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Dear Colleagues,

Welcome to 2021, The International Scientific Journal of Engineering and Technology (ISJET) would be five years old, and it is a pleasure to present the first issue and volume 5 of 2021.

This new issue of ISJET highlights multidisciplinary contents, which include six original research articles involving a work-related to Effects of Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) on Rooting and Shooting of Jiaogulan (*Gymnanthemum extensum*) Cutting Stem, Effect of Plasma Treatments and Low Temperature to Some Physical and Some Physiology of Fresh Fig Fruit (*Ficus carica L.*) cv. Black Jack, Experiences of Using Opensource Transport and Traffic Simulation Software for Transport and Traffic Studies in Thailand, Headline2Vec: A CNN-based Feature for Thai Clickbait Headlines Classification, Increasing Performance through Information Retrieval System for Design and Build Company, and *Let-It-Cold* Design Concept for Supporting Temperature-Sensitive Products.

All authors and readers from around the world are invited to visit the website <https://ph02.tci-thaijo.org/index.php/isjet/index>. This link will grant you to submit your research to publish in our journal or will access to electronic versions of all issues of our journal.

On behalf of the Editorial Board, I would like to take this opportunity to thank everyone who has complemented our goal by contributing to the ISJET.

With kind regards,

Asst. Prof. Dr. Korawit Chaisu

Associate Editor of Agriculture Science and Food Technology

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Effects of Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) on Rooting and Shooting of Jiaogulan (*Gymnanthemum extensum*) Cutting Stem

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Abstract—The effects of IBA and NAA on rooting and shooting of the Bitter leaf tree (*Gymnanthemum extensum*) cutting stems were investigated. The stems were obtained from a private garden in Chiang Mai Province. The 25 cm long cutting stems were dipped into distilled water (control), IBA, and NAA with 250, 500, 1000, 2000, and 3000 ppm concentrations for 30 minutes and put in plastic cups in the plant nursery (Program of Biotechnology, Faculty of Science, Maejo University, Chiang Mai) from April to May of 2019. The experiment was performed in a completely randomized design (CRD). The data was collected 30 days after treatments. The result showed that the cutting stem treated with 0 ppm (control), 250 ppm of IBA, and 500 ppm of IBA gave rise to the highest percentage of rooting (100%). In contrast, the cutting stems treated with IBA at 1,000 and 2,000 ppm concentrations yielded 80% of rooting. NAA at 250, 500, 1,000, and 2,000 ppm concentrations gave rise to 73, 73, 73, and 66.7% rooting, respectively. On the other hand, 3000 ppm of NAA provided the lowest percentage of rooting at 53.3%, respectively. Two hundred and fifty ppm of NAA gave the highest average number of roots per cutting compared to the other treatments. The average root length and average root width of control and all treatments were not significantly different ($P < 0.5$). The control, IBA, and NAA at 250, 500, 1,000, and 2,000 ppm concentrations gave the highest percentage of shooting (93 - 100%).

Index Terms—*Gymnanthemum extensum*, Indole Acetic Acid, Naphthalene Acetic Acid, Cutting, Rooting, Shooting

I. INTRODUCTION

Stems of the plant grow like wine, and the leaves have five oval-shaped, saw-toothed edges with white hairs. Jiaogulan can be cultivated from seeds and plant cuttings and can be harvested in 4-5 months after planting [1]. In Thailand, Jiaogulan can grow with good quality in the Northern region, which includes Chiang Mai, Chiang Rai, and Mae Hong Son provinces [2]. Jiaogulan is a popular medicine herb. The leaf and stem of the plant contain saponin glycosides and possess antioxidant activity [3]. Many researchers have reported the optimum concentrations of hormones used for root induction on cutting stems. IBA and NAA are plant bio-regulators that belong to the auxin group [4]. IBA that regulates growth and influences various developmental processes, induces early root formation, callus formation, stem elongation, enhance flowering, enzyme induction, and leaf and fruit senescence [5]. Mulberry stem cutting required plant growth regulators such as IBA and NAA to promote rooting and axillary shoot. Sokhuma et al.[6] reported that the using of IBA and NAA (500, 1,000, 2,000, and 3,000 ppm) on the mulberry stem cutting. The result showed that 3,000 ppm of IBA was the best result of concentration showing 3,000 ppm of IBA was 93.33% survival rate, 86.67 % of rooting, 18.8 roots, 10.82 cm of root length. NAA significantly increased the number of root and root length [7]. However, the effects of the plant growth hormones on Jiaogulan have not been previously reported.

The aim of this study was to investigate the effects of IBA and NAA on rooting and shooting of Jiaogulan cutting stems.

II. MATERIALS AND METHOD

A. The Plant Material

The cutting stems of Jiaogulan from private garden Chiang Mai province. The cutting stem was long 25 cm long and diameter about 0.8-1.5 cm.

The chemicals

The hormone concentrations used are given below:

IBA: 250, 500, 1,000, 2,000, and 3,000 ppm

NAA: 250, 500, 1,000, 2,000, and 3,000 ppm

B. The Other Materials

Plastic cup size (8 cm in diameter and 15 cm in height) with plastic cup lid and 750 ml of distilled water.

C. Experimental Design

The experiment was laid out in a complete randomized design (CRD) with 3 replicates. The total of 330 cutting stem samples were used. The sample size was maintained for each treatment with 10 cuttings/treatment. Prior to the treatment of cutting stem, the bottom of each was prepared with sharp knife to avoid the cutting damage and immersed for 30 minutes in the following treatments:

Treatment 1: 0 ppm (control)

Treatment 2: 250 ppm IBA

Treatment 3: 500 ppm IBA

Treatment 4: 1,000 ppm IBA

Treatment 5: 2,000 ppm IBA

Treatment 6: 3,000 ppm IBA

Treatment 7: 250 ppm NAA

Treatment 8: 500 ppm NAA

Treatment 9: 1,000 ppm NAA

Treatment 10: 2,000 ppm NAA

Treatment 11: 3,000 ppm NAA

The samples were air dried for 5 minutes, and the cutting stems were dipped in plastic cups and put in the plant nursery (Program of Biotechnology, Faculty of Science, Maejo University, Chiang Mai, Thailand) from April to May 2019. Over 30 days, the data on percentage of rooting, number and length of root, percentage of shooting, number of shoot, number of leaves, and width and length of leaf were collected.

All data were analyzed using Analysis of Variance (ANOVA). Significantly different means were separated according to the method of Duncan's New Multiple Range Test (DMRT) as described in Steel et.al. [8].

III. RESULTS

A. Percentage of Rooting, Number of Root and Length of Root

The results showed that all 11 experimental treatments were significantly different ($P < 0.05$) (Table I). The control, 250 ppm IBA, and 500 ppm IBA gave the highest percentage of rooting (100%) and follow: 1,000, 2,000 and 3,000 ppm IBA were 80.0, 80.0 and 73.3% respectively with significant difference ($P < 0.05$) (Table I, Fig. 1). NAA in the concentrations of 250, 500, 1,000, and 2,000 ppm gave higher percentage of rooting compared to that from the 3,000 ppm NAA treatment. The number of roots of the 250 and 500 ppm NAA treated samples were higher than those of control and others treatments. The 250 ppm NAA treatment gave rise to the highest length of root (10.69 cm), significantly different from the control ($P < 0.05$) (Table I, Fig. 1).

TABLE I
PERCENTAGE OF ROOT, NUMBER OF ROOTS AND
LENGTH OF ROOT

Treatments		Rooting (%)	Number of roots	Length of root (cm)
Control	00 ppm	1,100.00±0.00 ^a	99.33±1.52 ^b	66.99±0.85 ^c
IIBA	2,250 ppm	1,100.00±0.00 ^a	8.20±1.42 ^b	77.69±0.82 ^b
	5,500 ppm	1,100.00±0.00 ^a	8.47±1.36 ^b	77.69±0.82 ^b
	11,000 ppm	880.00±0.11 ^b	57.83±1.72 ^c	7.04±1.60 ^c
	22,000 ppm	880.00±0.12 ^b	75.58±0.95 ^c	4.35±0.94 ^d
	33,000 ppm	373.33±0.12 ^c	33.80±0.37 ^d	22.10±0.24 ^d
NNAA	2,250 ppm	773.33±0.12 ^c	111.64±2.33 ^a	110.69±0.54 ^a
	5,500 ppm	773.33±0.12 ^c	110.80±0.92 ^a	77.95±1.18 ^b
	11,000 ppm	773.33±0.12 ^c	9.73±2.16 ^a	77.05±0.77 ^c
	22,000 ppm	673.33±0.12 ^c	9.00±0.73 ^b	66.66±0.43 ^c
	33,000 ppm	553.33±0.13 ^d	77.82±1.82 ^c	55.35±0.80 ^d

*^{a,b,c,d} The different letters in the same column represent statistically significant differences ($P < 0.05$) by DMRT

B. Percentage of Shooting and Number of Shoot and Leaves

We found that the control, IBA, and NAA at 250, 500, 1,000, and 2,000 ppm yielded the highest percentage of shooting (93-100%). On the other hand, 3,000 ppm of IBA and NAA led to 60% shooting, which was the lowest shooting percentage, significantly different from the other treatments ($P < 0.05$) (Table II).

Compared to the other treatments, the control,

250 ppm IBA, and 250 ppm NAA led to higher number of shoots. The numbers of shoots and leaves significantly decreased with increasing concentrations of IBA and NAA ($P < 0.05$) (Table II).

The 3,000 ppm IBA and NAA treatments led to the lowest numbers of shoots and leaves (1.22 and 1.00, respectively) (Table II). In contrast, the numbers of leaves in the control, IBA, and NAA at 250 and 500 ppm were higher than those in the other treatments (Table II).

TABLE II
PERCENTAGE OF SHOOTING, NUMBER OF SHOOTS, AND NUMBER OF LEAVES

Treatments		Shooting (%)	Number of shoots	Number of leaves
Control	00 ppm	1,100.00±0.00 ^a	92.00±1.52 ^a	68.77±0.73 ^a
IIBA	2,250 ppm	1,100.00±0.00 ^a	22.13±0.14 ^a	78.83±0.82 ^a
	5,500 ppm	1,100.00±0.00 ^a	11.67±0.13 ^b	78.43±0.66 ^a
	11,000 ppm	8,100.00±0.00 ^a	51.60±0.16 ^b	77.80±0.48 ^b
	22,000 ppm	8,100.00±0.00 ^a	71.40±0.13 ^c	77.73±0.52 ^b
	33,000 ppm	360.00±0.13 ^c	31.22±0.15 ^d	25.11±0.82 ^c
NNAA	2,250 ppm	7,100.00±0.00 ^a	12.00±0.14 ^a	19.21±0.68 ^a
	5,500 ppm	7,100.00±0.00 ^a	11.73±0.12 ^b	88.77±0.73 ^a
	11,000 ppm	793.00±0.07 ^b	11.69±0.13 ^b	77.00±0.62 ^b
	22,000 ppm	693.00±0.07 ^b	11.43±0.13 ^c	67.36±0.54 ^b
	33,000 ppm	560.00±0.13 ^c	71.00±0.00 ^d	56.44±0.93 ^c

*a,b,c,d The different letters in the same column represent statistically significant differences ($P < 0.05$) by DMRT

IV. DISCUSSION

This result is an indication that control and IBA enhanced rooting in *Jiaogulan* (*Gymnanthemum extensum*) stem cutting better than NAA. Cutting of control and treated with IBA had the highest mean percentage of rooting (80 - 100%) than cutting treated with NAA having 53.33-73.3%. These were found to be significantly different ($P < 0.05$). IBA was more effective than NAA in enhancing rooting ability in *Jiaogulan* stem cutting. The result complies with that other tropical tree species like *Prunus africana* [9] and *Juniperus procera* [10] reported that IBA significantly enhanced rooting ability compared to NAA. Further, it has been evident that IBA was more effect in increasing the percentage of rooting as the case in *Jatropha curcas* [11] and in *Pongamia pinnata* [12] compared to NAA. IBA was more effective in inducing plants rooting than NAA, because the former was more stable than the latter, and more important, IBA can be changed into IAA (Indole Acetic Acid) by the mechanism of parallel to fatty acid oxidation [13].

In the present study, higher concentrations of IBA had significantly low rooting ability in *Gymnanthemum extensum* in agreement with studies varios on *Juniperus procera*, which demonstrated

significant difference in mean root numbers due to the variations in IBA concentrations [14]. Similar reported have also been reported in other tree species like *Dalbergia sisso* Roxb that have relatively poor rooting response in presence of high concentration of IBA [15]. The decline in rooting percentage with high concentration of IBA is inhibitory to root initiation, as has been recorded in a number of other tree species. Depending on the endogenous level of growth regulating substance, exogenous application of auxin may be promotive, in effective or even inhibitory for the rooting of cuttings [16]. Other results were rooting of cuttings may be influenced more by the other factors such as physiological age of the cuttings and status of rooting media in terms of aeration and drainage properties as stated by Narin and Watna [17].

