SOLITON SOLUTION IN (3+1)- DIMENSIONS

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ABSTRACT

Abstract—Solitons are among the most beneficial solutions for science and technology, from ocean waves to transmission of information through optical fibers or energy transport along protein molecules. The existence of multi-solitons, especially three-soliton solutions, is essential for information technology: it makes possible undisturbed simultaneous propagation of many pulses in both directions.

In this talk, we will use the Pfaffian technique, along with the Hirota bilinear method to construct new classes of exact multi-soliton solutions in the 3+1 dimensions to various of the most fundamental nonlinear partial differential equations such as the prestigious Korteweg-de Vries (KdV), nonlinear Schrödinger (NLS) equations, Kadomtsev-Petviashvili (KP), Davey-Stewartson (DS) equations, B-type KP equation, nonlinear equations of Jimbo-Miwa type and many others.

Index Terms— Pfaffian solutions, N-soliton solutions, NLPDEs, Soliton equations, Jimbo-Miwa.

I. INTRODUCTION

The Korteweg-deVries equation is a typical example of what is known as completely integrable nonlinear partial differential equation, whose many remarkable properties were first discovered in the mid 1960's. A surprisingly large number of such completely integrable nonlinear systems arise in a wide range of applications, and their analysis remains an active area of contemporary research. In 1971, Hirota [1] developed an ingenious direct method for obtaining the exact multi-soliton solution of the Korteweg-deVries equation and suggested an explicit and beautiful expression for N-soliton solutions. His method consists of employing a perturbation method after transforming the soliton equations into bilinear forms. This method was shown to be applicable to a large class of soliton equations such as the KP equation, the Boussinesq equation and the Burgers equation [2, 3]. A central issue in the study of soliton equations and non-linear evolution equations is that solutions may exist locally in time (that is, for short times) but not globally in time. Indeed, finite-time blow-up of solutions can often happen. One of the simplest nonlinear PDE's which exhibits blow-up is the in-viscid Burgers equation. Over the past decades, various kinds of powerful methods have been proposed to find N-soliton solutions to soliton equations such as the dressing method [4] and inverse scattering method [5]. In recent years, Hirota method has been extended to construct more general exact solutions for many soliton equations, including Wronskian determinant solutions [6, 7, 14, 17, 20, 21] and Grammian determinant solutions [2, 8, 12, 13,16, 18]. Interestingly, some Hirota bilinear equations even possess linear subspaces of their solutions [9]. Grammian solutions to a (3+1)-dimensional generalized KP equation were constructed in [10] and Pfaffian solutions to a (3+1)-dimensional generalized BKP equation were constructed in [11, 19].

In this paper, we would like to discuss the non-linear soliton equation [9]:

$$2v_{yt} + v_{xxxy} + 3v_{xx}v_y + 3v_x v_{yx} - 3v_{zz} = 0,$$

which can be written in terms of the Hirota bilinear operator. In fact, the above soliton equation belong to a class of 3+1 dimensional soliton equations of Jimbo-Miwa type presented in [9], but does not belong to a class of generalized non-linear evolution equations [16]:

$$(u_{x_1x_1x_1} - 6uu_{x_1})_{x_1} + \sum_{i,j=1}^{M} a_{ij}u_{x_i}u_{x_j} = 0,\ a_{ij} = \text{Constant},\ M \in \mathbb{N}.$$

We will show the above (3+1)-dimensional soliton equations have a class of Pfaffian solutions, with all generating functions for matrix entries satisfying linear systems of partial differential equations involving free parameters. The Pfaffian identities for determinants are the key to establish the Pfaffian formulation [13]. Examples of Pfaffian solutions are explicitly computed, and a few plots of particular solutions are made.

II. Bilinear form and Pfaffian

A. Bilinear Form

In the present paper, we consider the following (3+1)-dimensional soliton equation of Jimbo-Miwa type:

$$2v_{yt} + v_{xxxy} + 3v_{xx}v_y + 3v_x v_{yx} - 3v_{zz} = 0, \tag{1}$$

under the dependent variable Cole-Hopf transformations

$$u = 2(\ln\tau)_x, \quad v = 2(\ln\omega)_x, \tag{2}$$

the above (3+1)-dimensional nonlinear Jimbo-Miwa type equation are mapped into Hirota bilinear equation:

$$\left(2D_tD_y + D_x^3D_y - 3D_z^2\right)\omega.\omega = 0. \tag{3}$$

Here the bilinear differential operator D_x and $D_y : \Omega \times \Omega \to \Omega$ are defined by

$$D_x^nD_y^m g(x,y).f(x,y) = \left(\frac{\partial}{\partial x} - \frac{\partial}{\partial x'}\right)^n\left(\frac{\partial}{\partial y} - \frac{\partial}{\partial y'}\right)^m g(x,y)f(x',y')|_{x=x',y=y'},$$

where $n,m \geq 0$ and $g,f \in \Omega : C^\infty \to C$, where C^∞ is the space of differentiable functions. We can rewrite the equations (3) in terms of ω as follows

$$\left(\omega_{xxxy} + 2\omega_{ty} - 3\omega_{zz}\right)\omega - 3\omega_{xxy}`\omega_x + 3\omega_{xx}\omega_{xy} - 2\omega_t\omega_y - \omega_{xxx}\omega_y + 3\omega_z^2 = 0.$$

In this paper, we will use the Pfaffian technique to find exact solutions to the above (3+1)-dimensional soliton equation of Jimbo-Miwa type. In what follows, we will introduce two useful lemmas about the Pfaffian expansion and derivatives formulation.

B. Pfaffian

Let us recall some basics about the Pfaffian. The Pfaffian of even order denoted by $(\alpha_1, \alpha_2, \ldots, \alpha_{2N})$ is defined by [15]

$$(\alpha_1, \alpha_2, \ldots, \alpha_{2N}) = \textstyle\sum_\sigma \mathrm{sgn}(\theta)(\alpha_{i_1}, \alpha_{i_2})(\alpha_{i_3}, \alpha_{i_4}) \ldots (\alpha_{i_{2N-1}}, \alpha_{i_{2N}}), \tag{4}$$

where the summation is taken over all permutations

$$\theta = \begin{pmatrix} 1 & 2 & \ldots & 2n \\ i_1 & i_2 & \ldots & i_{2n} \end{pmatrix}$$

with

$$i_1 < i_2, i_3 < i_4, \ldots, i_{2n-1} < i_{2n}, i_1 < i_3 < \cdots < i_{2n-1},$$

and $\mathrm{sgn}(\theta) = \pm 1$ denotes the parity of the permutation θ. The elements (α_i, α_j) are called the Pfaffian entries satisfying

$$(\alpha_i, \alpha_j) = -(\alpha_j, \alpha_i).$$

The interchange of labels α_i and α_j changes the parity of each permutation θ in the sum, and thus, the Pfaffian has the skew-symmetric property

$$(\alpha_1, \ldots, \alpha_i, \ldots, \alpha_j, \ldots, \alpha_{2N}) = -(\alpha_1, \ldots, \alpha_j, \ldots, \alpha_i, \ldots, \alpha_{2N}), \tag{5}$$

where $1 \leq i \leq j \leq 2N$. The Pfaffian also satisfies

$$(\alpha_1, \alpha_2, \ldots, \alpha_{2N})^2 = \det(a_{ij})_{1\leq i,j\leq 2N}, a_{ij} = (\alpha_i, \alpha_j), \tag{6}$$

and so, it is denoted conventionally by

$$\mathrm{Pf}(a_{ij})_{1\leq i,j\leq 2N} = (\alpha_1, \alpha_2, \ldots, \alpha_{2N}) = \\ = \left| \begin{matrix} a_{1,2} & a_{1,3} & \cdots & a_{1,2N} \\ & a_{2,3} & \cdots & a_{2,2N} \\ & & \ddots & \vdots \\ & & & a_{2N-1,2N} \end{matrix} \right|.$$

When $N = 1,2$, the Pfaffian read

$$(\alpha_1, \alpha_2) = a_{1,2}, (\alpha_1, \alpha_2, \alpha_3, \alpha_4) = a_{1,2}a_{3,4} - a_{1,3}a_{2,4} + a_{1,4}a_{2,3}. \tag{7}$$

Moreover, the Pfaffian obeys an expansion rule

$$(\alpha_1, \alpha_2, \ldots, \alpha_{2N}) = \textstyle\sum_{j=1}^{2N}(\alpha_i, \alpha_j)\Gamma(i,j), \quad 1 \leq i \leq 2N, \tag{8}$$

with the cofactor $\Gamma(i,j)$ being defined by

$$\Gamma(i,j) = (-1)^{i+j}(\alpha_1, \dots, \hat{\alpha}_i, \dots, \hat{\alpha}_j, \dots, \alpha_{2N}), i < j,$$
$$\Gamma(i,j) = -\Gamma(j,i), i > j, \Gamma(i,i) = 0,$$

where $\hat{\alpha}_k$ means that the label α_k is omitted. We have several expansion theorems on the Pfaffian. Below we describe two of them, which are relevant to the present paper.

Lemma 1 Let n be a positive integer. Then

$$(\alpha_1, \alpha_2, 1, 2, \dots, 2n) = \sum_{j=2}^{2n} (-1)^j (\alpha_1, \alpha_2, 1, j) \, [(2, 3, \dots, \hat{j}, \dots, 2\mathrm{n}) + (1, j)(\alpha_1, \alpha_2, 2, 3, \dots, \hat{j}, \dots, 2\mathrm{n})] - (\alpha_1, \alpha_2)(\alpha_1, \alpha_2, 1, 2, \dots, 2n), \quad (9)$$

and

$$(\beta_1, \beta_2, \gamma_1, \gamma_2, 1, 2, \dots, 2n) = \sum_{j=1}^{2n} \sum_{k=j+1}^{2n} (-1)^{j+k-1} (\beta_1, \beta_2, j, k) \times (\gamma_1, \gamma_2, 1, 2, \dots, \hat{j}, \dots, \hat{k}, \dots, 2n), \quad (10)$$

provided that

$$(\beta_j, \gamma_k) = 0, \text{for } j, k = 1, 2.$$

We shall use the equality (11) and the equality (12) to express the derivatives of the Pfaffian by the Pfaffians of lower order. In the next lemma, we describe two of the identities of Pfaffians which correspond to the Jacob identity of determinants.

Lemma 2 Let m and n be positive integers. Then

$$(\alpha_1, \alpha_2, \dots, \alpha_{2m}, 1, 2, \dots, 2n)(1, 2, \dots, 2n) = \sum_{s=2}^{2m} (-1)^s (\alpha_1, \alpha_s, 1, 2, \dots, 2n) \times (\alpha_2, \dots, \hat{\alpha}_s, \dots, \alpha_{2m}, 1, 2, \dots, 2\mathrm{n}), \quad (11)$$

and

$$(\alpha_1, \alpha_2, \dots, \alpha_{2m-1}, 1, 2, 3, \dots, 2n-1)(1, 2, \dots, 2n) = \sum_{s=1}^{2m-1} (-1)^{s-1} (\alpha_s, 1, \dots, 2n-1) \times (\alpha_1, \alpha_2, \dots, \hat{\alpha}_s, \dots, \alpha_{2m-1}, 1, \dots, 2\mathrm{n}). \quad (12)$$

We shall use the above Lemma with $m = 2$ to get the desired Pfaffian identities

III. PFAFFIAN SOLUTIONS

In this section, we would like to discuss Pfaffian solutions to two (3+1)-dimensional soliton equations of Jimbo-Miwa type (1). Let us take the following Pfaffian

$$\omega_n = \mathrm{Pf}(\mu_{i,j})_{1 \le i,j \le 2n}, \quad (13)$$

$$\mu_{ij} = C_{ij} + \int_{-\infty}^{x} D_x \xi_i \cdot \xi_j dx, \quad i, j = 1, 2, \dots, 2n, \quad (14)$$

where $C_{ij} = (-C_{ji} \text{ for } i \neq j)$ are constants, and all $\xi_i, 1 \leq i \leq 2n,$ satisfy the linear differential equations:

$$\xi_{i,y} = 2\alpha^2 \int_{-\infty}^{x} \xi_i(x)\, dx, \quad \xi_{i,z} = \sqrt{2}\alpha\xi_{i,x}, \quad \xi_{i,t} = -\frac{1}{2}\xi_{i,xxx}, \qquad (15)$$

where α being an arbitrary nonzero parameter, and all ξ_i satisfy the boundary condition $\xi_i(-\infty) = 0$ for $i = 1,2,\ldots,2n$.

Theorem 3. If $\xi_i(x,y,z,t),\ 1 \leq i \leq 2n,$ satisfy (39), then the Pfaffian defined by (37) solves the Hirota bilinear equation (5) and the function $v = 2(\ln \omega_n)_x$ solves the (3+1)-dimensional soliton equation of Jimbo-Miwa type (2).

