company has difficulty in making ends meet.

L3 Intermediate Level Relatively skilled	D&A ability is qualified, the division of labor is reasonable, most of employees are capable of analyzing and processing data effectively. The utilization rate of data keeps growing and technology is less developed. The company can maintain basic profits and operations.
L4 Mature Level skilled	D&A ability is highly qualified, the division of labor is reasonable, and employees perform their duties with high quality and quantity. Most of the data have been made good use of. The company is on track.
L5 Excellent Level Highly skilled	D&A ability is excellent, division of labor is perfect, and employees has high comprehensive quality. Almost all data have been fully explored, and scientific and technological level takes the lead. The company develops at a surprising speed.

(Table 7: Hierarchical Model of D&A System Maturity)

3.3.3 Improved Trigonometric Whitening Weight Function Model

For the five levels of maturity evaluation above, we give the trigonometric whitening weight function:

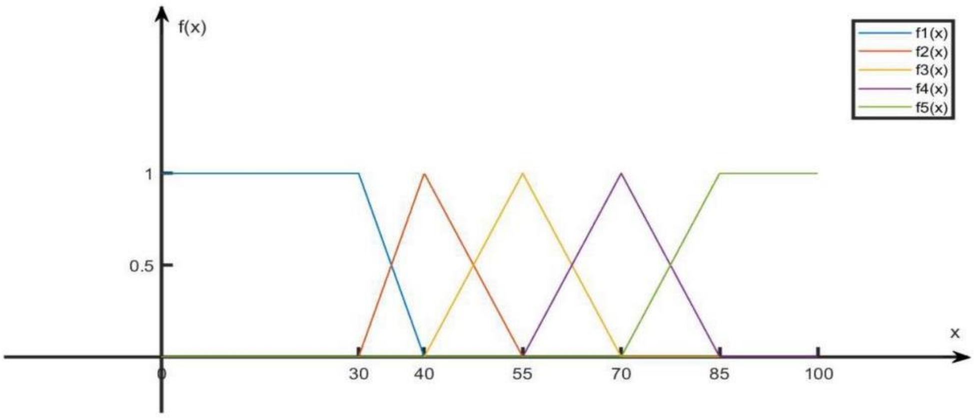
$$f_1^*(x) = \begin{cases} 1, x \in [0,30) \\ (40 - x)/10, x \in [30,40) \\ 0, x \in [40, +\infty) \end{cases}$$

$$f_2^*(x) = \begin{cases} (x - 30)/10, x \in (30,40] \\ (55 - x)/15, x \in (40,55) \\ 0, \text{else} \end{cases}$$

$$f_3^*(x) = \begin{cases} (x - 40)/15, x \in (40,55] \\ (70 - x)/15, x \in (55,70) \\ 0, \text{else} \end{cases}$$

$$f_4^*(x) = \begin{cases} (x - 55)/15, x \in (55,70] \\ (85 - x)/15, x \in (70,85) \\ 0, \text{else} \end{cases}$$

$$f_5^*(x) = \begin{cases} (x - 70)/15, x \in (70,85] \\ 1, x \in (85,100] \\ 0, \text{else} \end{cases}$$



(Figure 3: Trigonometric Whitening Weight Function of the Center Point)

3.3.4 Grey Clustering Evaluation Steps for D&A Maturity

1) Calculate the evaluation matrix of PEOM, TECM, PROM.

Assign (x_1, x_2, x_3, x_4), (x_5, x_6, x_7, x_8), $(x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14})$to the parameters of the trigonometric whitening weight function respectively.

$$M1=\begin{bmatrix} f_1^*(x_1) & \cdots & f_5^*(x_1) \\ \vdots & \ddots & \vdots \\ f_1^*(x_4) & \cdots & f_5^*(x_4) \end{bmatrix}$$

$$M2=\begin{bmatrix} f_1^*(x_5) & \cdots & f_5^*(x_5) \\ \vdots & \ddots & \vdots \\ f_1^*(x_8) & \cdots & f_5^*(x_8) \end{bmatrix}$$

$$M3=\begin{bmatrix} f_1^*(x_9) & \cdots & f_5^*(x_9) \\ \vdots & \ddots & \vdots \\ f_1^*(x_{14}) & \cdots & f_5^*(x_{14}) \end{bmatrix}$$

2)Calculate PEOM, TECM, PROM.