All treatments were significantly different in percentage of shooting, number of shoot, and number of leaves. The results found that control, IBA and NAA at 250, 500, 1,000, and 2,000 ppm were highest percentage of shooting (93.3 - 100%). In contrast IBA and NAA 3,000 ppm were the lowest percentage of shooting (60.0%). This study was similar to the previously reported effects of auxins (IBA and NAA) on shooting of mulberry (*Morus alba* Linn.) cv. Chiang Mai 60, which was decreased with high

concentrations of hormones (IBA and NAA). The result showed that the control (0 ppm), IBA and NAA at 250, 500, and 1,000 ppm were higher percentage of shooting than IBA and NAA at 2,000 and 3,000 ppm [18]. In This study we found that the high auxins (IBA or NAA) had decreased the percentage of rooting and shooting of Jiaogulan stem cutting. Since Jiaogulan stem cutting have adequate auxins which induce rooting and shooting. Thus the high concentrated of auxins can inhibit growth in term of rooting and shooting [19].

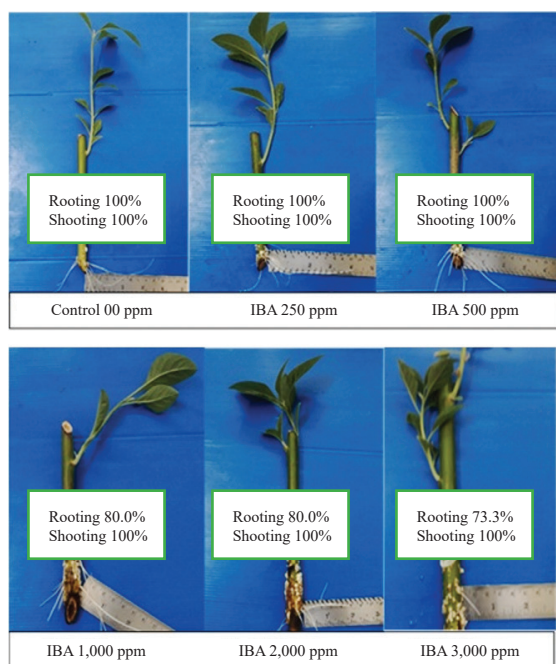


Fig. 1. Effects of IBA on rooting and shooting of Jiaogulan (*Gymnanthemum extensum*) cutting stem.

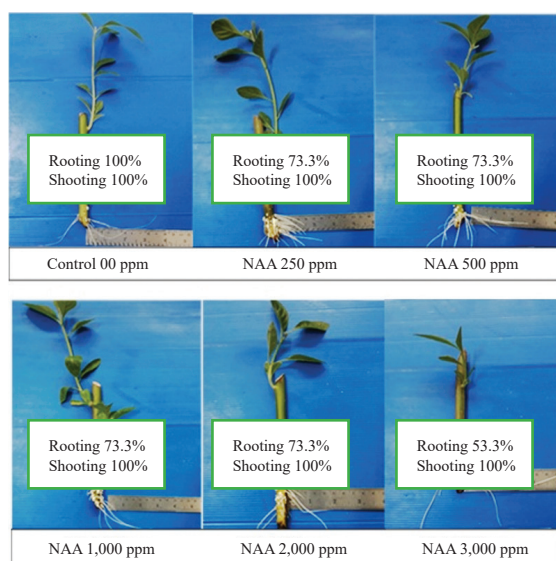


Fig. 2. Effects of NAA on rooting and shooting of Jiaogulan (*Gymnanthemum extensum*) cutting stem.

V. CONCLUSION

The results showed that there were significant differences on percentage of rooting, number and length of roots, percentage of shoots, number of shoots, number of leaves, and width and length of leaves. Slight selective response to growth hormone was observed in percentage of rooting, number and length of roots: the control and the IBA treated cutting formed roots better than the NAA treated cutting. However, the control (untreated) cutting gave the best performance for all the parameters assessed on roots and shoots of Jiaogulan.

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Effect of Plasma Treatments and Low Temperature to Some Physical and Some Physiology of Fresh Fig Fruit (*Ficus carica* L.) cv. Black Jack

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Abstract—The aim of this research was to study the effect of plasma treatments and low temperature on some physical and some physiology of fresh fig fruit (*Ficus carica* L.) cv. Black Jack during postharvest cold storage. We investigated the effects of different time plasma treatments including 2, 5, and 10 hours compared with the control (untreated) fruit during storage at 4°C. The results are found that plasma treatments reduced the metabolism of fresh fig including weight loss, respiration, and ethylene production during storage. The decreasing of firmness was reduced by plasma treatment, especially 2 hours plasma treated. Moreover, plasma treatments remarkably inhibited fungal incidents which prolong the storage life of fresh figs under storage at 4°C. However, these treatments did not affect the color change in this fruit. These findings suggest that plasma treatment combined with storage at low temperature has commercial potential and useful to reduce postharvest decay, maintain the quality and prolong the storage life of fresh fig fruit cv. Black Jack. More studies should be accomplished on this technique for other fig cultivars and nutritional properties after treatments.

Index Terms—Fig Fruit, Postharvest Quality, Plasma Technology, *Ficus carica*

I. INTRODUCTION

The fig (*Ficus carica* L.) Musaceae family is a traditional fruit believed to be originated from western Asia and to have been distributed by humans throughout the Mediterranean. There are four distinct types based on the flowering characteristics of figs including Caprifig, Smyrna, San Pedro, and Common fig. Caprifig is uneatable, only male flowers are observed, use for the pollen for pollination. Smyrna consists of only of female flowers that require the pollen from Caprifig for development. San Pedro produces female flowers, bearing two fig crops, one

borne on leafless wood without pollination, the other with pollination, borne on new wood. Common fig produces parthenocarp; do not require pollination to develop and mature fruit. The Common fig is a nutritious fruit, high in fiber, potassium, calcium, iron, and is free of sodium, cholesterol, and fat [1]. Additionally, figs are a source and abundant of vitamins, amino acids, and antioxidants. Fig varieties with dark skin (i.e. Mission, Checchik, Black Jack, Brown Turkey, and Bursa) contains higher levels of polyphenols, anthocyanins, and flavonoids and higher antioxidant activities than lighter skin figs (i.e. Brunswick, Kadota, Sierra, Tina, UCR200-43, and Panachee) [2].

Fresh fig is a kind of perishable fruit with is very short durability period (3-5 days) at room temperature. Fungal decay of figs can result in extensive losses for the farmer.



Fig. 1. Fungal decay incidence of fresh figs during storage and on shelf life.

Recently, the fig is becoming a popular and high potential crop in Thailand. Fig cultivation in the greenhouse is practical, growers could control the environmental factor conditions and other risks from pests and plant diseases, an increase of productivity and in quantity, and commercial opportunity. Black Jack is one of the most popular cultivars grown

in Thailand, because easy to grown and high productivity. The fruit of Black Jack is purplish-brown to purplish-black and the pulp is amber with rose tones. The skin is thin and spoilage sensitive. Moreover, it can be cultivated both in a greenhouse and open field conditions depend on preference, cost and type of the growers want to be [3].

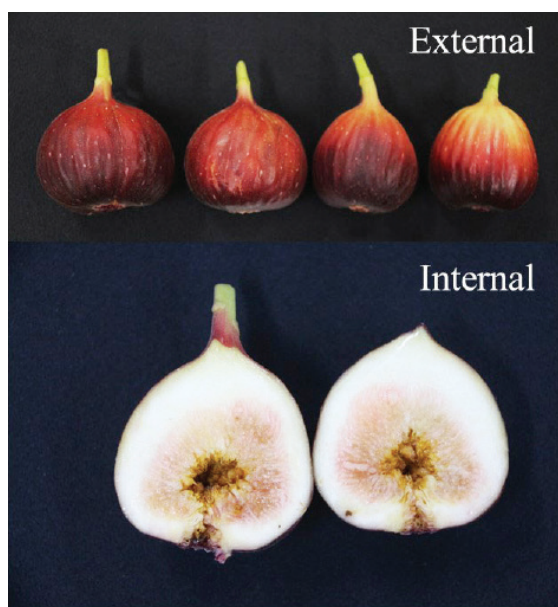


Fig. 2. External and internal of fresh figs cv. Black Jack

Different sizes of viols which are made of propylene (PP) were used for packaging fresh figs. The optimum and reasonable for consumers were 4 fruits capacity (Fig. 3).



Fig.3. Packaging of fresh figs put in the market and modern trade.

Plasma is the fourth state of matter and is an ionized gas, a gas into which sufficient energy is provided to free electrons from atoms or molecules and to allow both species, ions, and electrons, to coexist. Depend on the sources of plasma generated from, high or low temperatures. Plasma was devised into 2 types as thermal and cold plasma, respectively [4]. The cold plasma contains energetic reactive species including, electrons, positive and negative species, ultraviolet (UV), free radicals and excited or

non-excited molecules and atoms. On strawberries, decay during postharvest storage is mainly caused by the fungus. Cold plasma has been used on strawberries to prevent decay from microbial during storage [5]. Moreover, it has been reported that plasma treatment successfully inactivated microorganisms in liquid media [6] and on fresh produce [7]. Previous studies found that cold plasma is an efficient technique used for fruit and vegetable surface decontamination [8]. This technique is high potential and suitable for substantial applications, especially for maintained phytochemicals and quality of agricultural produces [9], [10].

Very little research has been showing the effectiveness of storage temperatures lower than 5°C in reducing the metabolic activity affected on the quality maintaining of fresh fig [11]. In present, there are no reported about plasma treatment on postharvest quality of fresh figs and there is very little research in figs postharvest physiology.

The objective of this research was to investigate the effect of plasma treatments on the quality and storage life of fresh figs at cold storage.

II. MATERIALS AND METHODS

Experiments were performed on (*Ficus carica* L. cv. Black Jack) at commercial-stage purchased from a local farm in Chiang Mai Province. The fruits were harvested and immediately packed in the boxes and transported to the laboratory of Quality Assurance, the King Mongkut's University of Technology Thonburi in Bangkhuntien Campus. Fruits were selected based on uniformity of size, color, and without defects. Selected fruits sample were placed in a sealed plastic chamber at 25°C. Using a plasma generator (PG), the fruits were treated for 2, 5, and 10 hours, respectively. After treatments, all fruits were transferred to an observation room under 4°C. The study was done following a completely randomized design (CRD) experiment using 4 replications.

A. Weight Measurements

After treatment, the fresh weight of the fruits was measured at room temperature (25°C) every 2 days.

B. Color Measurement

The Surface color was evaluated with a colorimeter (Minolta, model CR -300, Osaka, Japan). The L* and hue angle values in five positions of the fruit were measured.

C. Quantification of Ethylene Production and Respiration

Individual fruits were placed in 450-mL plastic boxes sealed with lids fitted with a silicone rubber injection port. The boxes were sealed for 1 hr at 25°C, and 1-ml gas samples were collected from the headspace to determine ethylene concentration

by gas chromatography with a flame ionization detector (model GC-15 A, Shimadzu, Kyoto, Japan) using an activated alumina column (2.0 m×3.0 mm I.D., Shinwa Chemical Industries Ltd. Kyoto, Japan). The respiration rate was determined by gas chromatography (model GC2014, Shimadzu, Kyoto, Japan) with a thermal conductivity detector using a Porapak Q column (1.0 m×3.0 mm I.D., Shinwa Chemical Industries Ltd. Kyoto, Japan).

D. Firmness

The firmness of the fruit (resistance to compression & penetration) was determined using an automatic penetrometer. The force required to induce 3 mm of deformation at a rate of 0.2 mm/s in five fresh fig fruits was recorded using an Instron texture analyzer (Instron 4302 Universal Testing Machine, Canton, MA, USA) with a 3.5 mm flat diameter cylindrical probe. Data were analyzed using Instron series software IX for Windows. This test measures the firmness of the fruit based on the resistance of the flesh to deformation by the probe [12].

III. RESULTS AND DISCUSSION

A. Weight Loss under Cold Room Storage

During storage, weight loss of fresh fig cv. Black Jack gradually increased. The weight of figs pronounced loss in the control fruit, highest throughout the experiment period. Fresh figs treated with plasma at 2, 5, and 10 hours were not different among the treatments (Fig. 4).

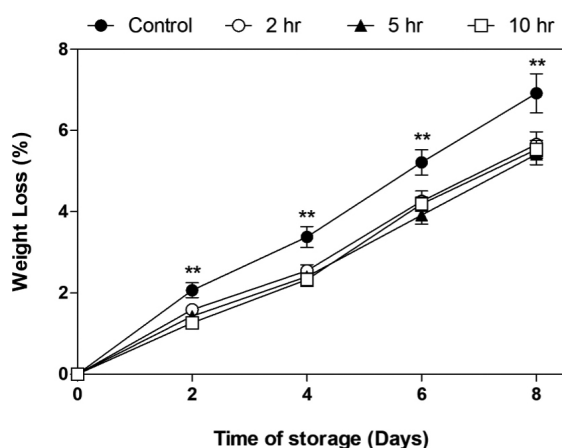


Fig. 4. Weight loss of fresh fig 'Black Jack' after treated with plasma for 2, 5, and 10 hours, respectively.

B. Color

Fruit color is a major quality factor that needs to be discussed after treated with plasma. Consumers are attracted by the black-red of fig cv. Black Jack. A Previous study reported that plasma treatment did not affect color change and the firmness of strawberries and cherry tomatoes contained in the package, significantly [5]. In this research, the lightness parameter (L^*) of plasma treatments and

control figs were gradually decreased throughout the experiment, and no significant difference among the treatments. The redness value (a^*) of treated fresh figs were constantly during storage and not significant differences among the treatments (Fig. 5).