Proof . Let us express the Pfaffian as

$$\omega_n = (1,2,\ldots,2n) = (\bullet). \qquad (16)$$

By using the same technique as before and the equation (38) and the equation (39), we may get

$$\mu_{ij,x} = \xi_j\xi_{i,x} - \xi_i\xi_{j,x} = (d_0, d_1, i, j), \qquad (17)$$

$$\mu_{ij,y} = \frac{\partial}{\partial x_{-1}} \int_{-\infty}^{x} [\xi_j\xi_{i,x} - \xi_i\xi_{j,x}]dx$$

$$= 2\alpha^2[\xi_i\xi_{j,x_{-1}} - \xi_j\xi_{i,x_{-1}}] = 2\alpha^2(d_{-1}, d_0, i, j), \qquad (18)$$

$$\mu_{ij,z} = \sqrt{2}\alpha(d_0, d_1, i, j), \qquad (19)$$

$$\mu_{ij,t} = -\frac{1}{2}[\xi_j\xi_{i,xxx} - \xi_i\xi_{j,xxx} - 2(\xi_{j,x}\xi_{i,xx} - \xi_{i,x}\xi_{j,xx})]$$

$$= -\frac{1}{2}[(d_0, d_3, i, j) - 2(d_1, d_2, i, j)]. \qquad (20)$$

Therefore, from the above results (17)-(20), we have the following di¤erential formulae for ω_n:

$$\omega_{n,x} = (d_0, d_1, \bullet), \quad \omega_{n,y} = 2\alpha^2(d_{-1}, d_0, \bullet), \qquad (21)$$

$$\omega_{n,z} = \sqrt{2}\alpha(d_0, d_1, \bullet), \quad \omega_{n,t} = -\frac{1}{2}[(d_0, d_3, \bullet) - 2(d_1, d_2, \bullet)], \qquad (22)$$

$$\omega_{n,xx} = (d_0, d_2, \bullet), \quad \omega_{n,zz} = 2\alpha^2(d_0, d_2, \bullet), \qquad (23)$$

$$\omega_{n,xxx} = (d_1, d_2, \bullet) + (d_0, d_3, \bullet), \quad \omega_{n,yx} = 2\alpha^2(d_{-1}, d_1, \bullet), \qquad (24)$$

$$\omega_{n,yxx} = 2\alpha^2[(d_{-1}, d_2, \bullet) + (d_0, d_1, \bullet)], \qquad (25)$$

$$\omega_{n,yt} = -\alpha^2[(d_{-1}, d_3, \bullet) - (d_0, d_2, \bullet) - 2(d_{-1}, d_0, d_1, d_2, \bullet)], \qquad (26)$$

$$\omega_{n,yxxx} = 2\alpha^2[(d_{-1}, d_3, \bullet) + 2(d_0, d_2, \bullet) + (d_{-1}, d_0, d_1, d_2, \bullet)], \qquad (27)$$

where we have used the abbreviated notation $\bullet = 1, 2, \ldots, 2n$. Substituting the above derivatives of ω_n into the LHS of the equation (5), we arrive at

$$\begin{aligned}(\omega_{xxxy} + 2\omega_{ty} - 3\omega_{zz})\omega - 3\omega_{xxy}\omega_x &+ \\ 3\omega_{xx}\omega_{xy} - 2\omega_t\omega_y - \omega_{xxx}\omega_y + 3\omega_z^2 & \\ = 6\alpha^2[(d_{-1}, d_0, d_1, d_2, \bullet)(\bullet) - (d_{-1}, d_0, \bullet)(d_1, d_2, \bullet) & \\ +(d_0, d_2, \bullet)(d_{-1}, d_1, \bullet) - (d_0, d_1, \bullet)(d_{-1}, d_2, \bullet) &\end{aligned}$$

$$= 0, \tag{28}$$

where we have made use of the equation (11) with $m = 2$ to get our Pfaffian identities for determinants. This shows that the Pfaffian $\omega_n = \mathrm{Pf}(\mu_{i,j})_{1\le i,j\le 2n}$, with the conditions (15) solves the (3+1)-dimensional soliton equation of Jimbo-Miwa type (1), which ends the proof.

The system (15) has the solution in the form

$$\xi_i = \sum_{j=1}^{p} \rho_{ij} e^{\varphi_{ij}}, \quad \varphi_{ij} = l_{ij}x + 2\alpha^2 l_{ij}^{-1} y + \sqrt{2}\alpha l_{ij} z - \frac{1}{2} l_{ij}^3 t + \varphi_{ij}^0, \tag{29}$$

where ρ_{ij}, l_{ij}, and φ_{ij}^0 are free parameters and P is arbitrary natural number. In particular we have the following specific solutions, letting

$$\xi_i = e^{\varphi_i}, \quad \varphi_i = l_i x + 2\alpha^2 l_i^{-1} y + \sqrt{2}\alpha l_i z - \frac{1}{2} l_i^3 t + \varphi_i^0, \tag{30}$$

where l_i and φ_i^0 are free parameters, and α arbitrary nonzero parameter. In order to investigate those solutions of (5), we choose special values for $(C_{ij})_{n\times n}$ and the function ξ_i. For example, let

$$\xi_i = e^{\varphi_i}, \tag{31}$$

$$\varphi_i = l_i x + 2\alpha^2 l_i^{-1} y + \sqrt{2}\alpha l_i z - \frac{1}{2} l_i^3 t + \varphi_i^0, \tag{32}$$

we obtain

$$(i,j) = C_{ij} + \frac{l_i - l_j}{l_i + l_j} \xi_i \xi_j. \tag{33}$$

Let us consider the two-soliton and three-soliton solution for the equation (5). For the two-soliton solution we may choose $\mathrm{C}_{12} = \mathrm{C}_{34} = 1,\ \mathrm{C}_{13} = \mathrm{C}_{14} = \mathrm{C}_{23} = \mathrm{C}_{24} = 0$. Then

$$\omega_2 = (1,2)(3,4) - (1,3)(2,4) + (1,4)(2,3)$$

$$= 1 + \frac{l_1 - l_2}{l_1 + l_2} e^{\varphi_1 + \varphi_2} + \frac{l_3 - l_4}{l_3 + l_4} e^{\varphi_3 + \varphi_4}$$
$$+ \frac{(k_1-k_2)(k_1-k_3)(k_1-k_4)(k_2-k_3)(k_2-k_4)(k_3-k_4)}{(k_1+k_2)(k_1+k_3)(k_1+k_4)(k_2+k_3)(k_2+k_4)(k_3+k_4)} e^{\vartheta_1+\vartheta_2+\vartheta_3+\vartheta_4}.$$

Putting

$$\varpi_i = \varphi_i + \varphi_{i+1} + \rho_i, \text{where } e^{\rho_i} = \frac{l_i - l_{i+1}}{l_i + l_{i+1}}, \tag{34}$$

we may rewrite ω_2 as

$$\omega_2 = 1 + e^{\varpi_1} + e^{\varpi_3} + l_{12}^{34} e^{\varpi_1 + \varpi_3}, \tag{35}$$

where

$$l_{ij}^{lm} = \frac{(l_i - l_l)(l_i - l_m)(l_j - l_l)(l_j - l_m)}{(l_i + l_l)(l_i + l_m)(l_j + l_l)(l_j + l_m)}. \tag{36}$$

In a similar way we can obtain the three-soliton solution for the equation (5) by select some special values to the parameters. We may choose $\mathrm{C}_{12} = \mathrm{C}_{34} = \mathrm{C}_{56} = 1$, otherwise $\mathrm{C}_{ij} = 0$, and then we may rewrite ω_3 as

$$\omega_3 = 1 + e^{\varpi_1} + e^{\varpi_3} + e^{\varpi_5} + l_{12}^{34} e^{\varpi_1 + \varpi_3} + l_{12}^{56} e^{\varpi_1 + \varpi_5}$$

$$+l_{34}^{56}e^{\varpi_3+\varpi_5}+l_{123}^{456}e^{\varpi_1+\varpi_3+\varpi_5}, \tag{37}$$

where

$$l_{ijp}^{lmn}=l_{ij}^{pl}l_{ij}^{mn}l_{pl}^{mn}. \tag{38}$$

Therefore, if we put $l_{ij}^{lm}=e^{L_{ij}^{lm}}$ then the N-soliton solution of the equation (5) is expressed as

$$\omega_N=\sum\exp\left(\sum_{i=1}^{N}\beta_{2i-1}\varpi_{2i-1}+\sum_{i<j<l<m}^{(2N)}L_{ij}^{lm}\beta_i\beta_l\right). \tag{39}$$

Where $\sum$ denotes the summation over all possible combinations of $\beta_1=0,1,\ \beta_2=0,1,\dots,\ \beta_{2N}=0,1,$ and $\sum_{i<j<l<m}^{(2N)}$ is the sum over all $i,\ j,\ l,\ m\ (i<j<l<m)$ chosen from $\{1,2,\dots,2N\}$. Furthermore, the equation (1) has the N-soliton solution

$$v=2\frac{\partial}{\partial x}(\ln\omega_N). \tag{40}$$

The following three Figs. 3.1, 3.2 and 3.3 of three dimensional plots and two dimensional contour plots show the corresponding Pfaffian solutions defined by (40) on the indicated specific regions, with specific values being chosen for the parameters. In the contour plots, we see the interaction regions and patterns of the involved solitons.

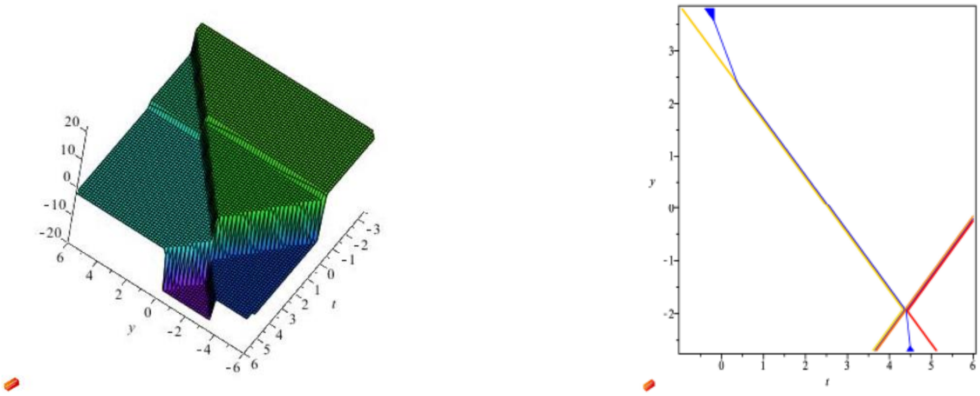

Figure 3.1: *N=3: k_1=-4,k_2=-3,k_3=-7,k_4=6,k_5=-1,k_6=5-6,a=6,x=-2,z=5.*

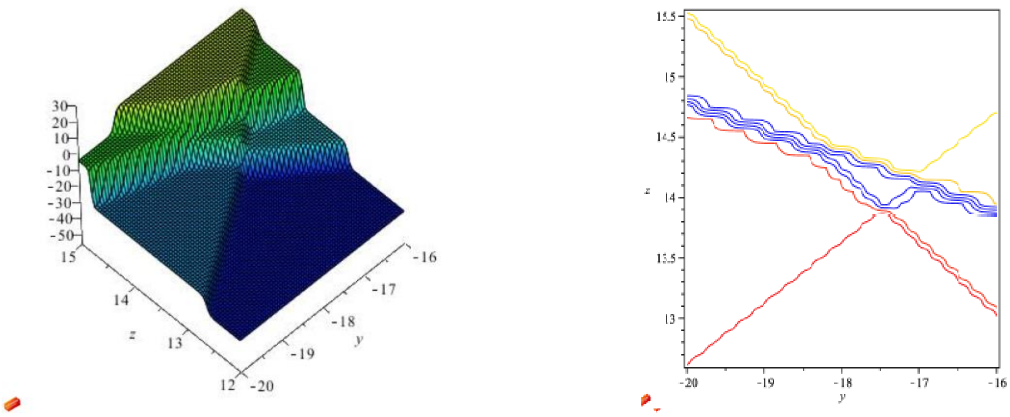

Figure 3.2: *N=3: k_1=7,k_2=-2,k_3=-3,k_4=-4,k_5=-5,k_6=-6,a=5,x=6,t=5.*

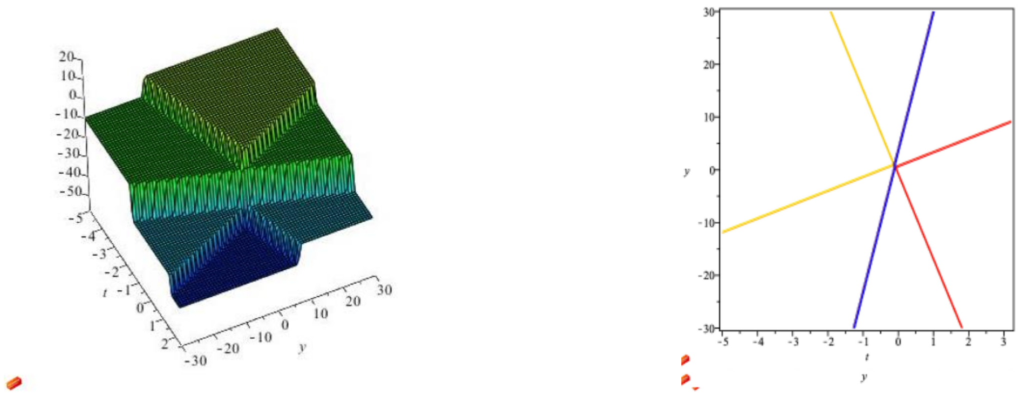

Figure 3.3: *N=3:* k_1=-5,k_2=-4,k_3=-3,k_4=-2,k_5=1,k_6=-6,a=-2,x=1,z=1.

IV. CONCLUSIONS

It is known that the Jimbo-Miwa equation is the second equation in the well-known KP hierarchy of integrable systems, which is used to describe certain interesting (3+1)-dimensional waves in physics but not pass any of the conventional integrability tests. In this paper, we have built an Pfaffian formulation for the (3+1)-dimensional soliton equation of Jimbo-Miwa type:

$$2v_{yt} + v_{xxxy} + 3v_{xx}v_y + 3v_x v_{yx} - 3v_{zz} = 0.$$

The facts used in our construction are the Pfaffian identities. Theorems 3 present the main results on Pfaffian solutions, which say that

$$v = 2\frac{\partial}{\partial x}(ln\,\omega_n), \qquad \omega_n = \mathrm{Pf}(\mu_{i,j})_{1\le i,j\le 2n},$$

where ω_n is defined by

$$\mu_{ij} = C_{ij} + \int_{-\infty}^{x} D_x\xi_i(x)\cdot\xi_j(x)dx,$$

with C_{ij} = constant, i, j = 1,2, ... ,2n, and ξ_i, $1 \le i \le 2n$, satisfying

$$\xi_{i,y} = 2\alpha^2\int_{-\infty}^{x}\xi_i(x)\,dx, \quad \xi_{i,z} = \sqrt{2}\alpha\xi_{i,x}, \quad \xi_{i,t} = -\frac{1}{2}\xi_{i,xxx},$$

where α is an arbitrary nonzero parameter, solve the (3+1) dimensional soliton equation of Jimbo-Miwa type (1). Examples of the Pfaffian solutions were made, along with a few plots of particular solutions. In Theorem 3, we only considered specific sufficient conditions: (15), though there is a free parameter α in the conditions. It would be great to look for more general conditions involving combined equations for Pfaffian solutions.