First, we use matrix multiplication to obtain maturity level membership degree, where $SPEOM^k$, $STECM^k$, $SPROM^k$ $(1 \leq k \leq 5)$ respectively are the elements of the resulting matrix.

$$\sigma_1 = \omega_1 \times M_1 = (SPEOM^1,\ SPEOM^2, SPEOM^3, SPEOM^4,\ SPEOM^5)$$
$$\sigma_2 = \omega_2 \times M_2 = (STECM^1,\ STECM^2, STECM^3, STECM^4,\ STECM^5)$$
$$\sigma_3 = \omega_3 \times M_3 = (SPROM^1,\ SPROM^2, SPROM^3, SPROM^4,\ SPROM^5)$$

Then, according to maximum membership principle,

$$PEOM^{k_1}=\max(SPEOM^1,\ SPEOM^2, SPEOM^3, SPEOM^4,\ SPEOM^5)$$

Similarly,

$$TECM^{k_2}=\max(STECM^1,\ STECM^2, STECM^3, STECM^4,\ STECM^5)$$

$$PROM^{k_3}=\max(SPROM^1,\ SPROM^2, SPROM^3, SPROM^4,\ SPROM^5)$$

k_j (1≤j≤3)is the maturity gray level of the subsystem: People, Technology, Process. Namely, PEOL equals to k_1, TECL equals to k_2, PROL equals to k_3.

At the same time, $PEOM^{k_1}$, $TECM^{k_2}$, $PROM^{k_3}$ equals to the confidence level of the respective evaluation.

3)Calculate DASL.

According to Cannikin Law, the formula of DASL is as follows:

DASL=min(PEOL, TECL, PROL)

4 TASK2: Model Presentation

ICM companies can use the model above to test their maturity and make appropriate adjustments aimed at weakness.

4.1 Calculate the DASL

Assuming that ICM invites a group of experts to score the D&A system from the angles of C1 to C14 in percentage. we take their mean value as the final evaluation value of the indicators to reduce subjective error.

Then, indicators of people can from C1 to C4 form a vector: $score_1$= [89,78,91,85], indicators of technology form a vector: $score_2$= [60,77,75,58] and indicators of process form a vector: $score_3$ = [98,76,88,70,82,91].

1) We can figure out M_1, M_2, M_3.

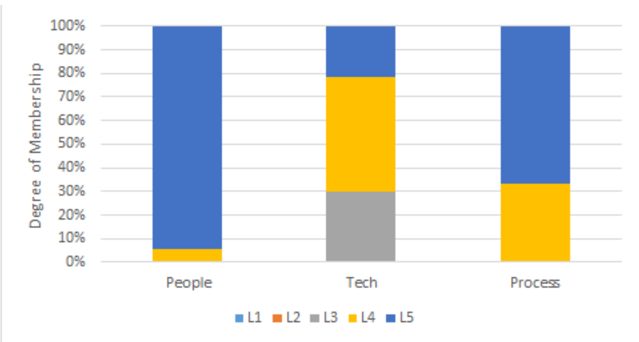
$$M1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 1.0000 \\ 0 & 0 & 0 & 0.4667 & 0.5333 \\ 0 & 0 & 0 & 0 & 1.0000 \\ 0 & 0 & 0 & 0 & 1.0000 \end{bmatrix}$$

$$M2 = \begin{bmatrix} 0 & 0 & 0.6667 & 0.3333 & 0 \\ 0 & 0 & 0 & 0.5333 & 0.4667 \\ 0 & 0 & 0 & 0.6667 & 0.3333 \\ 0 & 0 & 0 & 0.2000 & 0 \end{bmatrix}$$

$$M3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 1.0000 \\ 0 & 0 & 0 & 0.6000 & 0.4000 \\ 0 & 0 & 0 & 0 & 1.0000 \\ 0 & 0 & 0 & 1.0000 & 0 \\ 0 & 0 & 0 & 0.2000 & 0.8000 \\ 0 & 0 & 0 & 0 & 1.0000 \end{bmatrix}$$