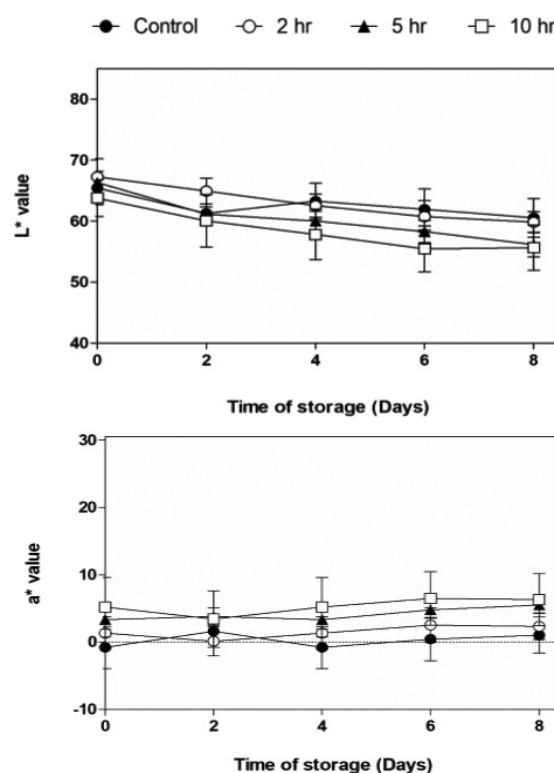


Fig. 5. Lightness (L^*) and redness (a^*) of fresh fig 'Black Jack' after treated with plasma for 2, 5 and 10 hours, respectively.

C. Ethylene Production and Respiration Rate

It is well-known that the deterioration rate of agricultural produces after harvested is generally related to the respiration rate [13]. After treated with plasma, the respiration rate in all treatments was decreased on the first 2 days of storage, lowest (10.86 mg $\text{CO}_2/\text{kg}\times\text{hr}$) on 5 hours plasma treatment (Fig. 6). Thereafter, the respiration rate was constant in both treated and untreated figs throughout the experimental period.

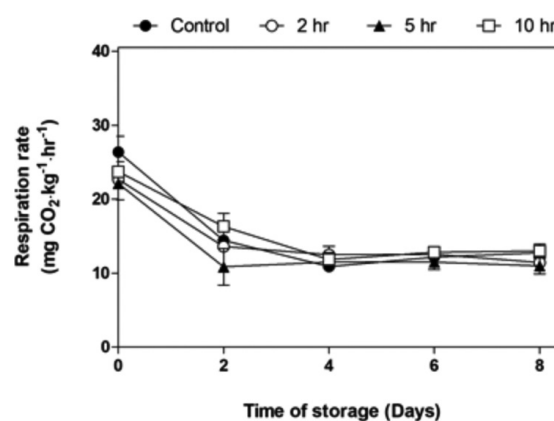


Fig. 6. Respiration rate of fresh fig 'Black Jack' after treated with plasma for 2, 5, and 10 hours, respectively.

In general, the ethylene production rate increases with harvest maturity and with physical injury, disease attack, elevated storage temperatures up to 30°C, and water stress. On the other hand, the ethylene production rate of fresh horticultural crops is reduced by storage at low temperature, reduced oxygen content (less than 8%) and increased carbon dioxide content (more than 2%) around the agricultural produces [10]. Ethylene production of fresh figs after treated with plasma was gradually increased from day 2 to day 6 during storage in plasma treatment for 2, 10 hours and control. Fresh figs treated with plasma for 5 hours were shown constantly ethylene production rate between 0.392 and 0.484 $\mu\text{l C}_2\text{H}_4/\text{kg}\times\text{hr}$ (Fig. 7).

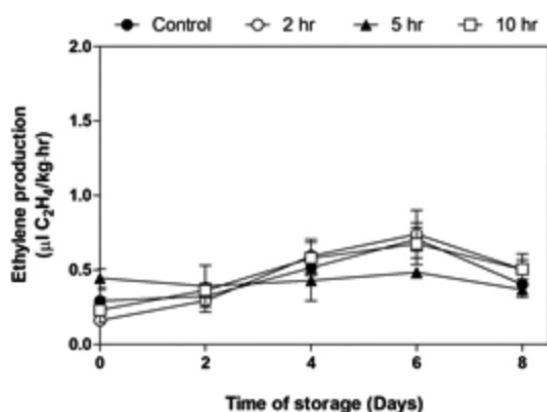


Fig. 7. Ethylene production of fresh fig 'Black Jack' after treated with plasma for 2, 5, and 10 hours, respectively.

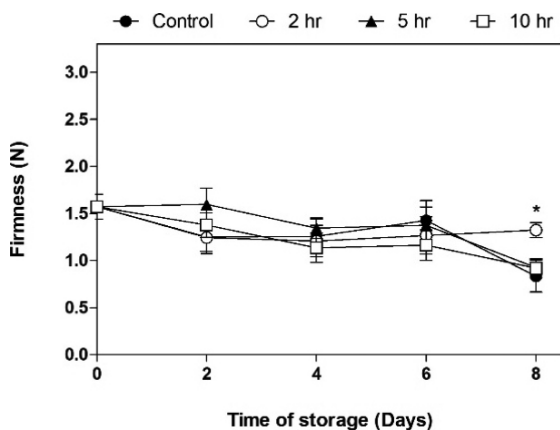


Fig. 8. Firmness change of fresh fig 'Black Jack' after treated with plasma for 2, 5, and 10 hours, respectively.

D. Firmness

The firmness of fresh figs in control and treated with plasma for 2, 5, and 10 hours are shown in Fig. 8. The Firmness of fresh fig slightly decreased from an initial value of about 1.5 N to below 1.0 N on 8 days of storage, indicating that the fruit increasingly softened with storage time.

Common figs, naturally, are soft fruits and very highly susceptible to loss of firmness, especially in the mature stage. In this research, plasma treatment did not influence firmness loss, although, on day 8 of

storage, fresh figs treated with plasma for 2 hours had higher than fresh figs in control and other treatments significantly. This is related to with the finding of Misra et al., [5] in strawberries.

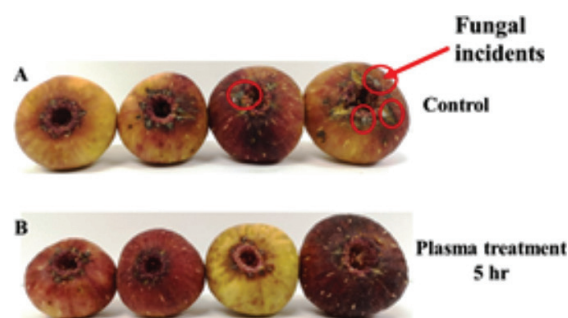


Fig. 9. Ostiole-end splitting and fungal damage appearance in control fresh fig (A) compared with Plasma treated fresh fig (B)

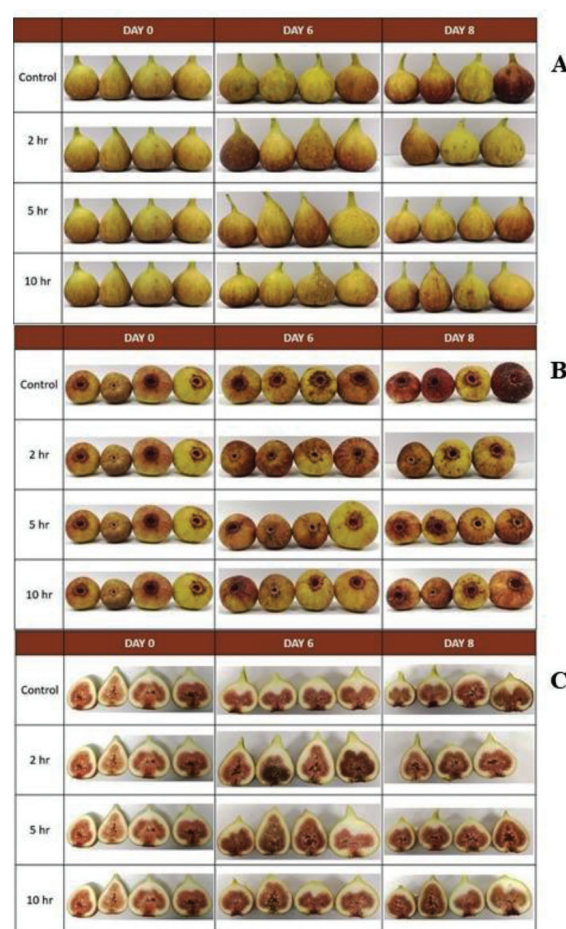


Fig. 10. External (A) ostiole-end (B) and internal (C) appearance of fresh fig cv. Black Jack after treated with plasma and stored at 4 °C

The fungal incident was inhibited by plasma treatment for 5 hours, while in control figs surface show fungal appearance (Fig. 9). It has been reviewed that the major mechanism for inactivation effect of plasma is reactive oxygen species (ROS)-induced oxidative damage [14]. Low temperatures application is one of the most significant factors in maintaining the quality and controlling spoilage of fresh figs [15].

IV. CONCLUSION

In conclusion, the result suggests that the common fig cv. Black Jack is being considered as proper crops with high commercial value. Plasma treatments remarkably reduced weight loss and prolong the storage life of Black Jack, but had no marked effect on color and fruit firmness. In addition, fungal incidents are absent in fresh figs treated with plasma. However, treatment duration is one of the most important factors affecting the efficiency of plasma treatment. Further studies should be conducted, especially in nutrition and antioxidant activities after treatment.

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Experiences of Using Opensource Transport and Traffic Simulation Software for Transport and Traffic Studies in Thailand

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Abstract—This article summarizes the experiences of using open-source transport and traffic simulation software for transport policy and planning works in Thailand. The first software is the TRANUS, which is the Land Use Transport Integration (LUTI) software. The other software is SUMO (Simulation of Urban Mobility), which is the traffic simulation software. The reviews are general software features, input data requirements, and potential outputs. The paper also discusses the example of project implementations, which uses TRANUS and SUMO for evaluating the impacts of the metro line services around the activity center area. Experiences show that, even though there is a learning curve for both software, it's free of costs, diverge user communities, and prompt software features, are representing that open-source transportation software platforms could be an alternative for future transport policy and planning work in Thailand.

Index Terms—Land Use Transport Integration (LUTI), TRANUS, SUMO

II. INTRODUCTION

The performance of Thailand's transportation infrastructure has been improved in the last 20 years. Perhaps, the tipping point was between 2005 and 2010, in which the performances had increased from 19.69 to 61.52 [1]. Additionally, after the first metro line opened its services in 1999, the metro system becomes the demanded public transportation services in Bangkok and its vicinity areas. Hence, from the first metro line in 1999, Thailand expects to have more than 400 kilometers of the metro transit serving a population who live in Bangkok and its vicinities by the year 2035.

According to Thailand's Infrastructure Development Master Plan (2015-2022), the new transportation development strategies (2015-2022) consist of 5 essential programs, including intercity rail

network, highway network capacity enhancement, Bangkok's public transportation network development, and air transport capacity enhancement. The total investment budget is approximately 3.38 Trillion Baht, with more than 50 percent of the budget allocating to the action plan in 2016.

Based on the prior demands of the transportation developments, various project studies which including demand estimation, environmental impacts, project costs, and project benefits, are growth parallel to the needs and demands of the development. Transportation modeling software becomes a vital tool that is needed to use for assisting the project studies and the planning and development decisions.

There are many transportation software, either travel demand estimation software or traffic simulation software (both mesoscopic and microscopic simulation), and already applied in various projects in Thailand. For example, Cube Voyager and Cube Land from Citilabs, The Cube Voyager is the tool that provides advanced transport modeling techniques: forecasting and assignment of local, regional, and long-distance demand and Cube Land is an econometric model of land-use allocation that brings into the modeling process concrete land-transport interactions [2]. Additionally, VISSUM from PTV is also one of the leading transport and traffic planning tools that carry out traffic studies, predictions, and data management based on the GIS. The software can model all road users and their relationships, plan for the public transit system, and develop transport strategies and solutions [3].

However, this paper discusses the experiences of using two open-source software. One is the travel demand estimation software based on land use and transportation integration (LUTI), TRANUS. The other is the traffic simulation software, SUMO (Simulation of Urban Mobility). Discussions of their general features, input data requirements, the potential outputs, and the implementation examples are next.

II. TRANUS

A. General Information

TRANUS is the travel demand modeling that considers the integration of land use and transport modeling. It can model the transportation demand for both the city and regional levels. The main feature of the program is the ability to evaluate the activity location and interaction, the real estate market, and the transportation systems and its demands. TRANUS has been used in various transport and urban studies projects. For example, it evaluates the different residential housing and transport development scenarios between 2020 and 2030 for the Urban Region of Grenoble, French [4]. A case study on Xiamen Island, China, also applies TRANUS to explore the relationship between urban transportation energy consumption and the transition of settlement morphology [5]. TRANUS also uses it to distinguish the land-use effects of road pricing based on the urban form [6].

TRANUS relied on several fundamental theories such as Von Thunen (Spatial Microeconomics), Hensen Lowry (Gravity and Entropy), Input-Output (Leontief), Random Utility (McFadden), and Transport Models (Dijkstra). TRANUS has its structure divided into two parts, (1) Activities and (2) Transport. The activity structure evaluates the traveling demands consuming by economic sectors. This part also connects the activities analysis base on land uses of the study area. The transportation system transfers economic activities into transport activities before assigning traveling demand into individual mode and route in the studied transport network [7].