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INTERNET-BASED COMMUNICATION INFRASTRUCTURE FOR AN ECO-ACCOUNTING SYSTEM USING WEB-BASED SERVICES AND RFID TECHNOLOGY

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ABSTRACT

The Internet-based information communication infrastructure for an ecological accounting system, so called myEcoCost, is reported in this paper, which is applied to deliver the ecological impact assessment results of products through the product' life cycle from one operation model within supply chain to another, predominantly from supplier to customer. The infrastructure consists of upperware, middleware, and resource layers. As a significant feature of the infrastructure, load balancing is developed to handle the information data within the myEcoCost system using the Web-Service application programming interface (API) to distribute the load of tasks across different computers. The case study has been conducted to transmit the product's ecoCost information from a supplier to a consumer over the Internet, which successfully validated the system developed.

Keywords—Communication infrastructure, ecoCost, environmental impact of products, Internet, load balancing, RFID, Web Services, Web-based interface.

I. INTRODUCTION

Supported by the Environment programme of the European Commission's Seventh Framework, an ecological accounting system is developed by myEcoCosy project [4]. The ecological accounting system measures products' ecological cost, or so called 'ecoCost' in short, throughout the product supply chain as shown in Figure 1 [1].

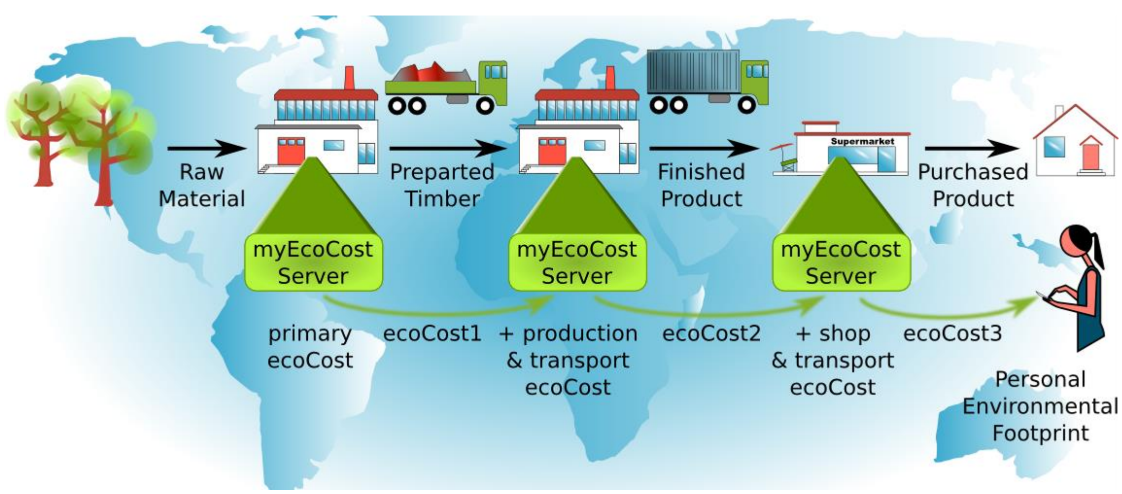

Figure 1 myEcoCost information flow

The myEcoCost project develops a methodology that defines a global collaborative network of resource accounting nodes. It provides a means of accounting for the usage of natural resources for products, services and technologies, to inform all economic actors on environmentally relevant information with dynamically calculated, near real time figures. Using an Internet-based Service Oriented Architecture (SOA), relevant and timely data is passed from supplier to customer recursively through the whole value chain to produce ecoCosts for each product or service [1] [4].

The project aims at developing key Information and Communication Technology (ICT) and software to demonstrate the resource accounting framework and infrastructure in a proof-of-concept prototype, involving users, environmental data processors and policy makers [4].

To fulfil the aim of the project, an Internet-based information communication infrastructure for myEcoCost environment is developed. It works as a top-level platform to coordinate the inter-operation among the operation models, including sustainable production and supply chain, environmental space, generic accounting systems, process supporting tools, distributed laboratory, and end user systems.

II. SYSTEM OVERVIEW

The information communication infrastructure is applied to coordinate and manage all the systems, platforms and interfaces within the myEcoCost environment. The infrastructure consists of upperware, middleware and resource layer.

As the top layer of the information communication infrastructure, as shown in the Figure 2, the upperware is developed to manage the middleware, which consists of intermediate systems and platforms (Web-based services, RFID-based mobile access network platform, load balancing system, and resource management system). Using a Web-based interfaces over the Internet, the upperware interacts with the operation models within the myEcoCost environment, namely suppliers and consumers using PC and mobile devices [1].

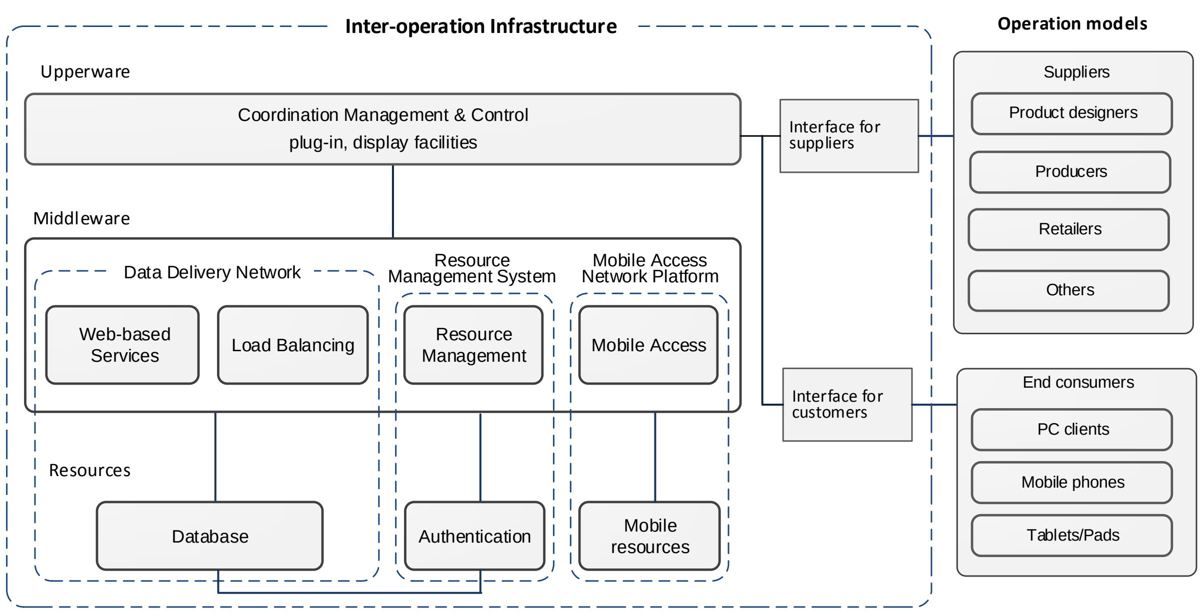

Figure 2 Overview of Information Communication Infrastructure

The major functions of the upperware includes controlling and coordinating mechanisms, plug-in and play facilities, to interact with the Middleware and integrate with resources (database, mobile facility and relevant resources).

The middleware's elements is connected to the upperware with the interface for the integration with middleware. To ensure that those interfaces are compatible with the upperware, the graphic user interfaces (GUIs) for the middleware are developed, which allows the manager to configure the systems and platform to manipulate the inter-operation among the systems. The necessary interfaces and GUIs are adapted to the different systems and platforms, and able to track and control the working status of those systems and platform through the wireless remote connectivity.

The middleware with the above systems and platform provides the following functions: Web-based interfaces and services for the interaction with operation models, the distribution of loads throughout the infrastructure, the optimisation of the flow of ecoCost information, management of the interfaces and related resources, and the mobile authorisation for the access to consumers. The resource layer interacts with the middleware and connects to the upperware via the interfaces.

III. TECHNOLOGIES APPLIED IN THE COMMUNICATION INFRASTRUCTURE

The major technologies used in the information communication infrastructure include Web-based services, RFID-based mobile access, load balancing, and resource management, which are detailed in the following sub-sections.

3.1 Web-based Services

Web-based services within the information communication infrastructure are used to produce and transfer the environmental impact value of products, which is called 'ecoCost' of products, from one operation model to another, for example, from a supplier's business server to a consumer's client computer. The major services implemented in the infrastructure contains invoice service, life-cycle inventory (LCI) service, consumer and business registration service, consumer account/HMI service, and software download service.

As a core service of myEcoCost system, the invoice service delivers ecoCost data from one business server to another one, and then to consumers. The data delivered by the invoice service include eco-invoice, eco-quote and eco-cost.

The invoice service allows for business servers to send and receive ecoCost data through the information communication infrastructure. For example, the business server initialises the contact with the infrastructure and submit a 'Send' request via calling the interface exposed by the Web server. Then the Web server passes the request on to the application server. The request includes ecoCost data to be transmitted to the next business in supply chain, and the ID of a session with which a business user is able to interact with the infrastructure. The application server performs the request via placing the ecoCost data in the correct location in the invoice database. After the operation successes, Web server sends back the result 'Success' to confirm with the business server regarding the completion of the operation.

3.2 Radio Frequency Identification (RFID)

Within each myEcoCost product, particularly electronic product, there is a RFID-based tag attached. The tag is written by the product's serial number. With identifying the serial number, the ecoCost information of product is able to be accessed from the myEcoCost system and then received by a consumer.

Also, the RFID technology is used to validate the consumer's identity when they try to access the product's ecoCost information from the myEcoCost system. Compared to traditional identification mechanism such as username/password, RFID simplifies the authentication process and facilitates the operation of consumers who is not required to enter the confidential [5] [6]. A RFID reader is used to capture the ecoCost information and relevant software is developed.

3.3 Load Balancing

Load balancing is developed to handle the information within the myEcoCost environment, which is streamed through the Web server and application server developed in the communication infrastructure. The load balancing system is able to automatically distribute the load of tasks across the different computers, to process and optimise the flow of myEcoCost information.

A typical load balancing system consists of a load balancer and load workers [1]. The load balancer is used to manage the distribution of load. With monitoring the physical computing resource of load workers, the load balancer is able to distribute the load to the load worker which has the lowest usage. The above-mentioned physical computing resource includes CPU usage, memory usage, and load progressing in load workers [1].

Within the load balancing system developed, there are a Web server, two application servers and a database server, which are deployed on the public/internal network available. The Web server works as a "load balancer" to distribute the load, which is related to a task/request from supplier or consumer, to the application server having the lowest usage; and the application server acts as a "load worker" to take over the load. In this case, the Web server itself does not execute a special task, while application servers are to perform the specific tasks assigned, so that the load is distributed across the different application servers. With interacting with the database server, the application server executes the querying, such as getting ecoCost information, and then returns the result to the Web server.

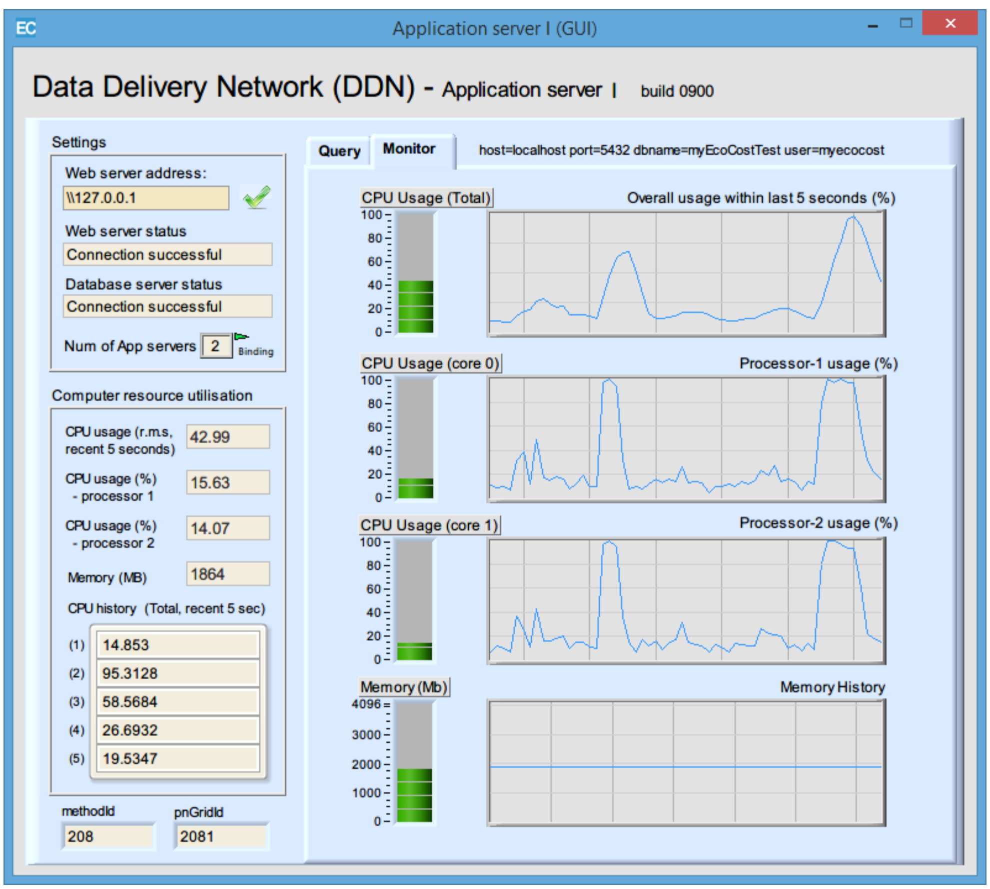

Figure 3 Monitoring of physical resource of the application server computer, including the usage of CPU and memory and load progressing in the computer

Figure 3 presents the usage of an application server via capturing the physical resource information of the computer. The application server's usage is determined by a group of parameters relevant to the physical resource and operation status of the computer, including CPU (processing power), memory and load progressing. The lowest usage indicates that the computer is running the fewer tasks and has the higher idle rate than other computers operating in the same distributed management model. Each server works at a stand-alone computer in the location somewhere on the internal network.

3.4 Database

Based on the life-cycle impact assessment (LCIA), the products' ecoCost information is analysed, such as the ecological impact indicators throughout the products' life-cycle. The ecoCost information is placed in the database with the PostgreSQL database management system.

The database is installed on the database server, which closely works with the application servers for product querying purpose. Also, the Web server and application servers have their own databases, which are used to store temporary exchanging data in the computer locally.

IV. CASE STUDY

The information communication infrastructure has been successfully developed to transmit the ecoCost information of products from a supplier to a customer over the Internet. Within this case study, a wireless networking environment (WLAN) formed by a Web server, two application servers and a database server, is set up to transmit the ecoCost information of products to a customer. With the wireless network established, the ecoCost information within the infrastructure is handled via distributing the requests/tasks to the different application servers.