2) We can figure out $\sigma_1, \sigma_2, \sigma_3$.

$$\sigma_1 = \omega_1 \times M_1 = [0, 0, 0, 0.0550, 0.9450]$$
$$\sigma_2 = \omega_2 \times M_2 = [0, 0, 0.2963, 0.4877, 0.2160]$$
$$\sigma_3 = \omega_3 \times M_3 = [0, 0, 0, 0.3350, 0.6649]$$



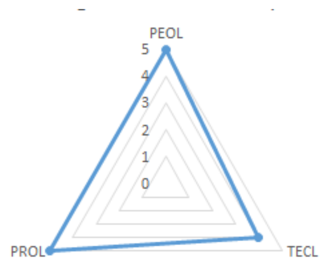
(Figure 4: Membership Ratio Diagram)

We can find that the maximum value in σ_1 is 0.9450 in the fifth column, the maximum value in σ_2 is 0.4877 in the fourth column and the maximum value in σ_3 is 0.6649 in the fifth column.

So, PEOL equals to Level 5 with 0.9459 as the confidence level of the evaluation, TECL equals to Level 4 with 0.4877 as the confidence level of the evaluation and PROL equals to Level 5 with 0.6649 as the confidence level of the evaluation.

3) DASL=min(5, 4, 5)=4

4.2 Advice on changes to the system



(Figure 5: Radar Map of PEOL, PROL, TECL)

During calculating the DASL, we can easily find the weak part in the system. It can be seen from 4.1.3) that the performance of TECL have a negative influence relatively.

Therefore, chances are that ICM takes actions to improve technology to reach a better situation. The changes that ICM can make now are:

Change 1: Better the most important indicator C7.

By weight matrix w_2, we can see that the most important role played in TECL is C7 Complete Order Attribution Function. Commercial tools which analyse the order information should be improved or replaced with better ones.

Change 2:

Promote the integration of port data resources, strengthen the whole process of port trade logistics information collection and build a unified, open, complete, safe and efficient big data management platform.

Change 3:

Achieve precise scheduling and orderly management of intelligent horizontal transport equipment of containers, and fully support the joint operation of all equipment elements of intelligent terminals such as automated quay bridge, automated rail bridge and intelligent horizontal transport equipment.

4.3 Other Aspects Based on our Models

4.3.1 People

Other things equal, we should give priority to those with higher technical level, which can effectively improve the maturity of people when hiring D&A talents. We advocate using professional D&A personnel instead of training existing employees to complete data analysis tasks. After all, the professional ability of the existing staff is not as good as that of D&A staff. But we still attach importance to making other non-professional staff informed of data.

Also, we focus on the question whether contracting or hiring talents. We can easily get four combinations of strategies as shown in the table:

Employee / Employer	Agree	Disagree
Agree	Success	Failure
Disagree	Failure	Failure

(Table 8: Combination of Behavioral Strategies in Signing Labor Contract)

Using Game Theory and Pareto Improvement Theory, we can conclude that signing labor contract contributes to achieving a win-win situation.

4.3.2 Technology

We summarize the main functions that a good data analysis tool should have by statistics and comparison of current commercial analysis tools. Analyzing tools such as Excel and Python, we find that Excel is weak in the processing of large data and Python is weak in the implementation of cross-platform. Therefore, we recommend that more advantageous analysis tools should be selected according to different data sets and task requirements.