B. Input Data Requirements

There are several inputs required for developing LUTI model. The most extensive inputs that, perhaps, are the barrier in developing LUTI model are land prices and land use data. However, other information is also crucial for modeling development. Notably, specific parameters represent traveling behavior, economic consumptions, and land consumptions in the study area. Table I summarizes the main TRANUS inputs that the authors use in the case studies, presenting in this paper.

TABLE I
SUMMARY OF TRANUS INPUTS IN THE STUDIES

Data	Description	Sources
Population (Zonal Data)	Number of population in the traffic analysis zone (TAZ), the data area usually evaluate base on population census while distributing in the smaller zone using land use data. However, this study uses the WorldPop Dataset	WorldPop Dataset, University of Southampton
Employment (Zonal Data)	Number of employment in each traffic analysis zone (TAZ), the employment may be classified into (1) primary, (2) secondary, and (3) tertiary or elaborate in more detail classes d	Business and Industrial Census (National Statistical Office)
Land Use (Zonal Data)	Land Use in the study area classified by land-use type that available in each TAZ in square meters	Manually create base on the project
Land Price (Zonal Data)	Land price is usually under the unit of Baht/Month/ Square Meter	Treasury Department
Road Network (Transport Infrastructure Data)	Roadway network including walk links	OSM file from the open street map network
Public Transport Service (Transport Infrastructure Data)	Link list for available public transport services can be both the same link as those provide for road network or separate links for individual public services (such as rail services)	Evaluate base on the specific survey results in the study area (Home Interview Survey)
Value of Travel Time (VOT) (Model Parameter)	Value of Travel Time or times spent while traveling from origin to destination including delay from traffic or signalize intersection in the study area	Home Interview Survey
Value of Waiting Time (VWT) (Model Parameter)	Value of Waiting Time or Time spent while waiting to travel usually occur for the public transport service	Home Interview Survey

TABLE I
SUMMARY OF TRANUS INPUTS IN THE STUDIES (CON.)

Data	Description	Sources
Percent of Vehicle Availability (Model Parameter)	Percent of vehicle ownership for each economic sector or group of traveler in the model (i.e., high incomes, medium incomes, and low incomes)	Home Interview Survey
Trip generation rate (Model Parameter)	Rate of trip generate for each economic sector or trip purpose, for example, home base work trip (HBW) for high-income persons, HBW for medium-income persons, and HBW for low-income persons	Home Interview Survey

C. Potential Outputs

Since TRANUS has two main programming structures that collaborate the land use and transport evaluation for the study area, the modeling outputs are various from transport performances to land use/land price indicators. So far, various outputs that the authors have used are those related to the Transit Oriented Development (TOD) indicators. The authors classified the outputs from TRANUS into 4 groups, including Density, Diversity, Design, and Transport. Table II summarizes the TRANUS outputs using in this study.

TABLE II
SUMMARY OF TRANUS OUTPUTS

Indicator Group	Indicators	Unit
Density	<ul style="list-style-type: none"> Population (residence) density Basic Employment density Service Employment density 	persons / square kilometers
Diversity	The proportion of land uses or land consumptions by land-use types, i.e., residences, commercial, industrial	Percent base on land use type or in square meters' base on land use type
Design	Accessibility evaluated by average disutility on accessing the study traffic analysis zone	Baht
Transport	Number of trips for each transportation mode (elaborate between private and public transportation services)	Trips or percentage of trips by mode

III. SUMO

A. General Information

Simulation of urban mobility (SUMO) is an open-source computer-aided multimodal traffic simulator created by the German Aerospace Center (DLR) [8], which capable of analyzing various tasks of traffic simulation. The specialty of SUMO simulator is self-made user assignment and the usage of faster data structures. These features compose the simulator to be quick and portable, which is a significant advantage for traffic analyses.

The features provided in this software included the applications for preparing road networks and relevant traffic data, modeling the traffic performance, and supporting different dynamic user assignment algorithms. Preparation of street network addressed in three methods as manually generation, employ the street network generation application through "Netgen" command, and import compatible street network file from external sources. Refocus on the external compatible file; there are several standard formats such as VISUM, Vissim, Shapefiles, Open Street Map (OSM), RoboCup, MATsim, OpenDRIVE, and XML-Descriptions. Simulation features support a traffic modeling based on space-continuous and time-discrete vehicle movement, various vehicle types, multi-lane streets with lane changing, assignable right-of-way, and traffic signaling rules to operate urban mobility simulation such as traffic evaluation, route-choice analysis, traffic forecast. An excellent example of using SUMO for real-world studies are: tracking the traffic emission reduction based on traffic management strategies [9], forecasting the traffic impacts for the City of Cologne during the world youth day in 2005 and the soccer world cup in 2006 [10], and testing and designing the Vehicle Actuated Intelligent Traffic Signal Control (VITAL) [11].

B. Input Data Requirements

Most input data requirements for SUMO using in this study are the road network and the Origin Destination (OD) matrix. The road network is gathered by importing the OSM files from the open street network. The road connectors and their turning scheme are then checked for their completeness. On the other hand, the OD matrix using in this study is transferred from the TRANUS model. Only OD for the peak hour traffic is used in this study, both morning peak hour and afternoon peak hour traffic.

Fig. 1 presents the idea of data transformation from TRANUS to SUMO.



Fig. 1. Data transformation from TRANUS to SUMO

C. Potential Outputs

The main outputs that the authors take from SUMO traffic simulation model are 1) the total network performance and 2) the individual (specific) link performances. The general indicators for the total network performances gathered from SUMO software are 1) Number of traffic enter and leave the study network, 2) average speed entering the network, 3) average speed leaving the network, 4) average speed while traveling in the network, 5) total waiting time, and 6) average delay. Additionally, the link performance indicators are used to collect the link data at the specific location in the model where the authors plan to test the small roadway improvement in such a location. Hence, only the two most common indicators are selected for representing the link performances. These indicators are average speeds and link delay. Table III summarizes the SUMO's potential outputs used in this study.

TABLE III
SUMMARY OF SUMO OUTPUTS

Indicator Group	Indicators	Unit
Network Performances	• number of traffic enter and leave the study network	vehicles/hour
	• average speed entering the network	kilometer/hour
	• average speed leaving the network	kilometer/hour
	• average speed while traveling in the network	kilometer/hour
	• total waiting time	second
	• average delay	second
Link Performances	• average speed	kilometer/hour
	• average delay	second

IV. CASE STUDY: TRANUS AND SUMO INTEGRATION FOR THE EVALUATION OF METRO LINE SERVICE IMPACTS AROUND THE ACTIVITY CENTER AREA

To evaluate the use of both modeling software (TRANUS and SUMO), the authors select the study area which is currently under the construction of the metro line services and expected to open for its operations within 2 years. This case study uses TRANUS to evaluate both the changes in land uses and travel characteristics in the study area. On the other hand, the authors use SUMO to simulate the traffic conditions along the main street of the study area and comparing the traffic performances before and after the construction period.

A. Study Area

The study area located in the North part of Bangkok. The area connects two districts, Pak Kred (Nonthaburi province) and Lak Si (Bangkok). The 8 lanes highway (Chaengwattana) is crossing the study area from East to West and Srirat expressway crossing from North to South. There is a 300,000 population (night time population) living in the study area [12]. Additionally, there is approximately 65,000 employment, which mostly (62.38%) is the employment from the commercial sector. Further, the employment for the industry sector, the office service sector, and the retail service sector is 4.83 percent, 24.97 percent, and 7.83 percent of the total employment in the study area, respectively. Fig. 2 presents the study area, and Table III presents the study boundary, both physical and temporal boundaries.

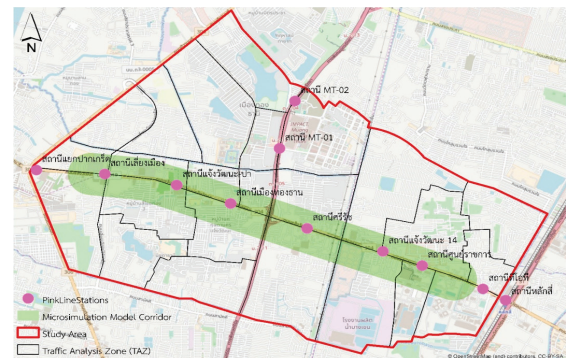


Fig. 2. Study area

TABLE IV
CONCENTRATED STUDY AREA BOUNDARY

Model	Physical Boundary	Temporary Boundary
TRANUS (Land-use Transport Integration Models)	the area located between Laksi District (Bangkok) and Pak Kred (Nonthaburi province) (Fig. 2 red color boundary)	daily traffic volume, morning and evening peak hour
SUMO (Traffic Microsimulation Model)	the 8 lanes highway (Chaengwattana) (Fig. 2 green corridor)	morning and evening peak hour

B. Modeling Structure

There are two components for the TRANUS modeling structure. The first component is the land-use model, and the second component is the transport model. For the land-use model, there are two types of economic sector, transport, and non-transport sectors. The transport sector is usually divided into three subgroups: basic employment (exogenous), service employment (endogenous), and residences. In this study, there are two sub-economic sectors for basic employment, which are the service sector (office employment) and the industry sector. Two sub-economic sectors for service employment, including retails (malls/markets) employment and retail (commercial service) employment. Also, for residences, this study divides residences into three income groups (high, medium, and low incomes). Further, there are four groups of the non-transport sector (industry building area, office building area, commercial building area, and residential building area). Fig. 3 presents a land-use modeling structure. Table IV summarizes the modeling structure for the transport sectors. Table V summarizes the modeling structure for the non-transport sectors.

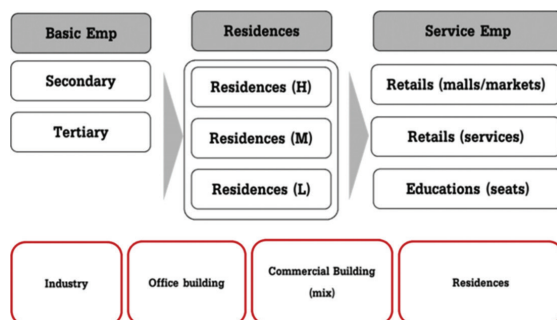


Fig.3. Land-use modeling structure in TRANUS

TABLE V
MODELING STRUCTURE FOR THE
TRANSPORT SECTORS

Activity Sectors	Main Sector	Type
1. Basic: Industry 2. Basic: Services	Basic Employment	Exogenous Exogenous
1. Service: education 2. Service: commercial 3. Service: retails 4. High inc. res. 5. Medium inc. res. 6. Low inc. res.	Service Employment	Induced by res. Induced by res. Induced by res. Induced by emp. Induced by emp. Induced by emp.

TABLE VI
MODELING STRUCTURE FOR THE
NON-TRANSPORT SECTORS

Land Types	Consumed by
1. Industrial	Industry emp.
2. Office building	Services emp and Retails emp.
3. Commercial Building (mix)	Retails (services)
4. Residences	Residence (high, medium, and low inc.) Industry emp, service emp, and retail emp

For the transport model, the model creates two groups of traveling based on the land-use model's economic sectors. The first group is the traveling demand from the household activities, which are Home Base Work (HBW) trips and Home Base Education (HBE) trips. The second group is the traveling demand from other activities or Non-Home Base (NHB), which are the trip to service (work trips) and the trip to shop/retails. Table VI summarizes the transport category

TABLE VII
TRANSPORT CATEGORY

Activity Sectors	Main Sector
1. Household	1.1 HBW High Incomes 1.2 HBW Median Incomes 1.3 HBW Low Incomes 1.4 HBE
2. Service / Retail / Education	2.1 Trips to Service 2.2 Trips to Shop/Retail

C. TRANUS Modeling Parameters and Assumptions

Several parameters and assumptions are used in the case study's model. Most of them are decided base on the survey results, while some parameters are assumed based on the secondary data or previous study results. The essential parameters are as follows.

1) Value of Time (VOT)

This study evaluates the VOT value based on monthly residence incomes, which classified into three groups (high income, medium income, and low income). The calculation assumes that there are 187.5 working hours per month (45 hours x 50 weeks x adjustment factor/12 months). The adjustment factors are assumed to be 0.6 for work trips and 0.5 for others.

2) Value of Waiting Time (VWT)

The VWT in this study is assumed to be two times the VOT.

3) Vehicle Availability

Gathering data from the personal interview survey, most population in the study area own or able to access personal vehicles (either motorcycle or car). Seventy-five percent of the population in the low-income population have access to private vehicles. There are also 88 percent and 98 percent of the population in the medium and high-income groups, respectively, owning private vehicles.

4) Trip Generation Rate

Trip generation rate for each trip category (Table VI) were estimated base on the personal interview survey conducted for the project. The results found that the low-income population travel at 2.69 trips per day (on average), while the medium and high-income population travels at 2.77 and 2.73 trips per day (on average), respectively. Results also found that the average trip for education is, approximately, 2.79 trips per day and the average trips to service is at, approximately, 2.99 trips per day.

5) Land Prices

This study estimates the average land price (rental price/month) base on the evaluation price of the property in the Nonthaburi province published by the Treasury Department. The rental price was then assumed to be 1 percent of those property prices. Additionally, the one percent assumption is considered base on the general depreciation rate.

D. TRANUS Results

The modeling outputs were evaluated by comparing the study area characteristics before and after implementing metro line stations in the study area. The model evaluates 3 scenarios including (1) BAU20: Business As Usual in 2020 or the base case study at the existing condition, (2) BAU30: Business As Usual in 2030 or the future year in 2030 with no implementation of the metro services, and (3) SCA: SCenario A or the future year in 2030 with the metro line service implementation.