A consumer ID card is made for the consumer to log in the myEcoCost system. There is a RFID-based tag embedded in the card, which includes the user's details (see Figure 4). Also, a computer mouse is used as a new product to be sold to the consumer for demonstrating the process. The Web server, as the core of the WLAN, is to validate the detail of consumer via the Internet and then send the ecoCost information of the product to the customer.

Figure 4 myEcoCost consumer ID card with RFID-based authentication

With a RFID-based reader, the consumer ID card is scanned, and a 13-digit serial number is acquired. To verify the consumer's identity, the serial number is sent to the Web server by invoking a Web-based service over the Internet. Based on the actual use of the application servers, the Web server allocates the request of validating the serial number to an application server with the lower usage. The necessary interaction with the database is conducted between the application server and the database server. After successful verification, the consumer is authorised to log in to further the interaction with the Web server. The consumer is enabled to obtain the product's ecoCost information reflecting the ecological impact of product.

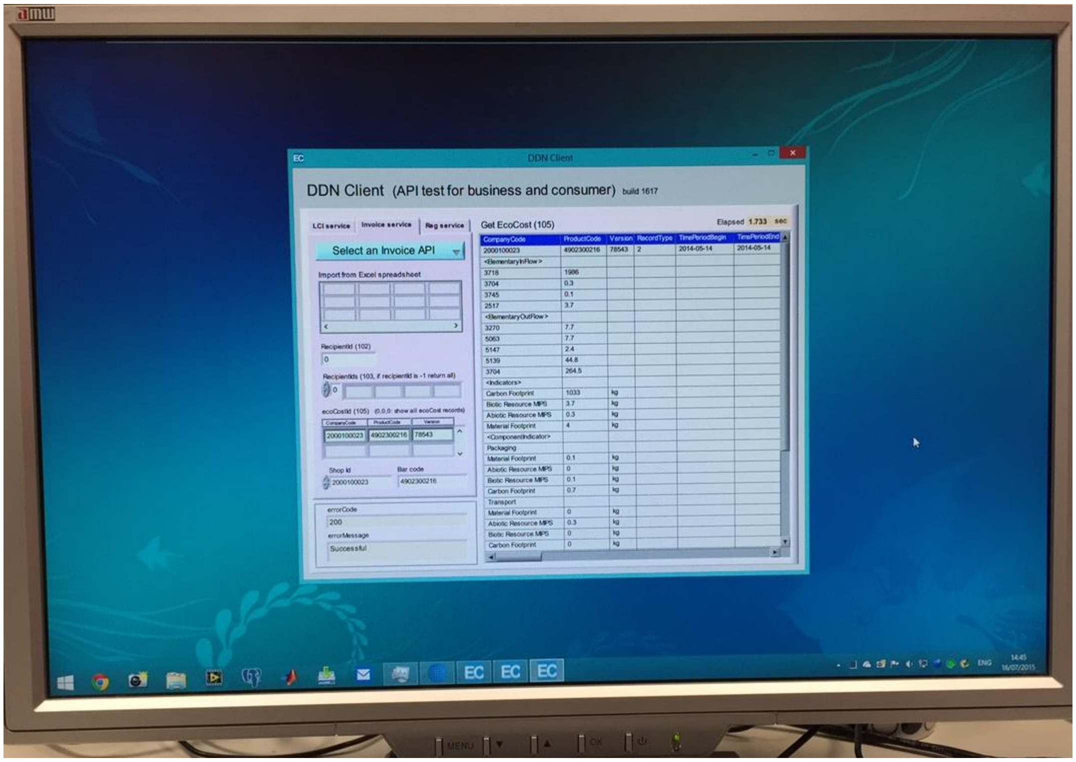

Figure 5 Product ecoCost information showing on the consumer's client computer

Then the computer mouse embedded with a RFID tag is read by the reader. The serial number of mouse is acquired from the tag, and sent it to the Web server to obtain the product information. The Web server works on the querying request and transmits the result back to the consumer client. Figure 5 presents the ecoCost information of the product, which was received from the Web server and shown on the consumer's client computer subsequently. The ecoCost information received includes the product's environmental impact indicators, such as carbon footprint (CF) and material footprint (MF), and the details of process flow and elementary flow relevant to product manufacture.

V. CONCLUDING REMARKS

The Internet-based information communication infrastructure for the myEcoCost ecological account system has been successfully developed. The information communication infrastructure is applied to produce ecoCost information of products throughout the life-cycle, and transmit the summary ecoCost from suppliers to consumers, which is a novel application in this area. With the environmental impact value of product, so-called ecoCost information, the consumer is enabled to make a comparison between different products, and choose and purchase a sustainable product.

The infrastructure consists of the following three layers: upperware, middleware, and resources. The upperware layer controls the middleware (Web services, load balancing, resource management, and RFID-based mobile access network) and associated resources, and interacts with the operation models operating in the myEcoCost environment, which is shown in the overall structure of the information communication infrastructure (see Figure 2). The case study illustrated the method developed via delivering the ecoCost information of a product from a supplier to a consumer through the Internet, which has successfully validated the system developed.

ACKNOWLEDGMENT

The authors would like to acknowledge the financial supports received from European Commission's FP7 myEcoCost project (Grant No. 308530).

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AN AUGMENTING OF DATA MINING TECHNIQUES AND ALGORITHMS FOR ACADEMIC MEASUREMENTS AND EVALUATIONS

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ABSTRACT

Academic measurement and evaluation are a methodology of testing and proofing the performance and success of learning technology, which is a continual growing and reputation process that provides a better understanding and creation of information societies. It is a dynamic and tactical research-based on the theory of education data exploration processes. It focused on the importance of appropriate teaching-learning process performance measurement for a successful and integrated education system. However, data in the education system and its demand are complex and challenging to extract valuable information. To overcome the problem and minimize information gaps, we proposed Data Mining (DM) techniques to explore educational data. It is a systematic approach to analyzing education data as its sources, time serious, and issues. Such heterogeneity of education data analysis is an advanced and integral of DM augmented technology to overcome the challenges and to convert the huge data into valuable information and knowledge. The outcome of the paper is the integrity of advanced analytical and computational technology into education systems, which underlying the technical matter of the sector based on education success and service evaluation. It can be inferred by the educational specialist, students and teachers in the sector how it can be integrated and maximized using advanced technology, via Data Mining.

Keywords: Data mining, algorithms, education performance, academic measurement, evaluation,

INTRODUCTION

The integration of learning technologies in a various educational level and systems are promoted and supported by a dynamic and advanced academic performance measurements and evaluations. The technique leads to enhanced learning outcomes (Karen et al., 2012). However, research on the impacts of academic measurements and evaluations are more subjective and depending on human perceptions. In the modern education system, such dynamic learning process and performance evaluation explored based on advanced analytic tools, such as Data Mining (DM). The methods what education industry use might be the better way and since it has no a mathematical formulations factorized perception leads the truth. DM technique can make it clear and interactive by developing data patterns for further knowledge and wisdom extraction (Baradwaj & Saurabh, 2011). Since, learning process or technology itself is a human cognitive processing, which can be characterized as human perceptions, thinking, creative and others to make a simple and interactive life. The perceptions varied with respect to "what" and "how" components. The "what" component concerned perception of what constitutes a technology. The "how" component concerned the perception of how the technology impacted on learning. Thus, augmenting such a dynamic exploratory tool for academic measurement is a systematic way of optimizations of education facilities and students achievements, which can lead to the successful integrated education system. For teachers also holding the techniques as professional development is proposed in how learning technologies can be used to encourage enhanced learning outcomes (Trinkle, 2005).

Education measurement is coined to knowledge as the succinctly conveys the critical role of educations. This scientific understanding gained by delves exploration of education data using DM techniques, which support to drive more proper predictions and evaluation. DM for education is a fundamental tool to assess or measure its effectiveness, learning and teaching facilities and techniques. It provides a clear understanding to develop 'smart', interactive learning materials (Barker & Campbell, 2010). It is a philosophy of education data and technology to solve performance measuring subjectivities and challenges, which support a clear understood of a changing world and new ways to share their findings with others. DM technique is an integral maximization of education modernity about the efficiency of the education research. It is a semantical way of unlocking the door to a more technological learning experience, which will motivate young people to study and better equip them for life beyond the classroom. Moreover, it helps to ensure education industry has a workforce with the skills required to succeed in today's highly competitive globalized economy (Pratiba & Shobha, 2014). The domain or education is also a prominent cultural institution used to perpetuate the prevailing values of the society and modernization. Advanced or modern education system has a sordid past largely rooted in industrialism. Its aim is to produce economically viable employable citizens. Nearly all our tweaks to the system in the last long years simply attempt to ensure that the graduates are prepared for the workforce (Azlinah et al., 2008).

Nutshell, DM for education measurement and evaluation is a tool to increase in speed and feasibility to the benefit of making replication much more existing data analysis and pattern developments. However, education data are complex, heterogeneous and sensitive (Carr-Chellman et al., 2000). It needs a technique that allows analyzing large-scale education data in its multiple levels of meaningful hierarchy, nature and level of users. It is the issue of how education data analyze as keeping its privacy? What technique is capable and scalable to develop or initiate proper education measurements? How academic measurement is subjective? What is the need of DM algorithms to analyze education measurement and it repercussion? For such challenges and a federated educational data demand integrated approach that can be adaptive and scalable. In the education system, the phenomenon and technology of big data are also highly reflective of education data type and characteristics (data deluge). Therefore, to support the existing academic measurements and evaluation and also integrate with the modern technology, endorsing advanced application tools such as data mining, machining learning, language processing, etc. are paramount. In this paper, we proposed these matured tools to optimize the measurements by exploring the ever-growing educational data. These analytic tools highly adopted in other domain such as businesses and engineering, which can have a great impact on education data analysis for a better of students' creativity, performances and outcomes.

This paper is organized as in section 2 we discussed the facts and advancement of DM for educational technologies related works. In section 3 we discussed DM for education or academic measurement and evaluations. In this section, we investigate and introduced novel ideas about educational data discriminations, the promising of DM for educations, its application, and importance. In section 4 we discussed DM application and its features in the education system. In section 5, we summarized the study and revealed the importance of the paper, which followed by the acknowledgments of the supporters of the paper and list of cited references.

1. Related works

DM method is considered as the most suitable technology in giving more insight into educational entities, including student, teacher, administrators, other communities (Baradwaj & Saurabh, 2011; Merceron, 2005). It serves as an active automated assistant in supporting academic measurements to make better decisions on their educational activities to improve decision-making processes in the teaching-learning process. This improvement would carry many advantages, such as increasing student's promotion, retention and transition rate, educational improvement ratio, student's success, student's learning outcome, maximizing educational system efficiency, etc. More than that by exploring the trend data, it gives a clear understanding of the development of academic measurement standards. Also to these, capable schools and institutes are looking for ways to adapt using DM to build information society (Abdous et al., 2012; Carr-Chellman et al., 2000). The domains know that students will seek opportunities that allow them to cross borders and boundaries in learning virtually. It supports beyond teaching-learning activity, such as administrators, understand DM to administer budgets and student services to ensure transparency, better distribution of resources and identification of at-risk students (Otobo et al., 2013).

Academic or learner measurement and analytics have received significant attention within the modern education system. It gains much interest to trace the research work in the domain for the better of educational performance and students achievements. Educational data analysis using DM tools are paramount to support the system by gaining a clear understanding of the applications for the implementation of student courses schedules and allocation at each level. Since education geared towards the fulfillment of the individual's curiosity, intelligence, soul and interest (Naeimeh & Somnuk, 2008). It is extremely important in growing the individual in many different ways. The outcomes of DM analyzes fostering education services to optimize its services, performances, developing proper academic measurements, cost minimization, etc. Therefore, DM for education is a fundamental analytic tools and technology to solve various educational problems.

DM for education is computational and mathematical methodology, which aimed at creating better learners or students at each level and increasing student's knowledge of the world around them. While primary skills are important, other skills such as critical thinking should be taught from a very young age by developing analytic thinking (Hrabowski et al., 2011). The humanities should be stressed, and material shouldn't taught for the purpose of regurgitation on tests, it should be discussed and analyzed using the collected and stored data. Data from diverse repositories having broadly similar learning experiences (such as using the same learning software). However, in very different contexts, gives leverage that was never before possible, for studying the influence of contextual factors on learning and learners. Education data is a historic or trend data, which is difficult to analyze using traditional methods to visualize the gap between teachers and classroom cohorts. It influences specific aspects of the learning experience, which involves the sort of analysis that becomes much easier with EDM (Zhou & Winne, 2012). Similarly, the concrete impacts of individual differences have been difficult to statistical methods. The analysis with traditional methods is more focusing on case studies, which is a basic ground to augmenting DM to extend a much wider toolset to the analysis of important questions about individual differences.

2. Augmenting data mining for academic measurements and evaluations

Augmenting DM for education system places great emphasis on measurement– grades, national averages, teacher performance, etc. It is a systematic approach to searching a solution for years to analyze things such as standardized tests challenges (Arnold & Kimberly, 2010). For example, in mining data about how students choose to use educational software, it may be worthwhile to consider data at the keystroke, answer, session, student, classroom, and school levels simultaneously. Issues of time, sequence, and context also play important roles in the study of educational records block mining model as it is shown in fig.1. EDM is a big potential domain, which emerges as an independent research area. It gives tremendous advantages, including a clear insight and understanding about laboratory experiments, in-vivo experiments, and design research, to make educational data to be feasible and others (Campbell et al., 2007). The data such diverse sources are often valid for the performance and learning of genuine students, in genuine educational settings, involved in authentic learning tasks, etc. It increases a rapid access and begins with research balancing feasibility with education demographic validity is often a difficult challenge for researchers in other educational research paradigms. These analyzes tend to focus on a measurement of what has been learned and how that compares to a larger population, all of which is important when evaluating students (Yas, 2011). Imagine a system that provides teachers with real-time insights to understand how a student is performing. The teacher can then use the data to spot weak areas and adjust the lesson plan accordingly. This type of tailored instruction can greatly improve student performance (Merceron & Yacef, 2008).