4.3.3 Process

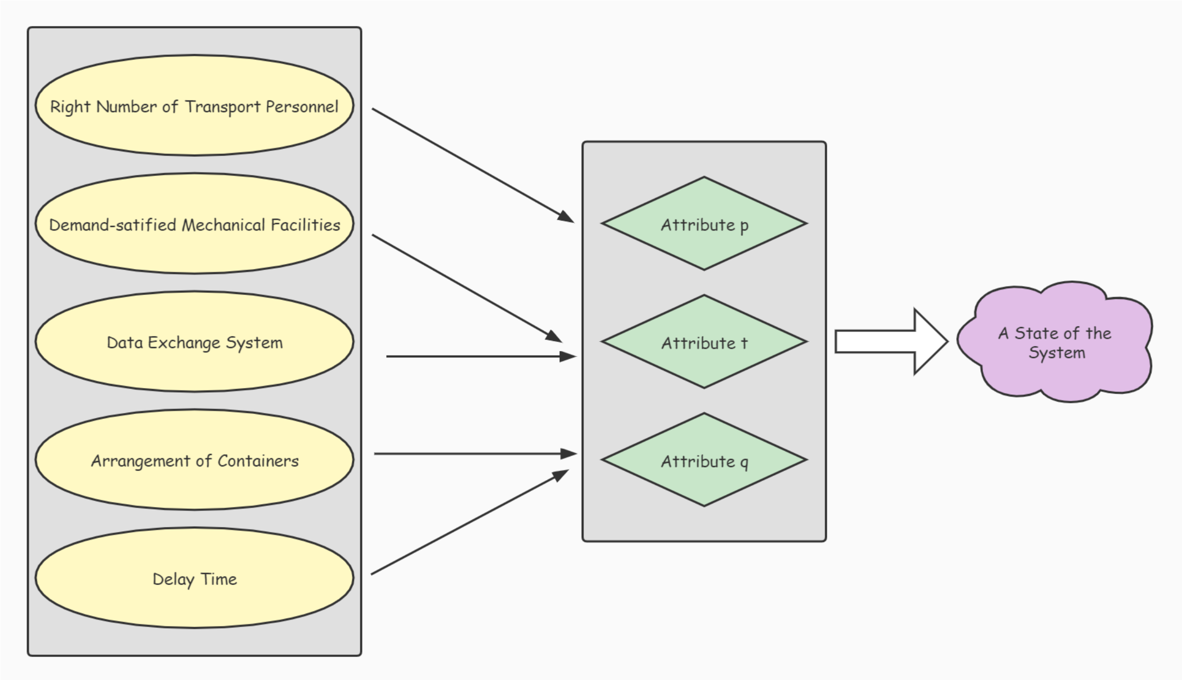
Good data governance can increase the value of data. Starting with metadata management, we present six points (C9~C14) in data governance we should pay attention to. It is recommended that the Information Security Officer (ISO) review the company's data governance plan against these points and make appropriate adjustments.

5 TASK3: Measure the Effectiveness of D&A System

Construction of System Effectiveness Analysis (SEA)

5.1 Determine the Relationship between System: Raw Parameters, Attributes and System State

Related to the business of ICM, we choose five indicators : Right Number of Transport Personnel, Demand-satisfied Mechanical Facilities, Data Exchange System, Arrangement of Containers and Delay Time written as X_1, X_2, X_3, X_4, X_5 respectively later as system raw parameters $\boldsymbol{X}$. They form three attributes written as *p*,*t*,*q* through some kind of function mapping written as f. Then, a state of the system can be mapped from *p*,*t*,*q* which construct a attribute space.



(Figure 6: the Relationship between System Raw Parameters, Attributes, and System State)

5.2 Steps for Measuring the Effectiveness

1) For our ideal goal, X_1, X_2, X_3, X_4, X_5 have a range of values. They form some consecutive points in attribute space, i.e., $\mathrm{L_m}$.

2) Let s be any state of the system which has a random distribution density $\mu(s)$.