From the density perspective, results present a slight decrease in population and employment in the overall study area after connecting the metro line services. The results present in the opposite

of common sense that the metro line should bring up more population and employment to the study area. However, considering the study area in Fig. 2, we could see that metro line service increasing the accessibility between the study area and the external zones. This connection provides more opportunities for people to decide to live or working out of the study area. Fig. 3 presents of results of density indicators on the model.

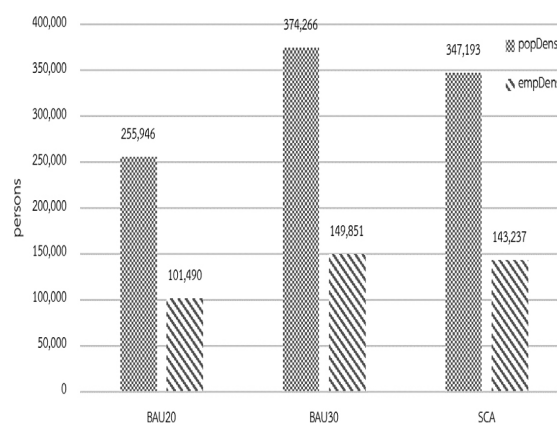


Fig. 4. Comparing population and employment density

Additionally, by introducing metro line services, the model presents that the proportion of the low-income and the high-income population living in the area is increasing, while the medium income population in the area is decreasing. However, these changes in diversity only show in small numbers. Fig. 4 presents income diversity results from the model. Further, the land-use diversity also changes after the implementation of the metro line, regarding the modeling results. More, activities in the study area tend to consume the office building and commercial building more than before introducing the metro services. Fig. 5 presents land-use diversity results from the model. From the figure, by introducing transit services in the study area, it helps to recover the proportion of commercial and office building back to the study area.

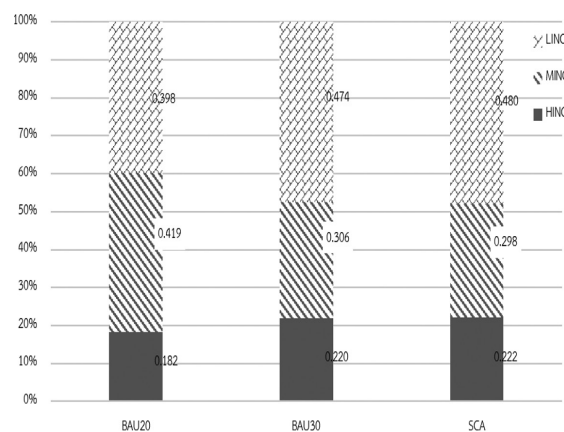


Fig. 5. Population income diversity in the study area

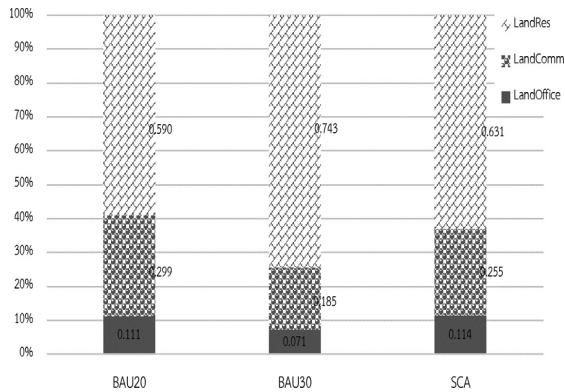


Fig. 6. Land-use diversity in the study area

In terms of design, the disutilities for each traveling purpose are measured from the model. The results present a notable trend (decreasing) of the disutilities for all traveling purposes after implementing the metro line services in the study area.

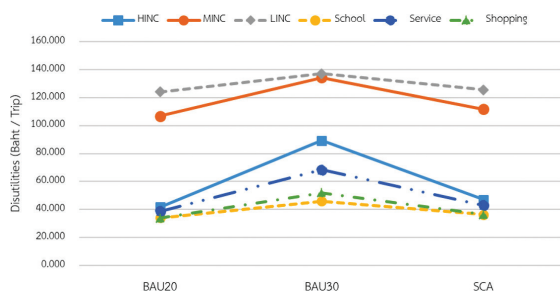


Fig. 7. Disutility measurements for each traveling purposes

Lastly, as expected, by introducing the metro line service to the study area, the number of trips traveling in by the private vehicles is decreasing, while walking trips and trips using public transport are increasing. Fig. 7 compares the number of trips in each traveling mode.

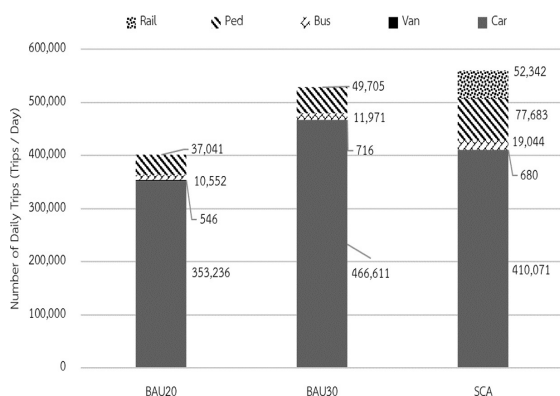


Fig. 8. Number of trips in each traveling mode

E. SUMO Results

Origin and Destination (OD) matrix outputs from TRANUS model are used as inputs in SUMO to evaluate the traffic characteristics on a micro-scale. Fig. 8. Presents the SUMO road network, which constructs a base on the open street map layer (<https://www.openstreetmap.org>). General traffic characteristics such as the total number of vehicles getting in-out of the study area, average speed, total waiting time, and average delay are measured from the SUMO model.

Results from the traffic simulation found that overall network performances are getting better after opening the metro line services. The average speed of the road network is getting slightly better both in the morning and evening peak hour traffic. Total waiting is quite different. After opening the metro line services, traffic for the overall network have a better total waiting time and average delay, especially during the evening peak hour traffic. However, the results from the simulation model present a very slight improvement for the average speed on the network. Table IV and Table V show the results of traffic characteristics for morning and evening peak hour traffic, respectively.

For the overall perspective on the model results by comparing network performances between before and after opening metro line services, results represent that there is minimal improvement in the traffic performances in the study area. Hence, only implementing the metro line services on the site may not be an overall solution to solve the traffic-congested problems in the area. Other policies must be considered: improving the feeder systems, encouraging non-motorized trips, or improving the traffic follow problems or bottleneck problems in a specific location in the area.



Fig. 9. SUMO network in the study area

TABLE VIII
TRAFFIC CHARACTERISTICS FOR MORNING PEAK
HOUR TRAFFIC

Indicators	Unit	BAU20	BAU30	SCA
Vehicles in-out of the network	veh/hr	37,782	44,224	44,395
Average Speed	km/hr	11	11.62	11.65
Total Waiting Time	min	43,676	38,709	35,277
Average Delay	min	10	11	11

TABLE IX
TRAFFIC CHARACTERISTICS FOR EVENING PEAK
HOUR TRAFFIC

Indicators	Unit	min	BAU30	SCA
Vehicles in-out of the network	veh/hr	min	36,342	36,371
Average Speed	km/hr	min	12.10	12.82
Total Waiting Time	min	min	28,238	3,084
Average Delay	min	8	9	2

V. CONCLUSION

This article summarizes the experiences of using open-source transport and traffic simulation software for transport policy and planning works in Thailand. The first software is the TRANUS, which is the Land Use Transport Integration (LUTI) software. The other software is SUMO (Simulation of Urban Mobility), which is the traffic simulation software. The reviews are general software features, input data requirements, and potential outputs. The paper also discusses the example of project implementations, which uses TRANUS and SUMO for evaluating the impacts of the metro line services around the activity center area.

From the case study, the TRANUS model helps evaluate the changing of land and transport activities in the study area. Results also represent the impacts of introducing the metro line services to the site and confirms that encourage excellent public transportation services could help to develop the site both in terms of traffic and economical in the area. However, this study also using the microscopic traffic simulation to evaluate the overall traffic performance in the study area, and results from the model only represent a slight improvement of the traffic performances on the study area road network. These results also present that, besides introducing the metro line services in the area, other improvement policies must be considered.

Finally, experiences show that, even though there is a learning curve for both software, it's free of costs, diverge user communities, and prompt software features. They represent that open-source transportation software platforms could be an alternative for future transport policy and planning

work in Thailand. However, barriers and limitations that should be aware of while applying these models and software in the future are as follows. First, TRANUS will require detailed data on land use and land prices in the study area. These data are usually not available in the area and, both time-consuming and costly to collect. Lacking land use and land price data will significantly affect the results of the model. Second, calibrating TRANUS model for its elastic demand (land consumptions) are not yet have standard tools. Hence, this step will take time for parameter calibrations and perhaps one of the critical parts that will make the model quite hard to use and apply in the case study. Third, for SUMO, this study only applies the OD matrix output from TRANUS directly to the SUMO traffic simulation program. At the same time, assume that all traffic demands are already good base on the TRANUS model development processes. Hence, there are needs for calibrating traffic microsimulation parameters for future improvements of the model to the local traffic, especially those in Bangkok, Thailand.

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Headline2Vec: A CNN-based Feature for Thai Clickbait Headlines Classification

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Abstract—Clickbait is an article title or a social media post that attracts readers to follow a link to the article's content. It is one of the major contributors to spread fake news. To prevent a wide-spread of fake news, it should be detected as soon as possible. This paper presents a content-based feature called *headline2vec* that is extracted from a concatenation layer of a convolutional neural network (CNN) on the well-known word2vec model for high dimensional word embeddings, to improve an automatic detection of Thai clickbait headlines. A pioneer dataset for Thai clickbait headlines is collected using a top-down strategy. In the experiment, we evaluate the headline2vec feature for Thai clickbait news detection using 132,948 Thai headlines where the CNN features are constructed using a non-static modelling technique with 50 dimensions of word2vec embedding with a window size of two, three, and four with epoch of 5. Using the proposed features, we compare three classifiers, naïve Bayes, support vector machine, and multilayer perceptron. The result shows that the headline2vec with multilayer perceptron achieves up to 93.89% accuracy and it outperform the sequential features that utilize *n*-gram with tf-idf.

Index Terms—Thai Clickbait Detection, Text Feature, Convolutional Neural Network, Headline2Vec

I. INTRODUCTION

In the past, research on natural language processing (NLP) has been focusing on tasks such as information retrieval, information extraction, and text summarization [1]-[3]. An emerging of social

networks results in many NLP related tasks such as opinion mining, sentimental, fraud detection, etc. While online contents become more popular, there are many attempts to add advertisements or useless elements into the contents, particularly news headline. Towards this issue, one interesting and impact application is to detect fake news, rumor, and clickbait, particularly news headlines have gained attention from researchers in the past 10 years [4]. Fake news is an intentionally and verifiably false news [5]. Rumor, on the other hand, refers to an unofficially confirm information that has been spread. Clickbait refers to article titles or social media posts are designed to attract readers to click on its hyperlink and then lead the actual article page [6]. Moreover, clickbait headlines are the major contributors to spread fake news [7]. The approaches such as Natural Language.

Processing (NLP), Data Mining (DM), and Social Network Analysis (SNA) have been applied for detecting false information. Two approaches are used to represent the news: (1) content-based and (2) context-based features [4]. The first features rely on the content such as news or headlines. On the other hand, surrounding information such as users characteristic, reactions, and network propagation are included in the context-based features.

Behavior-based analysis is an example of context-based features that remove clickbait posts from a social media website. Facebook analyzed a click-to-share ratio and length of time that the users spent on the post [8], [9]. Similarly, Twitter detects the clickbait tweets using the users' behavior together with a naïve Bayes classifier [10]. A disadvantage of this feature is that it could only detect the previously known clickbait headlines. To capture the news headlines,

machine learning approaches targeting NLP problems were introduced [11]–[17]. Content-based features extract from text. In text mining, terms acts as basic elements for constructing feature space [2]. Besides simple terms, some higher orders of terms, so-called n -gram, such as bi30 gram, trigram, etc., can be used. Together with the definition of terms, some weighting schemes, such as Term Frequency (TF), and Inverse Document Frequency (IDF), form the foundation of the processing. Based on the features constructed, a number of classifiers can be applied, such as Random Forest [10], naïve Bayes [y], and Support Vector Machine (SVM) [12], [14], [18] to recognize the clickbait headlines.

Recently, neural networks based on dense vector representations have been introduced. Most works utilize the word embeddings, called word2vec [19] that allow an input sentence to be transformed into a matrix and use it as source for any text processing tasks. Later meaningful or significant features are implicitly discovered or extracted from this matrix by means of a Convolutional Neural Network (CNN) enable multi-level feature extraction and automate discovery of significant features. The classification of the input text can be achieved by using deep learning [20]. In the past, based on this concept, Agrawal [21] applies CNN to represent English news headlines as a feature and classify them using deep learning.

As a real-world application, detection of clickbait from the Thai news headlines is useful and promising. The clickbait detection from Thai news headlines has been studied in [22]. Since it is an early-staged study, there is still much room for further investigation and performance improvement. In the past, the traditional approach usually used dictionary-based word segmentation to tokenize a Thai running text into a bag of words, the performance varied upon several factors, such as definition of words in the dictionary and the segmentation algorithm. This variety of word definition and algorithm affects the counting of term frequency and inverse document frequency [23], [24].