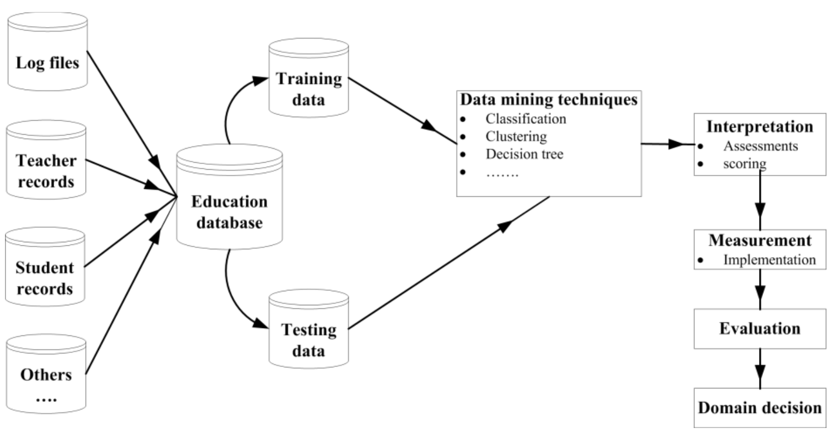

Figure 1: Educational data mining models

Education data need a clear understanding of the domain attribute behaviors. It begins with the education system, and teaching-learning activity records formats and contents, which gives a clear insight the domain and the knowledge content. It is not as such a simple uptake knowledge and use it to "compete" with some letter-grade "lab war" contrived in centuries past as it showed above (fig.2). However, it is the nourishment that changes our very capacity as we avail ourselves of understanding of the domain and applications how to handle and explore education data. If we are all "works in progress" experiencing different growth spurts in capacity, the entire model of "competition totality" becomes systematized dysfunction. To analyze educational data using classical exploratory tools is time-consuming steps, complex, long and narrows computational process. In such a case, the measurement and evaluations of education performance and achievements more challenging because of lack of delve synthesizing and understanding the data (Norris et al., 2008). DM for educational measurement and evaluation serves as a method of recruitment of schools, teachers, and students, scheduling of studies, and data entries. It implies using the current and trend data analysis and modeling, which can infer student attributes (such as strategic behavior and motivation) from the type of data in education databases.

3.1 Data mining augmenting methodological framework

The DM techniques are dynamic and scalable to handle and analyze supervised and unsupervised education data to discriminate and course management system events, as well as student academic performance. It helps to define the gaps between good standing and that are not doing well students using classification and clustering DM algorithms. The mining framework involves teachers and students' perceptions data, learning process, and the analytic outcomes by using or analyzing sample or test data. The DM techniques give tremendous advantages to optimizing academic measurements and evaluation. It gives a clear understanding and roadmap to handle, store and analyze educational data towards performance evaluations. The approach is essential for investigating the requirements for successful integration of learning technologies into measurement systems. Students' creativity and motivations are fundamental to gain the success of integration, specifically the amount of technology use, the ways in which the technology used to learn and their expectations about learning. Educational measurement focused data analysis is a systematic implementation of DM techniques. For teachers' and students' perceptions of teaching and learning contexts established a series of systematic associations linking teachers' perceptions and approaches with students' perceptions. As it is shown in fig.2 learning approaches and outcomes (Van et al., 2012; Trinkle, 2005). An explanation of these associations is important to understanding the significance of investigating teachers' perceptions of learning technologies.

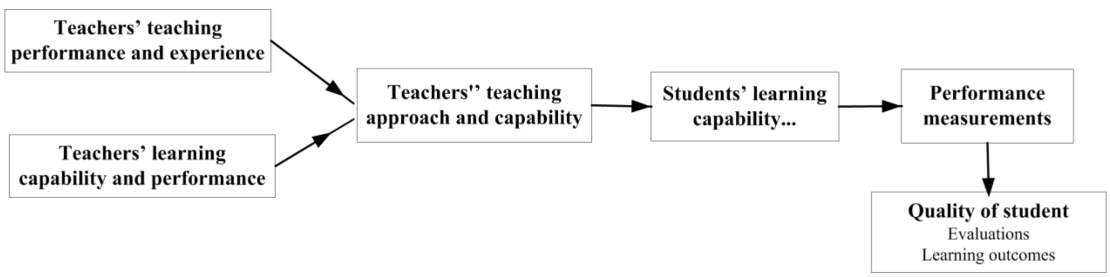

Figure 2: DM based teacher-student educational perceptions and quality of learning measurement framework

As it is shown in fig.2, students' approaches to learning are related to their teachers' approaches to teaching. Teachers who describe using a conceptual change/student-focused teaching approach are more likely to be teaching students who report using a deep approach to learning. Deep learning approaches have the intention to seek meaning in learning situations through linking aspects of the content (Dervis & Ibrahim, 2002). DM technique is playing an essential role by visualizing the key factors between the two associations, which provide a clear understanding to the teach-learning interaction as the students' capability. It also helps to develop a standard to the academic measure towards students-course associations and performance optimizations, which enhance the future education modernizations. As Baradwaj & Saurabh (2011) discussed, DM based empirical studies on deep learning approaches have been found to be strongly associated with conceptual change learning outcomes. In contrast, Trinkle (2005) showed that teachers who describe using an information transfer/teacher-centered teaching approach are more likely to be teaching students who report using surface learning approaches. Augmenting DM technique is a scale-up of these methodologies and an integrated way that help the system by developing a generic performance measuring standards.

3.2 DM based teaching-learning process and measurement standards

The learning context provided by a teacher is the practical implementation of the teacher's perceptions of learning and teaching, and approach to teaching. Students have been found to vary their learning approach in response to certain factors they perceive in the learning context. Students using deep learning approaches are more likely to value independence in learning, good teaching and clear learning goals, factors consistent with a student-centered teaching approach. Students using surface learning approaches are more likely to have different values, and, consequently different outcomes. The data collected as the teaching-learning process is vitally important to analyze using the DM techniques. Such analytic outcomes implemented to various academic performance optimizations. The EDM analyzes are being replicated across data from several learning systems or contexts to automate student assessment tool that combines their perceptional analytics to performance measurements. It not only grades exams faster, but also extracts student performance measurements and creates real-time feedback for teachers (Hattie & Timperley, 2007). It gives the teachers' ability to address quickly the reality that students learn concepts at different paces and in different ways. It supports to customize their teaching, so individually or in small groups, students get the extra attention they need to achieve. Instead of spending time scoring tests and making sense of the data, teachers can quickly access relevant views of the data and focus on meeting the needs of each student.

The successful integration of learning technologies leading to enhanced learning outcomes is unlikely unless teachers' performance and use technology as an integral part of a student-centered/conceptual change teaching approach. Only through students capability learning technologies as part of a learning context that encourages independence in learning and deep learning approaches are enhanced learning outcomes likely (Honeyet al, 2000). DM is playing a supportive role of educational data handling, analysis, and being promising to revolutionize modern learning systems. Based on these facts, the academic measurements are also clear and implementable as the domain facilities to improve learning outcomes for individual students. Based on the outcomes develop a curriculum at every level of the student learning process that can address student needs. It includes customized modules, assignments, feedback and learning trees in the curriculum that will promote better learning. Imagine how such knowledge can be used to give instructors the necessary intelligence to address directly a student's learning style or deficits. In this way, DM can amplify factors that contribute to student success – personalized courses, the instructor-student connection and a wired sense of community – despite being in the detached online learning environment.

3.3 DM based measurement processing and standards

The measurement of students' learning processes using DM techniques provides deep understanding student performance observations about what students do in the task as well as capture the context surrounding the behavior. The mining techniques are advanced in how such data are conceptualized, in storing and accessing. The techniques that give the capability to discover patterns from large-scale data are spurring innovative uses for assessment and instructional purposes as showed on fig.3. The significant of advanced exploratory tool is to resolve the challenge of academic measurement, which helps to improve learning via individualized instruction (Merceron & Yacef, 2008). Thus, DM based academic analytical process exists on a continuum of data and information, in which transformed by the story that tell about the domain performance and success. This transformation of information results from questions asked about the data that are captured and reported in the education system. By having clear and interpreted DM outcomes, predictions are made based on various indicators. The challenge for analyzing education data towards academic measurement and evaluation is the nature of the data, such as demographic data, which DM method is capable to avoid such risks. For example, student evaluation based on a very little information or incomplete data will make difficult for educators and administrators how to level the student performances. It demands DM techniques to handle such a complex or noisy education data. It is a systematic way to be a solution to the demand for learners, educators, and administrators challenge the expectations of the traditional and conventional classroom delivery.

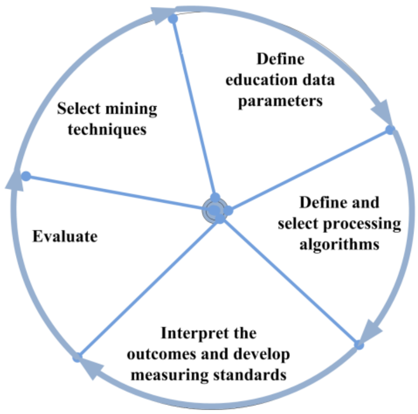

Figure 3: DM based academic measurement instruction sequences

The techniques of DM need to make the education data based analytics to develop a modern education system that are effective for meaningful, measurable, and monitored education system. Education decision that related to teaching-learning process aims in the context of an overall educational strategic plan, which support to discover success and effective learners. It is the serious process of academic activities, which involves academic decisions, implementation, measurement, and evaluation. For a clear understanding of the process, EDM based assessment and evaluation of academic performance are major tasks to carry on data analysis of the student, course, program, and other levels. The underlying algorithms and parameters that drive data collection and reporting can be modified to refine the academic measurement strategy focus to establish and enact interventions of education performance as needed (Romero et al., 2008). The data explored using mining techniques to identify and describe technologies and methods, which used, analyze and evaluate the impact of teaching-learning integrated into education performance and measurements.

4 Application of data mining for modern education analytics and discussions

DM has a big potential to create a great hope to transform education. It is capable of tracks interaction and direct feedback between learners and teachers performance measurement, continuous monitoring of progress and attendance, more opportunities for personalized learning and guided pathways to the students' interests. The users generate all kinds of data, and from those choices, they can be taken from one activity to the next. It is the learning analytics factor of DM methods, which can guide the students and teachers to understand better the trajectory of the learner's progress. The technique needs to adapt the learner's understanding of a subject, analyze students' social relationship and network. It is a systematic approach to evaluating the quality of the learner's input (Thomas & Nora, 2004). At the macro level, the analysis of this data can contribute to sound policy development by providing access to numerous factors from the environments, approaches, and pedagogies that bring about actual results. The techniques of DM is also promising to understand how people learn and how learning occurs or success, which support to design modern educational platforms and tools that can simultaneously analyze the students' behavioral and learning patterns. The need of DM for Education can be discriminated in various performance indicators that employ as an input, process and output levels as summarized in Table.1.

Table 1: The need of augmenting DM for academic measurements

No.	Performance indicators	objective	Mining method	Acquired knowledge	Teaching-learning process	Measuring process
1	Input indicator	Having good records	Education database	The pattern of trend data	Define parameters	Select indicators
2		Preprocessing education data	Cleaned data	The pattern of education trend data in its respective sources		Course measurement
3		Creating meaningful learning environments	DM techniques	Pattern development on student learning process		
4	Process indicator	Develop institutional measuring standards	"	Pattern of mined data	Evaluation	
5		Processing intervention, how to measure	"	The success of pattern development (as expected)		Student performance assessment
6		Predicting and	"	"		

		clustering the process				
7		Predicting student performance	"	Classified pattern of analyzed data		
8	Output indicator	Improving student quality	"	Interpreting and characterizing the pattern data towards student performances	Counseling	developing standards

Therefore, the techniques of DM are pertinent as to improve student models that provide detailed information about a student's characteristics or states, such as knowledge, motivation, metacognition, and attitudes. Modeling the individual differences between students capability to respond to those individual differences, this is a key theme in educational performance measurements and evaluations research. The approaches of education data analysis, different methods bring different prior knowledge to the process. In the last few years, EDM methods have enabled considerable expansion in the sophistication of student activities. The studies about academic measurement give a clear understanding of the need of education data analysis in which constituted as a relation between individual performances and the data outcomes. What is important, however, is that the findings are described and illustrated in a manner which scalable to the issues and the students characteristics. Since EDM methods have enabled researchers to make higher-level inferences about students' behavior, such as when a student is successive and where did not. Moreover, DM for education is pertinent to discover or improve the knowledge system of the domain, which provide a rapid discovering accurate domain models directly from data.

5 Conclusion

DM techniques based academic analytic provide a detailed description of the education methodologies towards measurement and evaluations, which helps to develop a modern and successive education systems or platforms. The power of DM lies to allow users to consider data from a variety of perspectives to discover apparent or hidden patterns academic measurements. This research derives its motivation from the need of augmenting DM techniques to academic measurements that can be used in practical settings to predict academic performance and carry out early detection of students at risk. The techniques presented in this paper are essential to developing an education data analytic framework for academic success. DM plays a supportive role to present the real facts in the data that tells about the real matter of the students' performance and future academic contents about teachers' perceptions and teaching-learning interactions. It is a systematic way of advancing education communities understanding about the content of their sector data about academic measurement and evaluation. It is an emerging and augmenting analytic technology into the field by investigating the impact that engagement in a teaching-learning process. Further research involving teachers' perceptions of learning technologies is warranted in some areas. The impact of relevant professional development programs on experienced teachers' performance of learning technologies could be assessed. Investigation of the interactions in classrooms between students, teachers and technology is vitally essential to achieving modern education systems. The investigation is also pertinent to the analysis of the impact of academic measurement and evaluation towards student creativity and achievements.

Acknowledgements

We are very thanks to the anonymous reviewers for their useful comments, and the works are supported by National Natural Science Foundation (NNSF) of China under Grant 61203321

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A STUDY ON THE GOVERNMENT STRATEGY FOR SPACE INDUSTRY ACTIVATION IN KOREA

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ABSTRACT

In this study, a business ecosystem of domestic space industry is comprehensively analysed to derive influence factors. Priority level of each element as well as the disparity between ideal and real scenario is investigated through literature review and expert survey. Three major influence factors determined contain: investment scale and approach, propulsion system, and finally, industrialization with overseas expansion. Related issues based on the current status are evaluated, followed by proposed activation strategies. Findings from the research offer a direction for research and development budget allocation on aerospace study and law system maintenance for the activation of space industry in Korea.

Keywords: space industry; space industry activation; influence factor; industry ecosystem; government R&D budget; vitalization strategy.