Easy to know,

$$\int_{\mathbf{s}} \boldsymbol{\mu}(\mathbf{s})\,\mathbf{ds} = \mathbf{1}$$

Then points on L_s written as m_s also have corresponding random probability density functions:

$$\boldsymbol{\lambda}(\mathbf{m_s}) = \boldsymbol{\lambda}\big(\mathbf{f}(X)\big),\ \mathbf{m_s} \in \mathbf{L_s}$$

The system efficiency can be taken as E meeting a formula:

$$\mathbf{E} = \int_{\mathbf{L_s} \cap \mathbf{L_m}} \boldsymbol{\lambda}(\mathbf{m_s})\,\mathbf{dm_s}$$

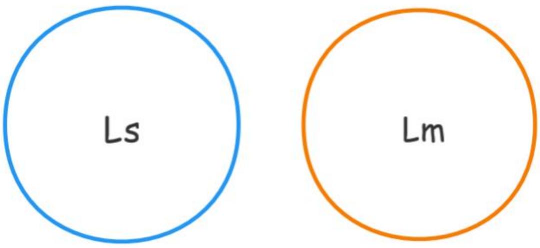
3) Specifically, if the points on L_s are uniformly distributed, i.e., $\boldsymbol{\lambda}(\mathbf{m_s}) = \frac{\mathbf{1}}{\mathbf{V}(\mathbf{L_s})}$, We define two indicators E^1, E^2 meaning matching score between L_s and L_m to measure the system effectiveness concretely, formulas are as follow where V represents the volume of Euclidean space:

$$\mathbf{E^1} = \frac{\mathbf{V}(\mathbf{L_s} \cap \mathbf{L_m})}{\mathbf{V}(\mathbf{L_s})}, \qquad \mathbf{E^2} = \frac{\mathbf{V}(\mathbf{L_s} \cap \mathbf{L_m})}{\mathbf{V}(\mathbf{L_m})}$$

5.3 Some Analyses under Uniform Distribution

We give the following five geometric relationships between L_s and L_m and show them in Venn diagrams vividly.

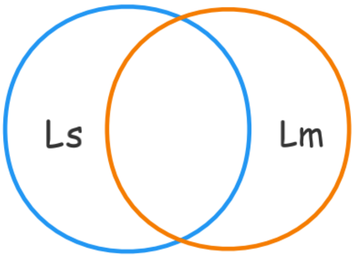
1) There is no intersection, i.e.,$(L_s \cap L_m)=\varnothing$.



(Figure 7: The First Relationship between L_s and L_m in Two-dimensional Space)

In this case, the effectiveness of the system is 0, because the system attributes do not satisfy the ideal attributes.

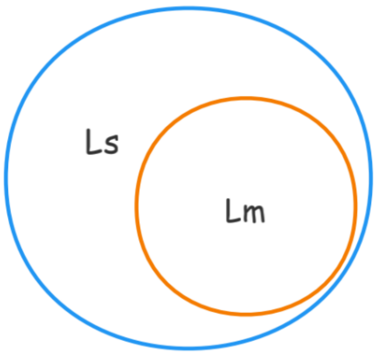
2)They have common points, but do not contain each other, $\text{i.e.}, (L_s \cap L_m) \neq \varnothing$ and $(L_s \cap L_m) < L_s, (L_s \cap L_m) < L_m$.



(Figure 8: The Second Relationship between L_s and L_m in Two-dimensional Space)

In this case, the system can meet some ideal attributes, but there are some functions outside the ideal, indicating that the system does not accurately understand the given task.

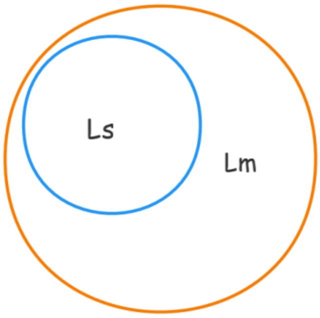
3) L_m is contained within L_s, $\text{i.e.} (L_s \cap L_m) = L_m$.



(Figure 9: The Third Relationship between L_s and L_m in Two-dimensional Space)

In this case where $L_s > L_m$ and $E^1 < 1, E^2 = 1$, the actual attributes meet ideal attributes, but the real capability of the system itself exceeds the requirements of the ideal attributes. In given ideal attribute, only part of the resources of the system are utilized, which indicates that the system functions are redundant and inefficient.