As an alternative to the dictionary-based word segmentation, Sarawoot et al. [22] proposed to apply word2vec [19] to encode each segmented headline as a matrix using conditional probability of the target term and its surrounding terms. In this approach, the text is encoded in the form of term vectors that are standardized and preserve the consistency between distance and similarity. The CNN-based term vectors are acted as features for representing a text and the deep learning algorithm is applied to learn the optimal classification model.

In this work, a feature called *Headline2Vec* is retrieved from convolutional neural network (CNN) architecture, originally proposed by Kim [25]. A number of experiments are conducted to investigate the performance of our proposed method, which

aims to optimize the hyper-parameters for clickbait classification from Thai news headlines. The experiment compares the classification performance of *Headline2Vec* features retrieved from CNN and the simple sequential feature, i.e. tf-idf. The experiments are conducted using three classification schemes: the SVM, naïve Bayes, and Multilayer Perceptron on a collected dataset of preprocessed Thai clickbait headlines, which is available online. This paper is organized as follows. Section 2 presents a number of works related to clickbait classification, word2vec feature extraction, and convolutional neural networks. Implementation details of our CNN architecture and our headline2vec method are described in Section 3. In Section 4, experimental settings related to hyperparameter selection are described and the experimental results on comparison of our headline2vec with tf-idf (the baseline) is discussed on four machine learning algorithms; naïve Bayes, decision tree, support vector machine, and convolutional neural network. Error analysis is made in Section 5, to identify the issue of our method. Finally, Section 6 provides the concluding remarks and future works.

II. RELATED WORK

A. Clickbait Classification from News Headlines

The machine learning approach for a clickbait detection was firstly introduced by Potthast et al. [10]. The work used the dataset of 2,992 tweets, including 767 clickbait tweets. To obtain an unbiased choice of publishers, this corpus was created by randomly selecting Twitters from a several social media platform by many content publishers; including Business Insider, the Huffington Post, and BuzzFeed; BuzzFeed. Each tweet was annotated independently by three assessors who rated them being clickbait or not. Judgments were made only based on the tweet's plain text and image but not by clicking on links. With majority vote as ground truth, a total of 767 tweets (26 %) out of 2,992 tweets are considered as clickbait. More details can be found from [10].

The clickbait tweets were classified into three categories: (1) the teaser message, (2) the linked web page, and (3) the meta information. The clickbait detection model was constructed based on 215 features of the tweets such as linked web page, word n -gram, and a sender's name. The result showed 76% precision and recall using Random Forest, which outperformed Logistic Regression and naïve Bayes.

Later, Chakraborty et al. [12] collected 7,500 non-clickbait headlines from Wiki-news and 7,500 clickbait from the clickbait websites. The Standford Core NLP tools [2] as applied to extract 14 features from the clickbait headlines such as sentence structure, or patterns, clickbait language, n -gram, etc. The experimental result shows that SVM achieved

93% accuracy, which outperformed Decision Tree and Random Forest.

Instead of using the set of manually selected features as in [12], [10], Agrawal [21] applied CNN to automatically discover the features of the dataset. The 814 clickbait and 1574 non-clickbait headlines were collected from Reddit, Facebook, and Twitter. The experimental result reported that the CNN model with word embedding from Word2Vec achieves 90.00% accuracy at 85.00% precision and 88.00% recall.

B. Feature Extraction

Shu et al. [26] classified the features for fake news detection into two categories: (1) Content-based and (2) Context-based. The content-based feature relies on the information that can be extracted from text. Text mining techniques such as number of content words or POS [27], [28]. Such features have also been applied with machine learning and deep learning approach for detecting rumors. The context-based considers the 110 surrounding information such as user's information [29].

1) Vectorized Word-based Features: Word2vec

Word embedding is a method that transforms text into a numerical representation. A common fixed-length features of text is bag-of-words. The limitation of bag-of-words is its inherited issue on lacking word orders and phrase structure. Word2vec is a word embedding that considers a continuous bag-of-word (CBOW) and a skip-gram models [29]. Given the context words surrounding by a target word across a window of size c , CBOW computes the conditional probability of a target word. On the other hand, the skip-gram model predicts the surrounding context words of the given target word.

In this way, the words with similar meanings tend to occur in similar context. Thus, these vectors capture the characteristics of the surroundings of the term. The advantage of this transformation is that the similarity between words can be captured [30] and computed using measurement such as cosine similarity. In our preliminary study in [22], a publicly available library called Gensim [31] was applied to compute a Word2Vec of the Thai headlines. Examples of the words in the same context are shown in Table I. The meaning of the words is similar.

A limitation of utilizing Word2Vec for a sentence or headlines classification in widely used classifier is its variable number of dimensions. To cope with this issue, the word embedding must be transformed in such a way that a headline is represented as a vector. The simplest method is to concatenate the word embedding of each word in the sentence [32].

2) Data Collection Strategies

To collect the dataset, two strategies are considered: (1) top-down and (2) bottom-up [33]. The first strategy requires a set of keywords and tag of the rumor or fake news for collection. The second strategy requires to manually evaluate by a human. The major drawback for this method is the requirement of the human resource. On the other hand, the fake news or rumor can be found when they were spread to collect using top-down approach.

Due to the small number of data such as rumors, fake news, or clickbait, there are not many datasets available for fake news, rumors, and clickbait headlines [4]. Moreover, the dataset of clickbait headlines in Thai language was initially be collected in our companion paper [22].

3) Convolution Neural Network

The convolutional neural network (CNN) has been utilized in computer vision application [34], [35].

It allows many filters to be used and automatically select the features that are able to represent the salient points in an image. In addition, the features can be refined using the feedback from the classification layer.

Recently, CNN has been applied to problems in Natural Language Processing (NLP) [25], [36], [37]. CNN enables us to extract salient n -gram features from the input sentence [25] to create an informative latent semantic representation for downstream tasks.

Given a word embedding of a sentence, a few convolutional filters, also called kernels, of different window sizes slide over the entire word embedding matrix to extract a specific pattern of n -gram. A convolution layer maps the feature into a vector by selecting the maximum weight of each window. The outcome is a fixed-length feature vector that keeps the salient n -gram of the whole sentence.

TABLE I
AN EXAMPLE OF WORDS IN THE SAME CONTEXT.

Word	Top 5 similar words
เหลือเชื่อ (incredible)	ทึ่ง (surprise), มหัศจรรย์ (wonderful), น่ากลัว (awful), แปลก (strange), สะพรั่ง (horrible)
ช็อก (shock)	ช็อก (shock), ขนหัวลุก (thrilling), ผงะ (flinch), หลอน (haunt), ตกใจ (shock)
โซเชียล (social)	โซเชียล (social), เมนท์ (comment), สนั่น (loudly), คอมเมนต์ (comment), โซเชียล (social)
แชร์ (share)	ลงโซเชียล (share to social), ไลค์ (like), ชื่นชม (admire), ว่อน (in a cloud), กด (push)
เพียว (magnificently)	แจ่ม (good), ชิค (chic), จ้าบ (prominent), อาร์ต (art), อลัง (magnificent)

TABLE II
AN EXAMPLE OF THE NEWS HEADLINE IN THE PREPROCESSING STEP

Collected headline	Output of text cleaner	Preprocessed Headline
<p>ทูตอินเดียเผยทางเชื่อม อินเดีย-เมียนมา-ไทย ใกล้ เสร็จ</p> <p>http://tnn24.tv/2qMf3n8 #TNN24 #ช่อง16 @tnnthailand</p> <p>Original Headline</p> <p>India Ambassador says; the India-Myanmar-Thailand road connectivity is almost done.</p> <p>Translation</p>	<p>ทูตอินเดียเผยทางเชื่อม อินเดียเมียนมาไทยใกล้ เสร็จ</p>	<p>ทูตอินเดียเผยทางเชื่อม อินเดียเมียนมาไทยใกล้ เสร็จ</p>

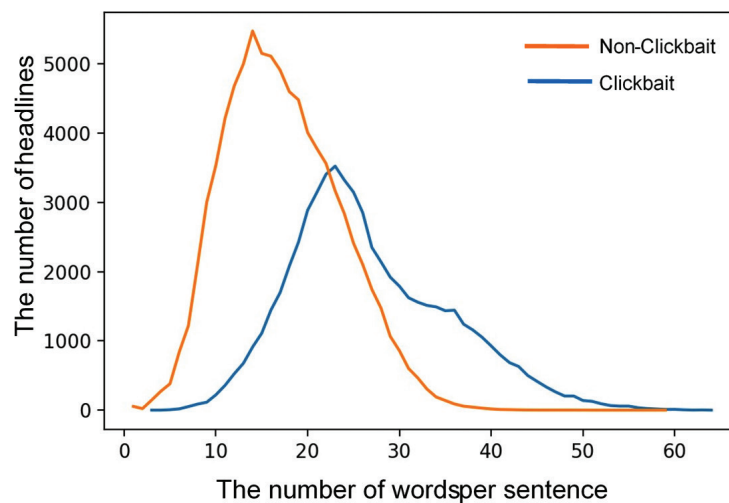


Fig. 1. A comparison of the number of words per sentence of clickbait and non-clickbait headlines.

III. THAI CLICKBAIT HEADLINES CORPUS

A Thai headline news corpus for a natural language processing task has initially been gathered in [22]. The headline news is gathered using top-down strategy. An online content crawler is used for retrieving headlines from known clickbait website. Then, text preprocessing is applied to remove any unwanted data from the collected headlines.

The sources of clickbait and non-clickbait headlines are identified by human. For the clickbait websites, the sources are selected from “Jobkaow” Facebook page, which shows the summary of the clickbait news. The sources of the news in this page

are considered as a clickbait website. On the other hand, the non-clickbait websites are selected from the Twitter account of the news agency in Thailand. Both clickbait and non-clickbait headlines are collected using an online content crawler.

The collected headlines as shown in the first column of Table II contains unwanted information such as a hyperlink, hashtag, and the source of the tweet. A regular expression called a text cleaner is used during the preprocessing to remove that unwanted information. The outcome of the text cleaner of the headline of the collected headline is shown in the second column of Table II.

To allow the text to be processed, each headline is segmented into a list of words using a software called LextoPlus [38], which is a segmentation for Thai text. An example of the segmented list of words is shown in third column of Table II. The total number of the collected headlines is 132,938, in which 11.96% of words are in out of vocabulary set (OOV). The number of clickbait and non-clickbait headlines are 60,393 and 72,545, respectively. The comparison of the number of words of the collected clickbait and non-clickbait headlines are shown in Fig. 1.

IV. CNN-BASED FEATURES FOR CLICKBAIT DETECTION

This section describes how to implement clickbait detection from news headlines, by extending the headline2vec concept proposed in our previous work [22]. Two issues; (1) feature extraction and (2) hyperparameter tuning in CNN are described.

A. Feature Extraction

To allow a computer to understand the text, the list of the segmented words of the headlines are transformed into a numerical representation, which is called a *word embedding*. In this work, two features are investigated to represent each segmented headline: 1) a simple sequential feature called tf-idf and 2) CNN feature extracted from Word2vec embedding.

1) Headline to Vector

To extract the patterns of the training set, each headline is presented in a form of a vector. Unlike a numerical data type, a word can be converted to a vector called a word embedding. A model called *Word2Vec* [19] allows a word to be represented as a vector in such a way that the relationship among words that frequently occurred in the same context is maintained. It is possible to transform a word into a vector and then use such vector for classification,

such as naïve Bayes, support vector machine, and multi-layer perceptron classifiers. Therefore, the word embedding must be transformed in such a way that a headline is represented as a vector.

Let $h \in H$ be a headline in the form of bag of words in the headline corpus H and m be the length of the longest headline in H . Let $W = \{w_1, w_2, \dots, w_{|W|}\}$ be the entire vocabulary of words in the headline corpus H . A segmented headline h is embedded on a Word2Vec model of size $m \times d$, where d is the word vector dimension. It is transformed into a feature vector using a Convolutional Neural Network (CNN) [25]. Two main parts are feature extraction and classification. In this work, a Word2Vec of the segmented headline is transformed into a vector feature at the concatenation layer of CNN architecture. See Fig. 2 for illustration. The detail of the feature extraction is described below. A word embedding of a headline h is given in the first layer as shown in Fig. 2. For each headline, let $w_i \in W^d$ represent the word embedding of the i^{th} word in the headline, where d is the dimension of the word embedding. The headline h is represented as an embedding matrix $W \in W^{m \times d}$, where m is the number of words of the longest headline in the corpus. Then, the word embedding is filtered using different window size and filter. It works correspondingly with n -gram. Let $w_{i:i+j}$ be the concatenation of vectors w_i, w_{i+1}, \dots, w_j . Convolution is performed on this input embedding layer by applying a filter $k \in W^{n \times d}$ to a window of size n to produce a feature vector of each window size. Then, a feature c_i is generated using the window of words $w_{i:i+n-1}$ in h of a filter as follow:

$$c_i = f(w_{i:i+n-1} \cdot k^T + b)$$

where, b is the bias term and f is a non-linear activation function, such as the hyperbolic tangent.