1 INTRODUCTION

1.1 Background and Objective

Space industry has enormous potentials to generate ripple effects over industry, economy, and technologies as well as new industry. Therefore, it is highly valued as the space industry can branch into diversity of new industries for next generation. However, insufficient critical technology and lack of industrial foundation have delayed advancement toward world market, making the space industry ecosystem feeble. In recent years, the government announced its intention to promote space industry actively and encouraged pre-development of the Korea Space Launch Vehicle beside other space industry as a part of national projects. Currently, it is considered as a turning point for the Korean space industry where budget and policy-related environments are under changes. It is significant to construct sustainable ecosystem and create pre-market in order to improve space industry continuously, and therefore, establishing efficient institutional support from the national and public sector is highly necessitated.

Various strategic methods have been proposed to vitalize space industry so far. Although many of the strategies exclude priority concept and some of them concern interests from specific classes. Applying such strategies could therefore be risky. This study aimed at deriving influence factors through analysing ecosystems of the Korea space industry, and suggesting the best strategy by considering priority among the measures for activation of space industry ecosystem.

1.2 Contents and Method

Ecosystem of space industry in Korea is broadly analysed to derive influence factors by considering budget flow. In order to deduct detailed influence factor, more specified investigation on overall space industry including satellites, projectile, and satellite information is suggested. Considering few limitations such as time, this study aims to draw prior promotive strategies for the activation of space industry at the same time. Based on the derived influence factors through broad investigation over the ecosystem, various factors obtained from literature review and expert interviews are thoroughly integrated.

Total 39 different influence factors come up through comprehensive survey on space industry, review on previous studies, and interviews from related experts. Significance on each influence factor and gaps between the ideal and real scenario are surveyed by asking 63 experts majoring in the field of space. Eight major influence factors having higher than mean significance and mean gap are deducted. The deducted influence factors are categorized into three major factors based on correlation analysis and qualitative evaluation. Three major factors contain scale and methods of budget investigation, promotive system of space development, introducing overseas market through industrialization of space technology. For each factor, critical trends and issues are examined and the results are supplemented to attain improvement plan besides experts' conference so that aerospace industry can be activated properly in Korea.

2 Comprehensive analyses on the ecosystem of space industry

In order for domestic space industry to be equipped with the ability to revive spontaneously, establishing sustainable industrial structure in terms of ecosystem is essential. Considering that space industry is government-oriented in Korea, analysis on budget flow is conducted so that the host of space industry and the correlation can be examined.

Figure 1 Flowchart of government budget on aerospace industry

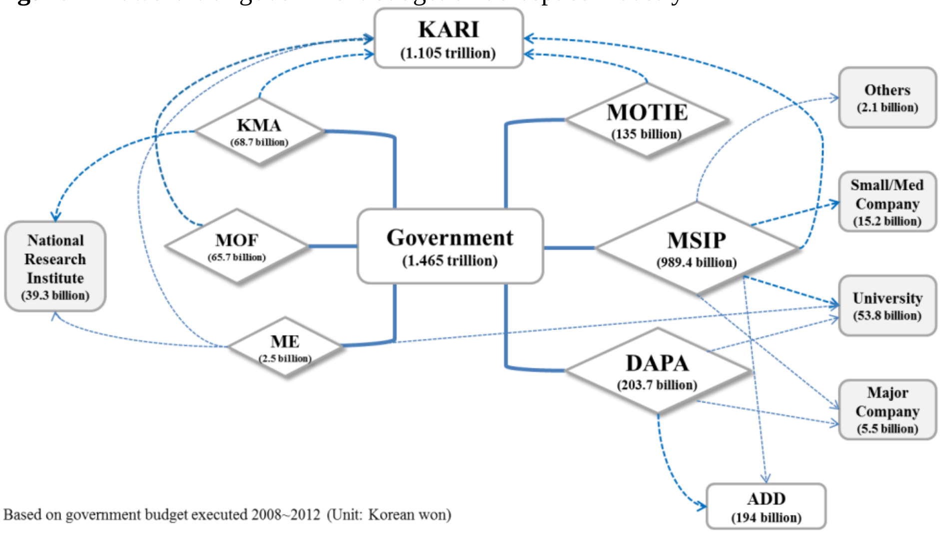


Figure 1 describes flowchart of government R&D budget on the field of space conducted during the year of 2008~2012 based on the national research institute where the chief institute belongs to. Among government ministry, the Ministry of Science, ICT and Future Planning is recognized as a major ministry taking 67.5% (989.4 billion won of 1.465 trillion won) of total government budget. Second and third major ministry are the Defense Acquisition Program Administration taking 13.9% (203.7 billion won) and the Ministry of Trade, Industry and Energy takes 9.2% (135 billion won) of total. Besides, the Korea Meteorological Administration, the Ministry of Oceans and Fisheries, and the Ministry of Environment are involved in procuring budget on developing geostationary orbit satellite as they participate in several parts of the space project.

Among national research institute, the Korea Aerospace Research Institute takes the most of domestic budget as it takes 92% of the MSIP budget in order to carry out both delegated and own business. Agency for Defense Development takes 95% of the DAPA budget to take charge of the aerospace research related to the national defense security. There are neither budget inputs from DAPA to KARI nor from MSIP to ADD. This suggests that cooperative research among two ministries and two institutes is not activated enough. In addition, the Korea Meteorological Satellite Center and other institutes take some part of the KMA budget. Rest of the KMA, MOF, and ME budget are mostly executed by KARI.

MSIP is responsible for 87% of the aerospace research-budget in Korean universities. The largest share of the budget is assigned to KAIST, Chungnam National University, Korea Aerospace University, Seoul National University, Hanyang University, and Yonsei University in that particular order. MSIP is responsible for 100% of the aerospace research-budget in small and medium companies. Participating companies are AP Aerospace Incorporated, i3System, Fiberpro, DACC, Justech ESD, Satrec initiative.

As above, the government budget flow on aerospace research is investigated to figure out the host of domestic space industry and its correlation. Three main factors interrupting the activation of space industry ecosystem are discussed as follows;

1 Aerospace research is highly dependent upon government investment. Naturally, it becomes hard to stand alone and susceptible to external variables. For instance, variations on governmental policy or budget directly affect space industry ecosystem, and therefore work as unstable factor. Worse, less private investors become willing to subsidize the research accordingly, which will finally hinder the construction of sound and stable industry ecosystem.

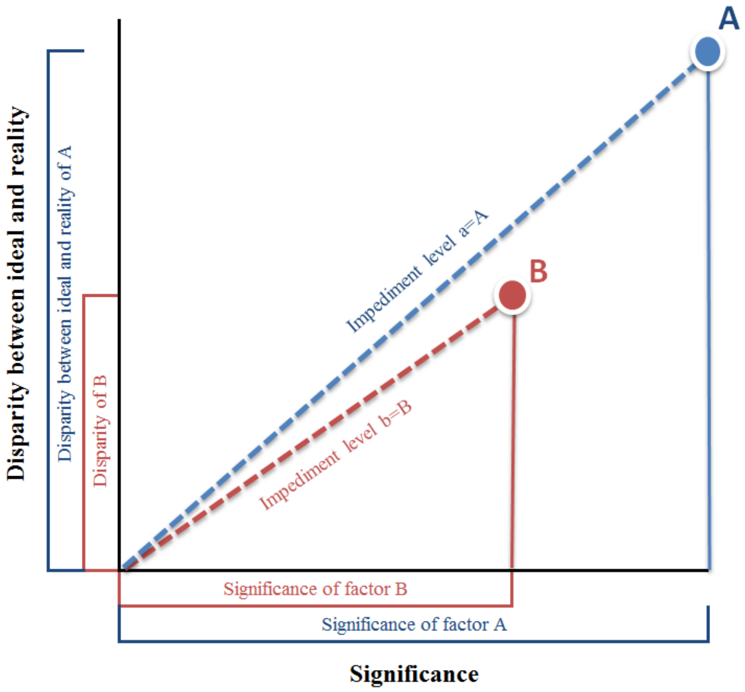
2 Role of each main research institute and relations between institutes are not clear. Under the aerospace researches conducted by MSIP and KARI, MSIP has trouble figuring out the technological demand over ministry and establishing long-term plan. Besides, there are limitations and inefficiency on classifying roles between industry and academia.
3 Preparation for secondary industry with highly added-value is still lagging behind far more than primary industry. In Korea, aerospace research is focused mostly on the development of technology, and then the application after technological strategies of advanced country. As a result, most of the national R&D projects are concentrated on retaining large-scale aerospace devices, whereas enhancement of secondary industry through the application of such devices is incomplete.

3 Analysis on influence factors of space industry ecosystem

3.1 Selection and Evaluation of Influence Factors on Space Industry

In order to supplement the comprehensive analysis on domestic space industry, further factors are added based on existing researches of space policy and industrialization of space technology. Interviews from aerospace experts are also referred to complement additional influence factors. Each derived influence factor is classified into one of the following conditions founded on Porter's Diamond; factor conditions, demand conditions, related and supporting industries, firm strategy, structure and rivalry, government, and chance. The selected 39 influence factors are examined by 63 aerospace experts - 26 from industry, 17 from institution, and 14 from university - for further analyses. Significance of each factor and gaps between ideal and reality are described in next section. Impediment level is defined as the root sum of squared each gap. The higher the significance and gaps, the higher the influence factors that interrupt space industry ecosystem, meaning that numerous endeavors are needed in order to enhance current level of influence factors (see Figure 2). Once improved, it will considerably contribute to the activation of space industry ecosystem.

Figure 2 Impediment level



3.2 Analysis of Influence Factor

3.2.1 Factor Condition

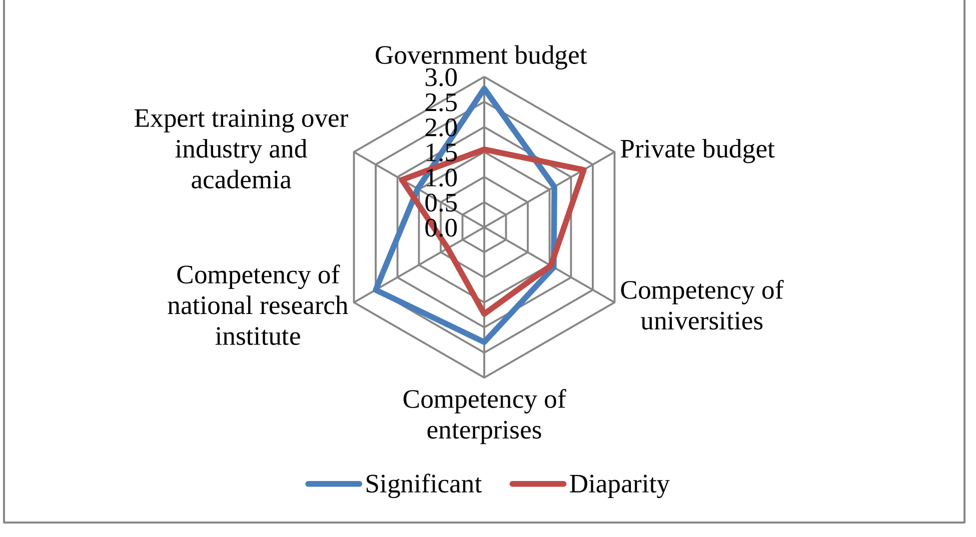
Factor condition signifies factors of production for competition including knowledge, financial affairs, social overhead capital as well as physical resource such as human resources, climate and location. In this part, conditional factors are considered as one of remarkable variations such as human, physical, and intellectual resources, and infrastructure. Significance, gap, and impediment level are described in Table 1.

Table 1 Evaluation results of influence factors; factor condition

Factor	*Sig.*	*Rank*	*Gap*	*Rank*	*I.L.*	*Rank*
Government budget	2.76	2	1.55	14	3.17	2
Private budget	1.61	23	2.29	2	2.8	7
Competency of universities	1.6	25	1.53	16	2.21	21
Competency of enterprises	2.29	5	1.73	10	2.87	5
Competency of national research institute	2.5	3	0.84	36	2.64	9
Expert training over industry and academia	1.53	29	1.89	7	2.43	12

Sig.: Significance; I.L.: Impediment level

Figure 3 Evaluation results of influence factors; factor condition



Budget scale from government and research competency from national research institute obtain the highest score in terms of significance. However, it seems that competency from national research institute is not far different from ideal level. Even the gap of budget from current government versus ideal level is not outstanding. Competency on aerospace technologies and industrialization of enterprises is considered as an influential factor for activation with remarkable significance and gap. Both budget scale from private sector and expert training system over industry and academia have large gaps though minor significance, meaning that it is hard to anticipate increased fund from private under current market size in Korea. Instead, strategic budget support from government could be more reasonable.

3.2.2 Demand Condition

Demand condition consists of both quantitative factor such as market size and its qualitative factor as essentials of market demand on commodities and service. In this study, demand condition contains overseas market and domestic stake-holders besides current domestic demands on space products and service. National defense, the main user of space technology, is considered as primary domestic demand, followed by private demand. Overseas market size as well as share over global market is considered as overseas demand. In addition to that, expectations and supports from citizens are added regarding that financial source of space development is partly depending on national tax.