4) L_s is contained with L_m , i.e. $(L_s \cap L_m) = L_s$.



(Figure 10: The Fourth Relationship between L_s and L_m in Two-dimensional Space)

In this case where $L_s < L_m$ and $E^1 = 1, E^2 < 1$, the system is not perfect for its attributes fail to live up to expectations.

5) They overlap each other completely, i.e. $(L_s \cap L_m) = (L_m = L_s)$.

In this case where $E^1 = 1$, $E^2 = 1$, the system can fulfill the given mission requirements very well, which is the best case for effectiveness.

6 TASK4: Extension of our PTP Model

We think that our PTP Model can also be used to measure the maturity of other systems.

6.1 For Ports of Different Sizes

For ports of different sizes, the weight parameters need to be adjusted. The larger the port scale is, the higher the requirements for data integration function and timeliness. Therefore, we can consider increasing the corresponding weight appropriately. Faced with more pressure on data transmission speed and coordination under this condition, we can also pay more attention to dealing with coordination within the system. On the contrary, the smaller the port scale is, the lower the requirements for speed of data transformation, so we should put more emphasis on the accuracy of the data instead of the ability to process large amounts of data.

6.2 For Other Industries

Our model applies to other industries too. Based on the system requirements of different industries, we can establish different evaluation indicators, assign weight to them, and measure the maturity using our method.

Taking trucking companies as an example, our model can also measure the maturity of trucking companies in some indicators such as personnel deployment, vehicle loading and transportation like People, Technology and Process in our PTP model. Companies can refer to the evaluation results of this model to better their own systems.

6.3 Benefits

Actually, our measurement model makes for mutual benefits. If one of ICM's customers uses our model to evaluate a similar situation, ICM will benefit from the optimized customer’s system.

For example, taking a truck transportation company as a customer of ICM, the whole process of moving containers in the port involves inland transport by track. Therefore, we can consider that the efficiency of ICM in port is related to the efficiency of trucking companies in inland transport. Trucking company had better accurately deploy vehicles to complete container transport in ports, so as not to cause cargo squeezing or idle vehicles, which also needs a similar PTP model to evaluate and optimize.

7 Conclusion

7.1 Strengths

1) Based on the function of D&A system and the business situation of ICM company, we establish three first-level indicators: People, Technology and Process, and select several second-level indicators that can describe the data analysis system and data governance. It is relatively comprehensive.

2) The results of the model are reliable. When calculating the maturity of the system, we use the methods combining subjective and objective. We adopt the whitening weight function to carry out gray clustering and give the confidence level of maturity.

3) Our model has high applicability and can give the corresponding maturity level in different cases.

4) By projecting the functions of the D&A system to the spatial level, we can more intuitively judge the operation of the current system and facilitate personnel to adjust the system.

7.2 Weaknesses

1) Analytic Hierarchy Process (AHP) are in line with common sense, but there are certain subjective problems in the construction of indicators and evaluation matrix. It is unavoidable although we take the average value to reduce subjectivity.

2) The selection of the center point of whitening weight function needs to be improved in combination with the evolution and development of system in practice.

7.3 Promotion

After knowing the detailed information of ICM company, we can select more accurate indicators, or use TOPSIS method to provide ICM company with tailored service.

A Letter to Customers

Dear Sir/Madam,

Very glad to tell you about the recent situation of our company! We have introduced a model termed PTP to measure maturity level of the data and analytics(D&A) system we use to provide better service.

Detailed methods of measurement go as followed.

Firstly, we determine fourteen factors affecting the maturity of D&A system. With Analytic Hierarchy Process (AHP), we obtain three weight vectors through evaluation matrix of multiple experts, all of which pass the consistency test.