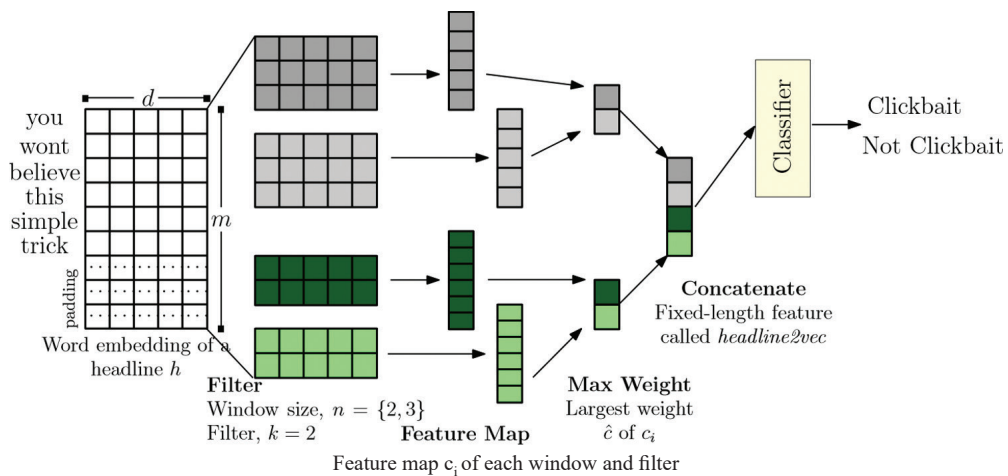


Fig. 1. The headline feature extraction using Convolutional Neural Network (CNN) architecture for clickbait Detection.

The filter k is applied to all possible windows using the same weights to create the feature map as shown in Fig. 2. It can be defined as followed:

$$c = [c_1, c_2, \dots, c_{v-n+1}]$$

The convoluted word vector is passed to a maximum-pooling layer to adjust an appropriate weight for representing a vector of each word. A limitation of the feature map is the dimension of c is depended on the length of the headline and the filter k . To cope with the problem, the input is subsampled by applying a max operation on each filter in such a way that $\hat{c} = \max\{c\}$. In this way, the output is mapped to a fixed dimension while keeping the salient n -gram features of the whole headline.

The concatenation of the weight \hat{c} of the word features of the headline h using n windows and k filters results in a vector of size $n \times k$. This vector is a Headline2Vec of an input headline h . It is used for classifying into 'clickbait' or 'not clickbait' using the SoftMax function.

The Headline2Vec is a feature vector of a headline h , whose size is $n \times k$, where n is a window size and k is a filter. See, concatenation layer in Fig. 2. In this way, the machine learning techniques such as naïve Bayes, Support Vector Machine (SVM), and Multilayer Perceptron can utilize the feature vector for a headline classification task.

2) TF-IDF

Term frequency (tf) is the frequency of a word occurs in the document. If a certain word occurs frequently, the term has the great effect on the document. Given a segmented headline h where $h \in H$ of the headline corpus, let $f_{w_i,h}$ be the raw count of the word w_i in the headline h , where it is equal 1 if the word w_i occurs in h and 0 otherwise. The term frequency is defined as the ratio of $f_{w_i,h}$ to the size of the words in h . Inverse document frequency (idf) measures how often a word occurs in the documents. Let $idf(w_i, H)$ be an inverse document frequency of the word w_i of the corpus H . It can be defined as $idf(w_i, H) = \log \frac{|H|}{|\{h \in H : w_i \in h\}|}$. In this way, tf-idf of the word w_i in a headline h of the corpus H can be defined as $tfidf(w_i, h, H) = f_{w_i,h} \times idf(w_i, H)$. The tf-idf feature of h is a vector $tfidf(w_i, h, H)$ of size $|W|$.

A limitation of representing each headline using tf-idf feature is the exclusion of the relationship among the surrounding words, which results in the different vector representation of the wrong segmentation words.

B. Hyperparameters for CNN

To achieve a good classification result, the four hyperparameters: (1) numbers of epoch, (2) word vector dimension, (3) window size (n -gram), and (4) modelling technique are studied.

The epoch is the numbers of times that the entire dataset is passed through a neural network for

updating the weights. On the other hand, the small number of epoch may make model underfit and overfit. The word vector dimension is the vector size d that represents each word in a dictionary of millions of words into a small dense vector. It relates to the efficiency of the features because the high number of the dimension could lead to a sparseness and results in the loss of its semantic. The window size for surrounding words is considered as an n -gram. There are three model variations of CNN, i.e., static, non-static, and random. The static is the model that uses the weight in the first layer, i.e. Word2Vec, to represent all word in dataset and kept its static. On the other hand, the non-static technique initially uses the weight from the Word2Vec. Then, it is adjusted during training of the model. The random variation initially assigns a random weight to every word and modified during model training.

V. EXPERIMENT

The preprocessed and segmented [38] headlines from Sarawoot et al. [22] are used in the experiment. The data set contains 132,938 headlines. The total number of the headlines in the training and the testing sets are 106,350 and 26,588, respectively. See Table III for the detail.

Two features are extracted from the dataset: (1) Headline2Vec and (2) tf-idf. The features are separated into training and testing set, where the number of each set can be found in Table III. The experiments of the classification performance of each feature are conducted using the separated training and testing set. The detail of each step is explained in the following subsections.

Two experiments were conducted in this work. The first one is to find the value of the hyperparameters that enable the CNN to achieve the best performance. The hyperparameters are (1) numbers of epoch, (2) word vector dimension, (3) window size (n -gram), and (4) modelling technique. The second experiment compares the performance of the feature vectors, i.e., Word2Vec which are extracted from CNN, and tf-idf. The classification methods being used are naïve Bayes (NB), support vector machine (SVM), multilayer perceptron (MLP), and deep learning. The machine learning libraries of Python are used for NB, SVM and MLP. The CNN feature extraction and classification implementation of Kim [25] is applied.

The performance of the classification is evaluated using four measures precision, recall, F1-score, and accuracy. Precision is the percentage of the correctly predicted headlines for a clickbait by the size of the test set. Recall is the percentage of correctly predicted headlines for a clickbait divided by the total number of clickbait headlines over the test set. F-measure is the weight of precision and recall. Lastly, accuracy is the percentage of the retrieved headlines that are

correctly in the same class as the query by the number of headlines in test set.

Hyperparameters Tuning of CNN

To study the effects of the hyperparameters of CNN, a number of experiments were conducted. Four hyperparameters: (1) Modelling technique (2) n -gram (3) Epoch, and (4) Dimension of Word2Vec are being focused.

For the modeling technique, we applied *static*, *non-static*, and *random* weight adjustment techniques. The experimental result in Table IV shows that the non-static modeling technique achieves the highest accuracy of 95.28%.

To find an appropriate window size for the word embedding, the numbers of n -gram are {2,3,4,5,6,7} are applied. The experimental result can be found in Table V. The result shows that the most appropriate window size is $n = \{2,3,4\}$, which gives 95.284% accuracy. Combining the three modelling techniques and the different window size, the result can be found in Fig. 3. The graph shows that the *non-static*

modeling technique 305 with the window size $n = \{2,3,4,5,6\}$ gives the highest accuracy of 94.37%.

The number of epochs equals to {1,5,10} are used in the experiment. The result in Fig. 4 shows that 5 passes gives the highest accuracy of 95.28%. The comparison of the accuracy of the combination of the three modeling techniques and the different number of epoch can be found in Fig. 4. From the figure, the *non-static* model 310 and epoch equals to 4 achieves the highest accuracy of 94.82%.

Lastly, the dimensions of Word2Vec are set as {25,50,100}. The comparison of the result in Table VI shows that using 25 dimensions gives the highest accuracy of 95.28%. Applying the non-static modeling technique using 50 dimension gives the highest accuracy of 93.36%. Combining the parameters that individually achieves the best result, i.e. n -gram equals {2,3,4}, 50 dimensions of word2vec, epoch equals to 5, and non-static model, it achieves 94.373%. The comparison to the other models can be found in Table VII.

TABLE III
THE NUMBER OF COLLECTED HEADLINES.

	Headlines	Training Set	Testing Set
Clickbait	60,393	48,314	12,079
Non-Clickbait	72,545	58,036	14,509
Total	132,938	106,350	26,588

TABLE IV
RESULT OF APPLYING THE THREE DIFFERENT MODELING TECHNIQUE

Setting	Precision	Recall	F1	Accuracy
Static	95.11%	94.76%	94.93%	94.46%
Non-Static	95.15%	95.34%	95.24%	95.28%
Random	93.28%	92.74%	93.01%	92.80%

TABLE V
RESULT OF APPLYING THE THREE DIFFERENT MODELING TECHNIQUE

n -gram	Precision	Recall	F1	Accuracy
2	94.85%	94.79%	94.82%	94.86%
2,3	95.06%	95.16%	95.11%	95.15%
2,3,4	95.15%	95.34%	95.24%	95.28%
2,3,4,5	94.58%	95.08%	94.83%	94.84%
2,3,5	95.25%	95.22%	95.23%	95.27%
2,3,5,7	94.27%	94.98%	94.62%	94.61%

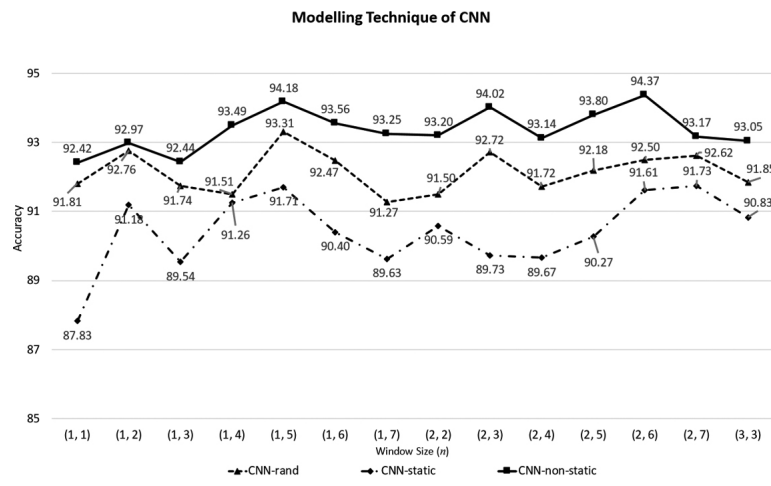


Fig. 3. Experiment result of the three modelling techniques using the different number of window size.

TABLE VI
RESULT OF THE DIFFERENT WORD2VEC DIMENSION.

Dimension	Precision	Recall	F1	Accuracy
25	95.45%	95.09%	95.27%	94.90%
50	95.15%	95.34%	95.24%	95.28%
100	95.00%	95.13%	94.07%	95.11%

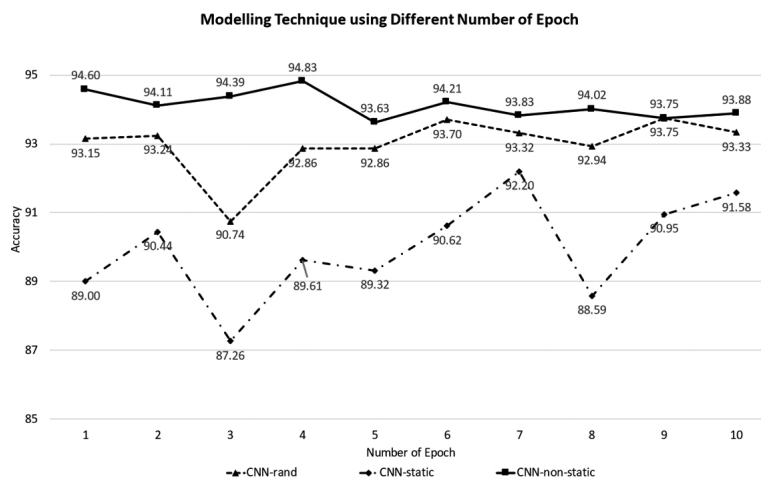


Fig. 4: Experiment result of the three modeling techniques using the different number of epoch.

TABLE VII
RESULT WHEN APPLYING THE DIFFERENT MODELLING TECHNIQUES ON N-GRAM EQUALS {2, 3, 4, 5, 6}, 50 DIMENSIONS OF WORD2VEC, AND 5 EPOCH.

Modelling Technique	Precision	Recall	F1	Accuracy
Non-static	93.526%	94.055%	93.79%	94.37%
Static	87.532%	93.591%	90.46%	91.61%
Random	94.644%	89.466%	91.982%	92.50%

1) *TF-IDF Features*

The classification results of tf-idf feature are reported in Table VIII. The accuracy of NB, SVM, and MLP are 89.69%, 92.05%, 90.88%, respectively. Comparing to the accuracy of the most appropriate hyperparameter setting of CNN, it achieves higher accuracy of 94.37%. Fig. 5 shows the comparison to the CNN and tf-idf features using different window sizes. The CNN feature achieves the highest accuracy for every window size.

2) *Headline to Vector*

The Headline2Vec of every headline is extracted using the hyperparameters of the highest accuracy as reported in Table VII. The headlines are embedded on a 50 dimension of word2vec. The non-static modelling technique with n -gram of {2,3,4,5,6} and 5 epoch of CNN framework is used to extract the headline2vec feature.

The comparison of the classifiers can be found in Table IX. Among the classifiers, Multilayer Perceptron achieves the highest result of 93.89% which outperform SVM and naïve Bayes. Comparing the result using tf-idf feature in Table VIII, the Headline2Vec achieves higher accuracy for every classifier. However, the accuracy of Multilayer Perceptron classifier using Headline 2Vec in Table 9 is still lower than the classification of the CNN architecture, which achieves 94.37%.