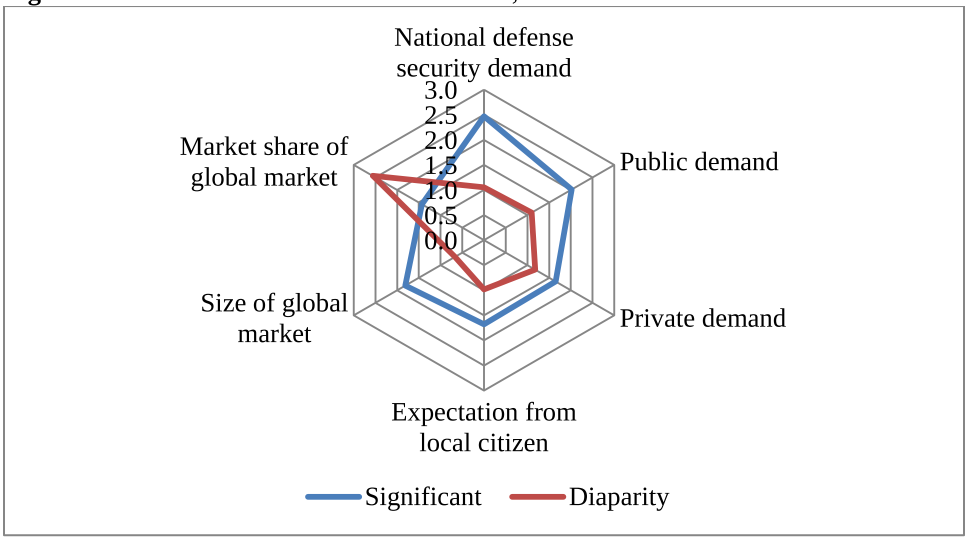
Table 2 Evaluation results of influence factors; demand condition

Factor	*Sig.*	*Rank*	*Gap*	*Rank*	*I.L.*	*Rank*
Defense security demand	2.47	4	1.05	32	2.68	8
Public demand	2.02	8	1.1	29	2.3	18
Private demand	1.65	22	1.18	26	2.03	25
Expectation from local citizen	1.68	20	0.98	34	1.95	30
Size of global market	1.81	15	0.67	38	1.93	31
Market share of global market	1.43	31	2.56	1	2.93	3

Sig.: Significance; I.L.: Impediment level

Market share of aerospace devices over global market appears to have a lower gap. This stands for current status having only a few cases of exportation of products as being intermediary role. It is, therefore, necessary to expand domestic market share in global market. Demands on technologies and products regarding public needs, such as national defense and security, have the highest significance, while the gap appears relatively low. This suggests that space development is conducted mainly by government and thus, technological demands from government and defense authority is critical. This corresponds to lowly evaluated significance and gap on private demand. On account that the main budget source and application demand come mostly from national defense authority and government, it is natural that gap between ideal and reality be low.

Figure 4 Evaluation results of influence factors; demand condition



3.2.3 Related and Supporting Industries

Related and supporting industries include either vertically or horizontally related industries and service industries supporting targeted industry. Service industry includes finance, accounting, consulting, and others. In this research, technology levels, degree of activation and utilization are studied for space related industry. First or all, technical level, size and activation degree of satellite information application are concerned. Technical level and degree of utilization are considered for defense industry, aerospace, and ICT industry that are known to make high efficiency on merging to space technology.

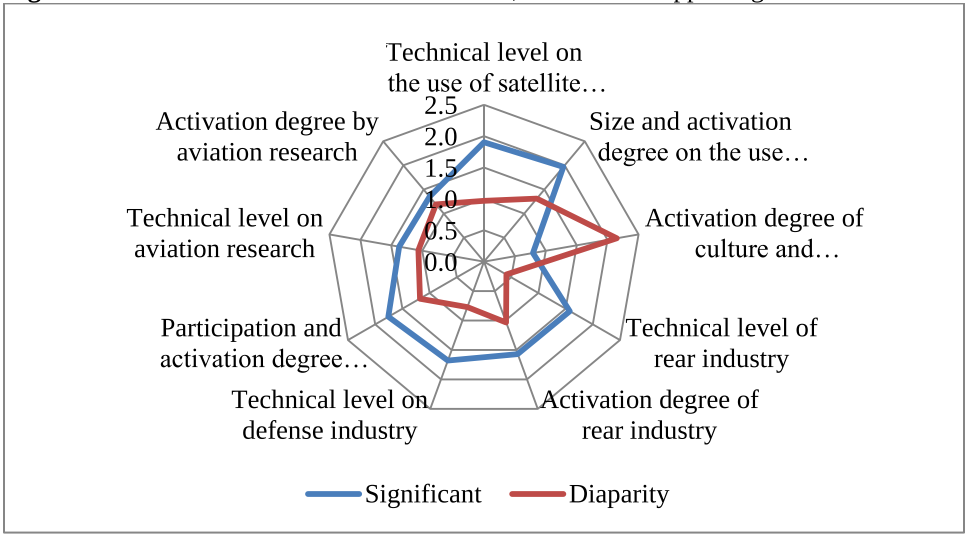
Relatively low significance and gap are observed from the related and supporting industries. This is mainly because current state of technical level and industrial size is not large enough to anticipate convergence toward other industries. Technical level, as well as size and activation degree on the application of satellite information ranked highest significance among these factors, followed by participation and activation degree on space technology at defense industry. Although the activation degree of industry on culture and sightseeing contents has lower real-ideal gap, its impediment level seems to be low due to its little significance.

Table 3 Evaluation results of influence factors; related and supporting industries

Factor	*Sig.*	*Rank*	*Gap*	*Rank*	*I.L.*	*Rank*
Technical level on the use of satellite data	1.9	11	0.97	35	2.14	23
Size and activation degree on the use of satellite data	1.97	10	1.31	22	2.36	16
Activation degree of culture and sightseeing contents	0.79	39	2.15	3	2.29	19
Technical level of rear industry	1.58	26	0.41	39	1.63	37
Activation degree of rear industry	1.57	28	1.03	33	1.88	33
Technical level on defense industry	1.68	21	0.77	37	1.85	34
Participation and activation degree by defense industry	1.76	16	1.18	27	2.12	23
Technical level on aviation research	1.37	32	1.06	31	1.74	36
Activation degree by aviation research	1.35	33	1.19	25	1.81	35

Sig.: Significance; I.L.: Impediment level

Figure 5 Evaluation results of influence factors; related and supporting industries



3.2.4 Strategy, Structure and Rivalry

Strategy, structure and rivalry represent overall structure and strategies on creation, organization, and operation of a certain business, and the environment that create competitive relation in domestic market. In this study, propulsion system of domestic aerospace development, industrialization strategy, and competition relations in domestic and overseas market are mainly discussed, considering that most of space industry in Korea is initiated by government. As propulsion system of domestic aerospace development, R&D propulsion system concerning each role of the governmental ministry and research institution, promotive degree on the integrated enterprises and the specialized company, and establishment of the supervision organization are analyzed. In terms of industrialization strategy, exertion toward the excavation of niche market and investment on export products, exertion toward the diplomacy strategies for exportation and the discovery of overseas market, and vitalization of entrepreneurship and assistive system toward business starters are discussed. In regards of competition relations among domestic and overseas market, degree of competition among domestic markets, degree of clusterization on aerospace industry, establishment of cooperative growth over major and small/mid-size companies, and degree of motivation induced by the competition among nearby rival countries including the North Korea and the Northeast Asia are included.

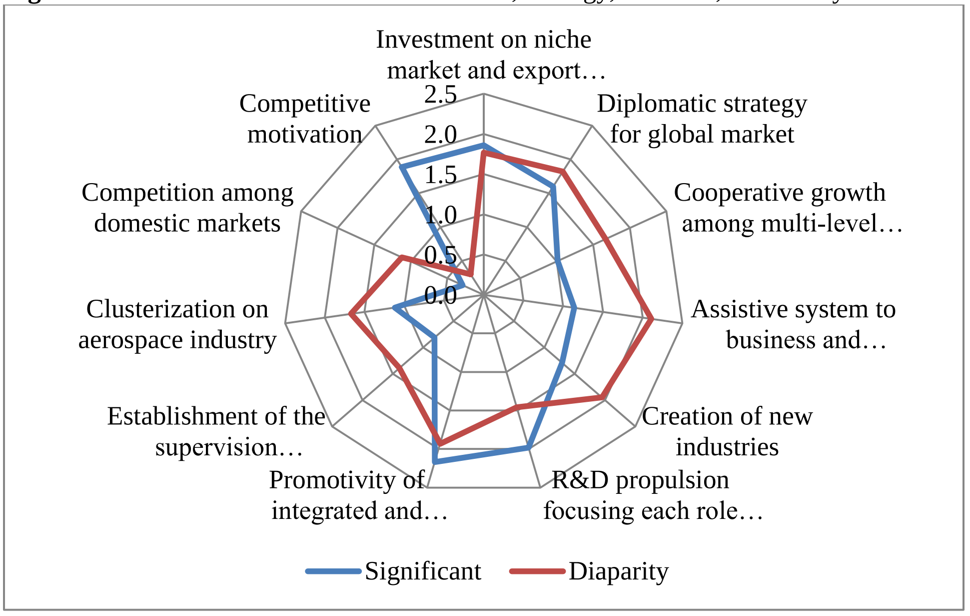
Table 4 Evaluation results of influence factors; strategy, structure, and rivalry

Factor	*Sig.*	*Rank*	*Gap*	*Rank*	*I.L.*	*Rank*
Investment on niche market and export products	1.86	13	1.77	9	2.57	10
Diplomatic strategy for global market	1.6	24	1.82	8	2.42	13
Cooperative growth among multi-level companies	1.01	37	1.67	13	1.95	29
Assistive system to business and business starters	1.14	35	2.11	4	2.4	15
Creation of new industries	1.29	34	1.95	5	2.34	17
R&D propulsion focusing each role of ministry	1.98	9	1.46	18	2.46	11
Promotivity of integrated and specialized enterprises	2.17	7	1.93	6	2.91	4
Establishment of the supervision organization	0.81	38	1.39	19	1.61	38
Clusterization on aerospace industry	1.12	36	1.67	12	2.01	26
Competition among domestic markets	0.29	40	1.12	28	1.15	39
Competitive motivation among nearby rival country	1.89	12	0.3	40	1.92	32

Sig.: Significance; I.L.: Impediment level

When it comes to significance, R&D propulsion system on aerospace study concerning each role of the governmental ministry and research institution, and promotive degree on integrated enterprises and specialized company on aerospace technology ranked the highest among these factors. This implies strategic needs to nurture specialized businesses in order to improve national research based aerospace development and establish industry bases. Exertion toward excavation of niche market and investment on export products, and diplomacy strategies for exportation and discovery of overseas market are evaluated having high significance and gap as well. Currently, most of aerospace R&D budget rely on government fund. Under such condition, government can try to reduce its budget portion by exporting space devices and related services to vitalize space industry ecosystem.

Figure 6 Evaluation results of influence factors; strategy, structure, and rivalry



3.2.5 The Role of Government

By setting the tone for environment providing innovative motivations, government policy has effects directly and indirectly on other components; factor conditions, demand conditions, related and supporting industries, and so on. This acts as catalyzer and challenger to encourage competitiveness, and therefore, is signified as the role of government. As being typically governed by national policy, aerospace industry is susceptible to government policy and its budgeting. Considering these conditions and space industry is in the early stage of its development in Korea, this part focused on the role of government; structures of decision making, budget securing system, law system maintenance, and others.

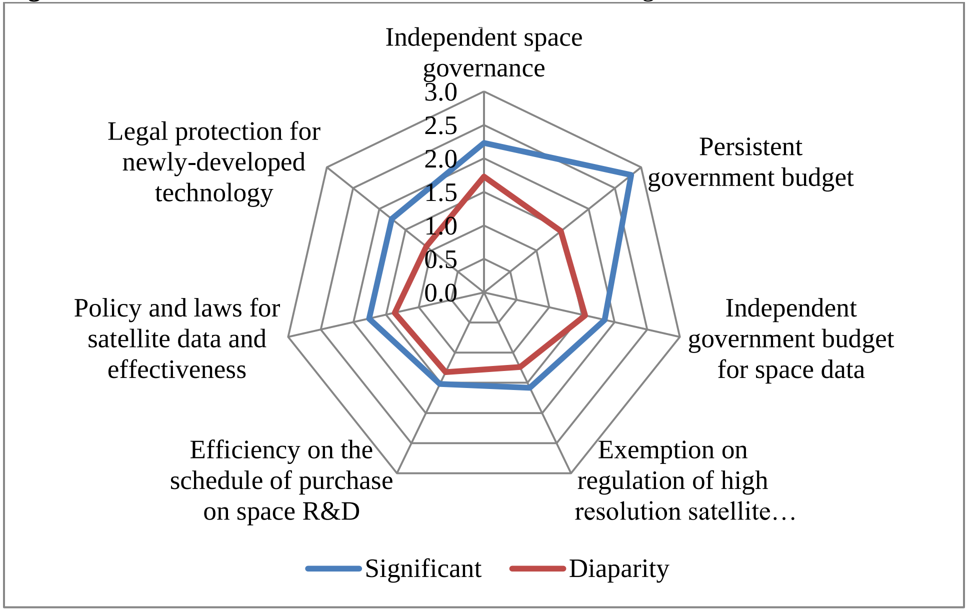
Table 5 Evaluation results of influence factors; the role of government

Factor	*Sig.*	*Rank*	*Gap*	*Rank*	*I.L.*	*Rank*
Independent aerospace governance	2.23	6	1.73	11	2.82	6
Long-term and continual governmental budget	2.81	1	1.47	17	3.17	1
Independent budget for space data by government	1.85	14	1.55	15	2.42	14
Exemption on regulation of high resolution satellite data	1.58	27	1.24	24	2.01	28
Efficiency on the schedule of purchase on space R&D	1.52	30	1.32	21	2.01	27
Policy and laws for satellite data and effectiveness	1.76	17	1.37	20	2.23	20
Legal protection for newly-developed technology	1.76	18	1.1	30	2.07	24

Sig.: Significance; I.L.: Impediment level

From the above factors, long-term and continual government budget was evaluated of highest influence factor. In Korea, space development budget is so susceptible to initiation and termination of large scale government R&D or other external changes that there are few difficulties on maintaining industrial human resources and establishing the industry foundation. Therefore, the stability and persistency are highly valued than absolute budget scale. Efforts on setting up independent aerospace governance and assigning budget properly are highly appreciated as well when it comes to significance and ideal-reality gap. This implies the importance of assembling discussion by overall governmental departments including not only the Defense Acquisition Program Administration, but also other satellite demanding departments.