On this basis, we adopt the gray clustering method to evaluate the D&A maturity which is divided into five levels. For three independent groups: People, Technology and Process, we calculate their evaluation matrix respectively and cluster them by using the center point triangular whitening weight function, and obtain their maturity level membership degree. According to the principle of maximum membership degree, we get the grey class level of system maturity about people, technology and process respectively. According to the Cannikin Law, we take the minimum value among them as the level of D&A system maturity.

Meanwhile, we use another model System Effectiveness Analysis(SEA) to evaluate the effectiveness of the D&A system.

Based on PTP and SEA, we could pinpoint the weaknesses of our D&A system and make more appropriate adjustments to supply more high-class service with high quality, quantity and efficiency for you.

All in all, knowing importance of the port, we ICM Cooperation concentrate on continuous development as well as the strategic goal of building a first-class port with innovation, intelligent operation and superb logistics capacity. We always try our best to service our customers, heart and soul.

Your favor is the biggest reward for our dedication.

Yours sincerely

ICM Cooperation

References

[1]Dong, F.Y. et al. Construction Method of Whitenization Weight Function in Grey System Teaching. Journal of North China University of Water Resources and Electric Power, 2010,31(3):97-99. DOI:10.3969/j.issn.1002-5634.2010.03.030.
[2]GB/T 36344-2018, Information Technology data quality evaluation index[S].
[3]Guide to selecting commercial Web analytics tools. Retrieved from http://www.searchmarketingart.com/commercial-web-analytics-tool-selection-guide-feature-articles.html
[4]Ji, C.S..J． The basis of talent evaluation. Journal of Xuzhou Education College, 2004(1). DOI:10.3969/j.issn.1674-358X.2004.01.012.
[5]Ke, H.F. & J.L, Zhu. et al. Grey Clustering Approach of System Maturity of Information System under Given Confidence Level. Journal of Academy of Armored Force Engineering, 2018(4). DOI:10.3969/j.issn.1672-1497.2018.04.018.
[6]Li, Z.M. Research on effectiveness evaluation method based on SEA.National University of Defense Technology, 2003. DOI:10.7666/d.y519920
[7]Zhang, Z.H. & W.Wang. Analysis on the Decision-making Behavior in Signing of Labor Contracts. Journal of Business Economics, 2009(5). DOI:10.3969/j.issn.1000-2154.2009.05.006.

Appendix

1.AHP.m

```
disp('Input criteria layer judgment matrix A(n order) ');A=input('A=');
[n,n]=size(A);[V,D]=eig(A);
tempNum=D(1,1);
pos=1;
for h=1:n
    if D(h,h)>tempNum
        tempNum=D(h,h);
        pos=h;
    end
end
w=abs(V(:,pos));w=w/sum(w);t=D(pos,pos);
disp('Eigenvector of criteria layer w=');disp(w);disp('the largest eigenvalue of criteria layer t=');disp(t);
CI=(t-n)/(n-1);RI=[0 0 0.52 0.89 1.12 1.26 1.36 1.41 1.46 1.49 1.52 1.54 1.56 1.58 1.59 1.60 1.61 1.615 1.62 1.63];
CR=CI/RI(n);
if CR<0.10
    disp('Pass the consistency test!');
    disp('CI=');disp(CI);
    disp('CR=');disp(CR);
else disp('Fail the consistency test, please re-score!');
end
```

2.grey_maturity.m

```
y1=@(x)(1.*(x>=0&x<30)+((40-x)/10).*(x>=30&x<40));
y2=@(x)(((x-30)/10).*(x>30&x<=40)+((55-x)/15).*(x>40&x<55));
y3=@(x)(((x-40)/15).*(x>40&x<=55)+((70-x)/15).*(x>55&x<70));
y4=@(x)(((x-55)/15).*(x>55&x<=70)+((85-x)/15).*(x>70&x<85));
y5=@(x)(((x-70)/15).*(x>70&x<=85)+1.*(x>85&x<=100));
disp('input vector x');x=input('x=');
res=[y1(x);y2(x);y3(x);y4(x);y5(x)];
ress=res'
disp('input wight w');w=input('w=');
final=w*ress
```