Figure 7 Evaluation results of influence factors; the role of government



3.3 Analysis and Integration of Influence Factor

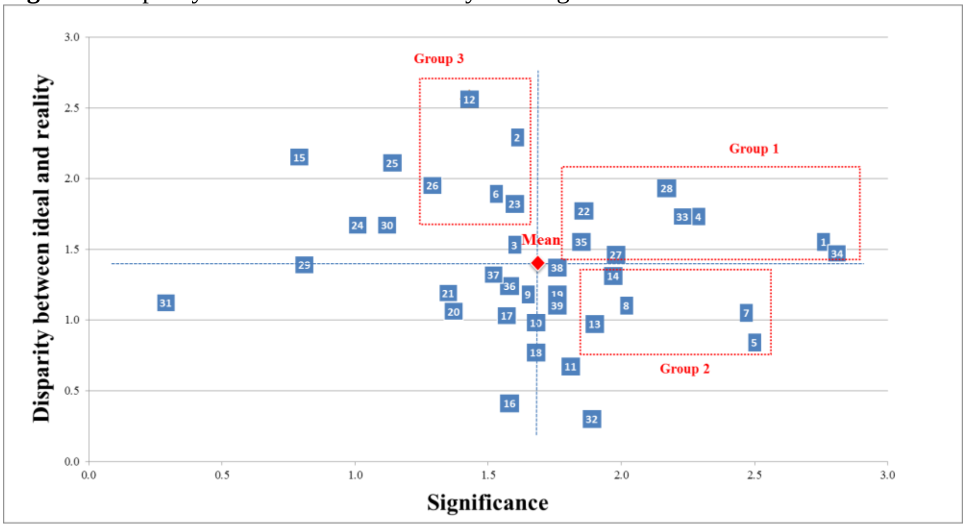
The most significant influence factors are chosen among the factors discussed in part 3 for the revitalization of space industry. The gap between ideal and reality over the significance is described in Figure 8. On the graph, group 1 appears to have the most influential factors as it has the highest values on both the significance as well as the disparity. For each factor, trends and issues are analyzed through the case analysis from both domestic and foreign.

Table 7 summarizes 8 influence factors showing the most influences with the highest values on both the significance and the gap. These influence factors are integrated and categorized into three different influence factors depending on their correlation.

1 Considering that most of the space industries rely on the governmental R&D budget in terms of both scale and type, the national finance is essential sustenance for the ecosystem of space industry. The low gap on the ideal-reality implies the necessity for efficiency on budget scale and method of investment.

2 Propulsion system for domestic space industry becomes one of critical elements establishing virtuous circle. This signifies the importance of building improvement plan for space development system led by government ministry and national research institute.

Figure 8 Disparity between ideal and reality over significance



3 Objective of the industrialization of space technology is under the creation of added value through application and development of technologies and devices. Therefore, the industrialization and overseas export will be crucial elements that can expand the ecosystem of the aerospace industry.
To sum up, three main influence factors are come up on this study. From the results discussed above, detailed strategy should be derived in order to activate space industry ecosystem.

Table 6 Main influence factors

8 influence factor	*Impediment level*	*Mean*	*3 influence factor*
Government budget scale	3.17		
Long-term and continual governmental budget	3.17	2.92	Budget and investment type
Independent budget for space data by government	2.42		
Promotivity of integrated and specialized enterprises	2.91	2.73	R&D propulsion system
Independent aerospace governance	2.82		
R&D propulsion focusing each role of ministry	2.46		
Competency of technology and enterprises	2.87	2.72	Advancement to global market
Investment on niche market and export products	2.57		

4 Elicitation of the activation strategy on space industry ecosystem

In this section, each three influence factor, issues, and domestic and foreign cases are analyzed in order to elicit improvement plan for the activation of space industry.

4.1 Budget scale and method of investment on space industry

In Korea, budget investment is usually executed short-term and has unstable supply every year. Controversies over stable financial assistance and its scale are added since the development plan of space industry has not considered integrated opinions from other governmental ministries but focused only on the opinions from MSIP and KARI. Therefore, establishing long-term and secured investment from the government based on public demand has a significant role on R&D budget investment. In order to expand budget scale on space industry, general investment including informationization budget should be considered rather than R&D budget. Depending on its application, space budget could be classified into R&D budget itself, system procurement, and construction of infrastructure so that each allocation is used for each field. In Korea, participation of space R&D among private businesses and enterprises is lagged behind. Other than just net scale of budget, specific objectives are essential to make achievements as planned. Therefore, rather than its scale, stable and persistent government fund will play a significant role. To promote space enterprises to take part in aerospace industry, it is desirable to induce the businesses gradually after establishing national space development plan with concrete projects. Prior to the establishment of national plan, national and public demands on space exploration should be scrutinized. A group of people composed with technology demanders, rather than suppliers, can be organized to predict technological demands on aerospace. Based on public demands, national space development plan can be deducted with approval from overall related ministries. Founder of the plan should consider mid-term fiscal plan of government and make consultations with budget managing department. In addition, the budget assigned to general fund rather than just R&D fund, need to be reviewed for increment. For example, satellite operational tasks revolving meteorological observation and informational purpose should be converted to general budget, where periodic management of devices is highly required. Budgets concerning storage, application, and distribution of satellite data can be reviewed for increment by converting to informationization budget management. It is reasonable to see the application of satellite data as national informationization service that concerns application by demander rather than just research development. Informationization budget in 2012 reached 3,281 billion KRW, about 12 times that of aerospace R&D. Therefore, once make connections a part of informationization budget to satellite information application budget, secured fiscal sources of aerospace R&D can be achieved and finally, space research and development will be activated.

Table 7 Budget trend of government informationization

Contents	*2008*	*2009*	*2010*	*2011*	*2012*
Government budget on informationization	3,467	3,245	3,287	3,298	3,281
Percentage change of informationization budget	1.7	△0.6	1.3	0.3	△0.5

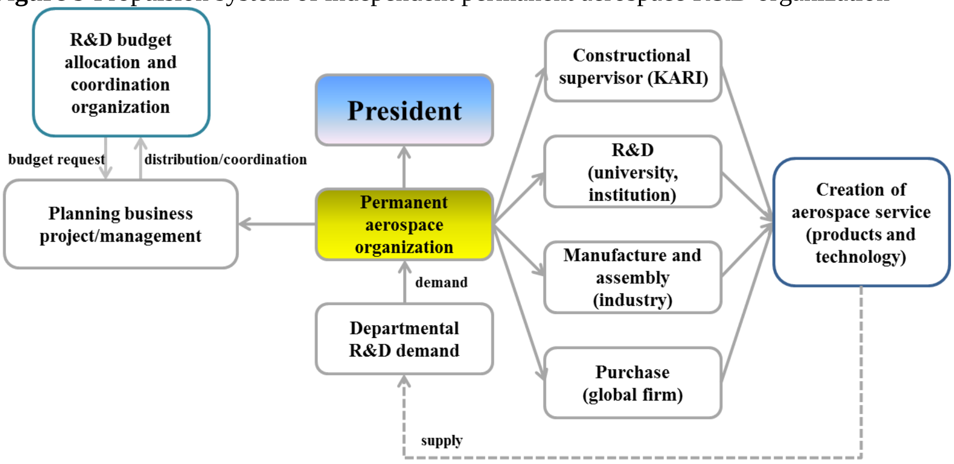
Unit: billion KRW

Entire space budget can be reviewed in various fields classified in their application characteristics; R&D, procurement of aerospace system, and establishing infrastructure. If the technology is hard to obtain via or cooperate with global market for persistently, MSIP should make intensive investment. When it comes to obtaining aerospace system for the purpose of demander application, the demander ministry should be in charge of its budget and let research institute or universities to produce the system. MSIP can be induced to relieve its budget by assigning demander ministry to fund itself to make use of climate satellite information. By converting R&D budget into general budget and introducing contract type, facilitation of development and purchase of products can be enhanced. In case of space center and large satellite experiment facilities where large amount of budget is required, exclusive management of budget should be governed by national policy.

4.2 Propulsion system of domestic space R&D industry

There have been difficulties on consistent propulsion of space R&D businesses as they are mainly executed by MSIP without regarding the entire related governmental ministries. Especially for the space R&D business, lack of permanent organization makes each governmental ministry to obtain its R&D budget by itself, and therefore makes it hard to share and interchange research results. It becomes natural to generate similar research in the end. In addition to that, roles of industry and academia are separated in the field of aerospace that the research is managed only by specific ministry and research institute. This can be worked out by establishing independent and centralized space R&D governance that can be applied to the whole governmental department. Figure 9 describes a case of independent permanent space R&D organization.

Figure 9 Propulsion system of independent permanent aerospace R&D organization



The organization should be able to assist effective consultation among main aerospace R&D governmental department including MSIP and MND (Ministry of National Defense) beside its original object of obtaining secure budget. No matter how small the organization is, it needs to be upper level organization that has roles on every single governmental department by helping building national long- to mid-term aerospace R&D project. The permanent aerospace organization takes charge of establishing space R&D project considering public demand and policy-related propulsion direction. Based on these factors, the organ will take care of procurement, distribution and coordination of the allotted budget. By focusing all space-related projects from the entire department to a single aerospace organization, the coordination between each department will be eased and redundancy among similar projects will be reduced. Furthermore, professionalism will be fortified among governmental officials and this is expected to help long-term and secured policy execution. When it comes to keeping dispersal space R&D system, permanent organization taking care of space industry finance which takes part in establishment of space plan and development of working satellite based on public demand will be in need.

Figure 10 Propulsion system of independent permanent aerospace R&D organization

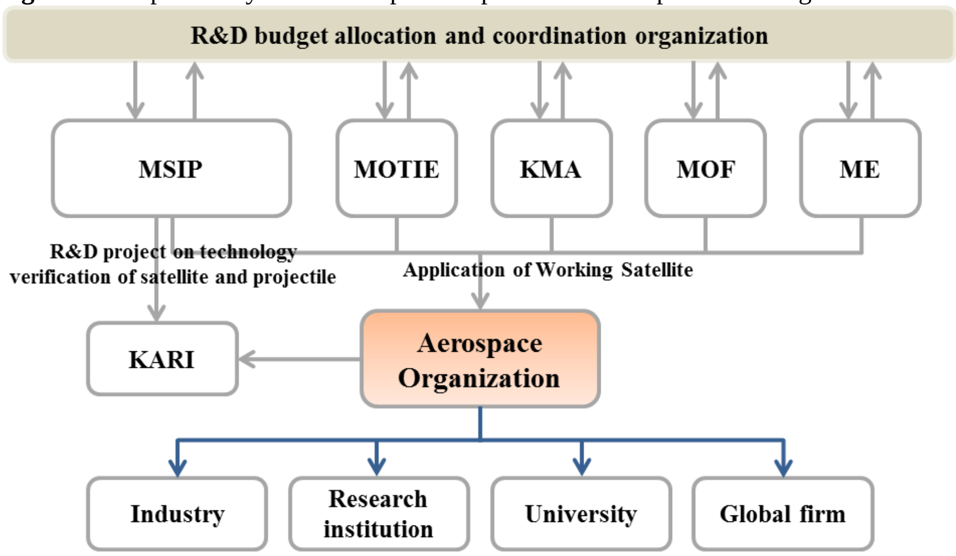


Figure 10 represents permanent aerospace organization in case of dispersal space R&D system. Major executive department and minor department are supposed to fund building permanent space organization and retain stake as both participate in managing the organization. They coordinate aerospace R&D project, collect reviews from relevant department to build up space R&D plan, manage project, and integrated management and service of satellite information. Previously, public demand on space industry has investigated formally by developers. But now, aerospace organization is in charge of surveying the demand in terms of mechanical application enhancing effective use of the technology and distributing to varied department. While suggesting effective public demand on space industry in department of satellite application, coordinated budget is expected to minimize gaps between plan and investment. Once satellite projects concerning multi-purpose and geostationary orbit satellite are placed an order in favor of aerospace organization, the organ can directly contract to KARI, other industries, and overseas firm to obtain space system. This may help building horizontal relation between KARI and industry rather than vertical that KARI used to execute space budget and industries become subcontractor. Naturally, industries can strengthen their ability by themselves. MSIP will focus more on development of critical technology elements and previous studies via KARI especially on R&D project rather than commercial projects regarding technology verification such as space launch vehicle and projectile. Satellite information that was managed and serviced by KARI, KMA, and KIOST is integrated by aerospace organization to intensify applicability of domestic space asset and minimize redundant investment. Space-related departments need to collaborate to manage the space organization and its quota investment.

4.3 Advance global market via space technology industrialization

Considering that the ultimate goal of space development is in creation of added value, industrialization and export of space technology are critical factors that expedite space ecosystem to expand. However, domestic aerospace market is restricted to small and midsize satellite, although global market is continuously expanding. Only a few domains are participating in industrialization and lack of target enterprises to export technologies is another challenge. Therefore, strategic approaches are necessary to get involved in global space market.

First and foremost, approachable target market should be chosen considering current technologies and their capacity to industrialize. Customized strategy will be designed accordingly. These strategies include setting target markets on remote-sensing satellite, landsat imagery, and additional service, and developing small economic remote-sensing satellite, landsat imagery, and other solutions. This aims at obtaining differentiated market competitiveness with improved technologies and economic price. In addition to that, it is necessary to induce targeted market to expand in the order of small-size satellite and mid- to large-size working satellite. Cooperation through G2G and technology transfer through official development assistance for underdeveloped countries will also facilitate advancement toward an emerging global market.

Secondly, conversion from government lead to privately-managed system is required for further improvement of space industrialization to encourage the roles of private sector. In Korea, aerospace industry is government-oriented and needs to blend public and private sector by increasing private roles. To keep up with the changes in satellite market and application objectives, differentiated civil military satellite besides working satellite is essential, and accordingly, diversified and specialized chain supply including cooperative program by government and private industry is required. It is also necessary to review nurturing Korean landsat image market for the expansion of global satellite image market.

5 Conclusion

So far, diversity of strategies has been proposed to enhance aerospace industry vitalization, without considering priority of influence factor. Worse, some strategies reflect interests of specific class, made it risky to realistic application. By analyzing domestic space industry ecosystem, influence factors of space industry activation, and the priority were derived to suggest better activation strategy. Total 39 influence factors were come up by reviewing existing literature and interviewing experts. Opinion of space specialists was investigated on significance and gap between ideal and reality of each factor. As a result of the investigation, the most influential three factors were selected and their improvement measurements were studied. In both investment scale and style, persistent and stable budget funding by government is highly required under precise demand prediction. General fiscal investment including informationization budget should be reviewed instead of R&D budget. In addition, entire space budget can be classified in their application characteristics; R&D, procurement of aerospace system, and establishing infrastructure. For propulsion system in Korea aerospace development, independent and centralized space development governance is needed. If maintaining dispersal space R&D system, permanent organization taking care of space industry finance concerns establishment of space plan and development of working satellite based on public demand in need. To enhance efficiency of the system, expansion of space industry's role in national R&D is highly necessitated. Finally, industrialization of space technologies and strategic plan will enable advancement toward global space market. This study is anticipated to contribute to set up effective investment indication and arrange judicial system for the activation of space industry ecosystem.

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