3) *Sentiment Dataset*

The proposed framework for extracting headline2vec is applied with a dataset for a sentiment analysis from the comment of the restaurants in Thailand. The dataset can be found on the web site. The experimental result is shown in Table X. The classification using MLP achieve 98.49%, which is lower than SVM.

4) *BERT Feature Extraction*

Bidirectional Encoder Representations from Transformers (BERT) is a new language representation model [39]. In this experiment, BERT is applied for extracting features from the headlines. The same classifier as shown in Fig. 2 is used to predict the result. In this work, an implementation from [40] was utilized. The experimental result shows 58.34% accuracy.

VI. ANALYSIS

The experimental results in Table VIII and Table IX show that the Headline2Vec feature extracted from CNN achieves a higher accuracy than tf-idf for every classifier. The reason is that the Word2Vec can capture the similarity between words and CNN preserves n -gram feature of the whole headline. With the characteristic of Word2Vec and CNN, it allows the proposed Headline2Vec to classify the text even if the keywords are not existed in the headline. Comparing to the classification result using the Headline2Vec feature and CNN architecture [25], the Headline2Vec using Multilayer Perceptron achieves lower accuracy. However, the different is 0.48%. One reason is because the CNN architecture allows the weight to be adjusted to achieve the best accuracy of the headline classification in the last layer.

We also applied BERT [39] model to extract feature from the headline. The result shows that BERT achieves lower accuracy than the proposed method. The reason is the segmentation outcome of BERT is finer than the word level. Since the length of the headline is not long as compared to the text in the paragraph, the extracted feature becomes sparse.

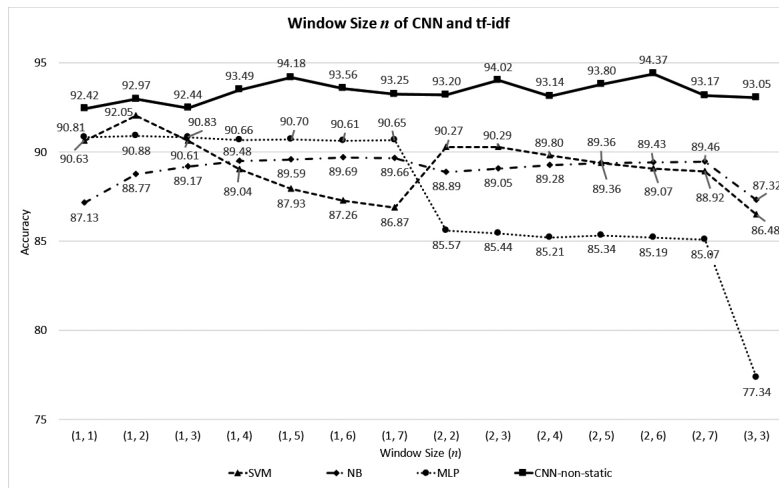


Fig 5. Experiment result of the CNN and tf-idf features using the different number of window size.

TABLE VIII
RECALL, PRECISION, F1 SCORE, AND ACCURACY USING TF-IDF FEATURE ON THAI CLICKBAIT DATASET.

Classifier	Precision	Recall	F1	Accuracy
Naive Bayes	86.78%	91.21%	88.94%	89.69%
Support Vector Machine	89.37%	93.63%	91.45%	92.05%
Multilayer Perceptron	87.76%	92.88%	90.25%	90.88%

TABLE IX
RECALL, PRECISION, F1, AND ACCURACY USING HEADLINE2VEC THAI CLICKBAIT DATASET.

Classifier	Precision	Recall	F1	Accuracy
Naive Bayes	98.77%	71.81%	86.14%	86.78%
Support Vector Machine	92.70%	93.47%	93.64%	93.69%
Multilayer Perceptron	94.32%	92.11%	93.83%	93.89%

TABLE X
RESULT OF THE SENTIMENT ANALYSIS DATASET.

Classifier	Precision	Recall	F1	Accuracy
Naive Bayes	49.03%	100.00%	51.27%	55.60%
Support Vector Machine	100.00%	99.37%	99.72%	99.73%
Multilayer Perceptron	97.34%	99.16%	98.46%	98.49%

VII. CONCLUSION

A comparison of the traditional sequential feature and Headline2Vec extracted from the two-dimensional word embedding for Thai clickbait classification using CNN is presented. The two-dimensional word embedding allows a widely used automatic feature extraction architecture called CNN to be used as an input. However, it cannot be used with the machine learning techniques such as SVM, naïve Bayes, and Multilayer Perceptron. In this way, a feature vector called Headline2Vec is retrieved from the last layer of the feature extraction of the CNN architecture. The Headline2Vec allows a learning techniques to utilize a high dimension Word2Vec embedding, which is a word embedding that includes the relationship among the surrounding words.

A number of experiments were conducted to find the most suitable hyperparameters settings for the CNN configuration. Moreover, the experiments of applying the Headline2Vec feature and the traditional tf-idf feature are conducted with SVM, naïve Bayes, and Multilayer Perceptron. Comparing to the traditional feature, the Headline2Vec achieves higher accuracy for every classifier. It can be concluded that relationship among words of Word2Vec improve the accuracy for classifying the clickbait headline for Thai.

VIII. ACKNOWLEDGEMENT

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Increasing Performance through Information Retrieval System for Design and Build Company

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Abstract—Developing a progress report is a requirement in many types of business, including design and build business. This is because the purpose is to provide information on the progress of the project and other necessary information, such as problems, solutions, etc., for the project owner to be aware of the status of the project. The progress report is also linked to the payment of the project budget based on the progress. However, the report preparation of project might require various information from more than one parties; thus, the process would certainly be time-consuming. Moreover, the process might be redundant and prone to error when information is extracted from one source and incorporated in other. The Objective of this research were to analyzed, design and develop the automatic document report system for Design and Build Business and to evaluate the performance of the system. In the design of this prototype system, information is automatically extracted from submitted reports prepared by various working parties and, finally, generated the progress report for the contractor to submit to project owner in an effective and efficient way. The prototype system could help reduce the process time and work load on the staff, while ensuring the correctness of the information and document.

Index Terms—Information Retrieval, Automatic document Generate, Data Extraction, Design and Build, Progress Report

I. INTRODUCTION

Collaboration is an important key to success for Design and Build business. Design and Build business is a unique construction business that provides a wide range of services including design service for buildings, facilities, utilities, etc., and construction services for the project. The service also includes management, monitoring and controlling

of the project. The size of the Design and Build projects, such as construction building, airport, mass rapid transit, requires the system to incorporate sub-contractors working together in their parts to complete the projects. For example, the 1st sub-contractor is responsible for the ground clearing and pavement, the 2nd sub-contractor for office building construction, the 3rd sub-contractor for depot station operation and construction, the 4th sub-contractor for providing and integrating the system for operation between the office building and depot station, etc. By involving many parties to complete the project, a collaboration between parties is very important to ensure that each party would know the status of the project and what to be carried on.

Collaborating to complete the work may seem simple, but it can be a challenge to achieve because sub-contractors can be from different companies and from various places. Normally, even people working with other people in one company, communication among them could be complicated. Thus, this level of people working with other people in different companies to complete the project could be even more challenging. Document format is another problem when working together as well. The document must be accessible to all parties and must comply with the project owner. The document report is certainly crucial in the project because it states the progress of the work, and is used to withdraw the budget from the project owner. However, the preparation of the document must be well prepared and this can be difficult when working with more than one parties. The main contractor must gather necessary information from sub-contractors and prepare a final report to present to the project owner. In collaboration, time is one factor that effects many aspects of the project, significantly, when it concerns payment withdrawing schedule. Each month the main contractor must submit a progress report of the work to the project owner, and if the project progress is up to a certain percentage, then the main contractor will

be able to withdraw the budget to carry on the project. However, failure in report submission would result in the delay of payment, causing delay of the whole system and then back to more delay of payment.

Therefore, collaboration is crucial in working together for Design and Build business. By sending paper reports to the main contractor to generate one whole report is not effective because the process can be time consuming. The information from sub-contractors might be incomplete with some details missing can affect the whole report. In this aspect, technology becomes a key to success in increasing the collaboration performance. The purpose of this research, thus, aims to study the need of such system to help increase collaboration and reduce time consumed in developing report for Design and Build Business. The system of automatic information retrieval is applied to gather information from the progress reports of sub-contractors. Then, the information thus incorporated is automatically generated as a final progress report, as well as a presentation. This system can help reduce the time of work, while monitoring the progress and informing each party of any necessary information.

II. LITERATURE REVIEW

Design and Build business is a unique business that contains all services of a construction project for customers. It can be a new construction project or a renovation of the existing one. Design and Build business provides design and construction services under a single design and build contract [1]. The benefit of this type of business is that the customer signs a single contract with the service provider, then the service provider provides all services including engineering, architectural work, labor, materials, etc., while still focusing on the time, cost, and quality. The main advantage of Design and Build includes faster delivery due to collaborative project management, cost saving by integrated team toward efficiency and better quality. Other advantages include singular responsibility, by having one company as the key contract for all the work; thus, it can reduce burden of contract and management. It also reduces risk from management and miscommunication [2]. However, in a very large scale of project, the sub-contractor is sometimes required to be able to complete the project in a short time. So, the main design and build business needs to outsource labor, engineering, technology, etc. from sub-contractors in order to manage and complete the project efficiently and in specified time.

Document automation can be used to support work process collaboration by reducing the time and redundant process. The key factors for collaborative document are the motivation competence and the trustworthiness [3]. Though there are various technologies that provide and support communication

in various ways, documents are the most preferred and effective ways to communicate engineering information [4]. In addition, many managing software documents are available in the market; however, due to the different processes, formats, and natures of work, this often results in many of processes still requiring intensive manual operations. Therefore, for the system to be able to support work process, the system has to be smart enough to know which information is required for use in other parts of the report. There are two aspects of document automation [5]:

- Automating processing of received documents: this is the process where the system automatically collects required data from different types of documents and make use of them.
- Automatic generation of documents: this is the process where the system creates new documents like invoices, contracts, and order forms from the data extracted in the previous stage.

In order for the system to be able to understand the content, the document need to be structured. The structured document is well organized document that the system can understand to be able to process and create output.

Once document format is structured, the system can process the data. The research on Inter-Governmental Collaboration through E-Document Computation: A Case Study of Provincial Budgeting in Thailand shows how documents could be extracted and automatically generated to support government work [6]. The system was developed using semantic web and ontology to extract data from a number of submitted projects in the province. The system checked the similarity of submitted projects to prevent duplicated ones, and then automatically generated a final report in the Word file. The research shows that, with structured documents, the content can be extracted and reused to create a final report. Ontology is also needed for the system to understand the relation of individual words to compare similarity. Semantic web has been used widely in document retrieval [7]. By creating the document through the semantic process, documents are managed by both people and procedure. This helps the system able to understand and represent knowledge. In addition, the semantic information can be applied to multimedia data [8].

Other example of document automation is using document automation system in law firms' knowledge management [9]. The research focused on implementation of knowledge management and resourcing. The study shows that a well-prepared document can enable the automation effectively. Moreover, through document automation, the system becomes a powerful tool for internal knowledge development and enable collaboration. The result

from this research study helps ensure that the developed system for project progress report can help with collaboration and knowledge management for design and build companies.

III. METHODOLOGY

The system is developed based on the offline

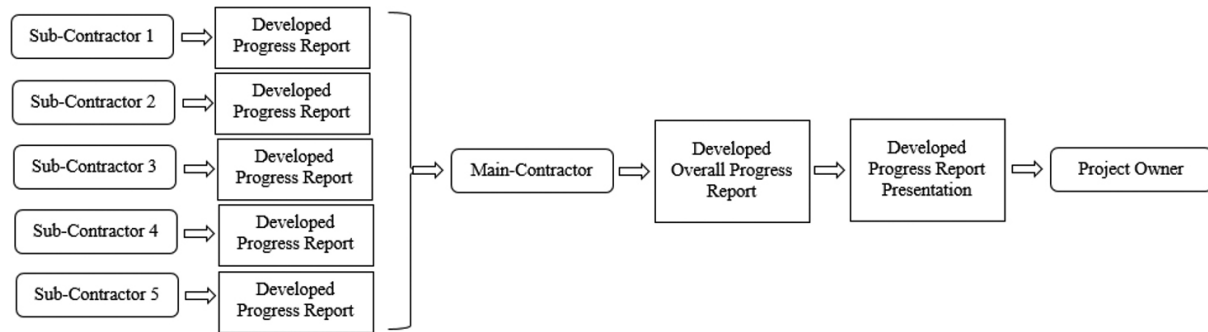


Fig. 1. Process of developed progress report

The sub-contractors develop their progress reports based on the performance of that month and submit them to the main contractors. After reviewing and inspecting the progress, the main contractor would create the overall progress report of that month to submit to project owner. The contractor would receive the budget payment if the project progress were on track. The problem could arise when the sub-contractors submit the wrong information. As a result, the main contractor would have to wait for the sub-contractor to resubmit the revised progress report, so the main contractor could continue the process.

The system is developed in the offline system to protect information of the business. To reduce the process, the system is developed to accept report documents as input data. Then the system will go through the document and extract data as assigned and put in the overall progress report. The system is designed to use the keyword on the subject to as a checkpoint to which section of the document the information would go. After completing the first sub-contract progress report, the system would proceed to the next one and continue the process until completing all sub-contract progress reports as shown in Fig 2.

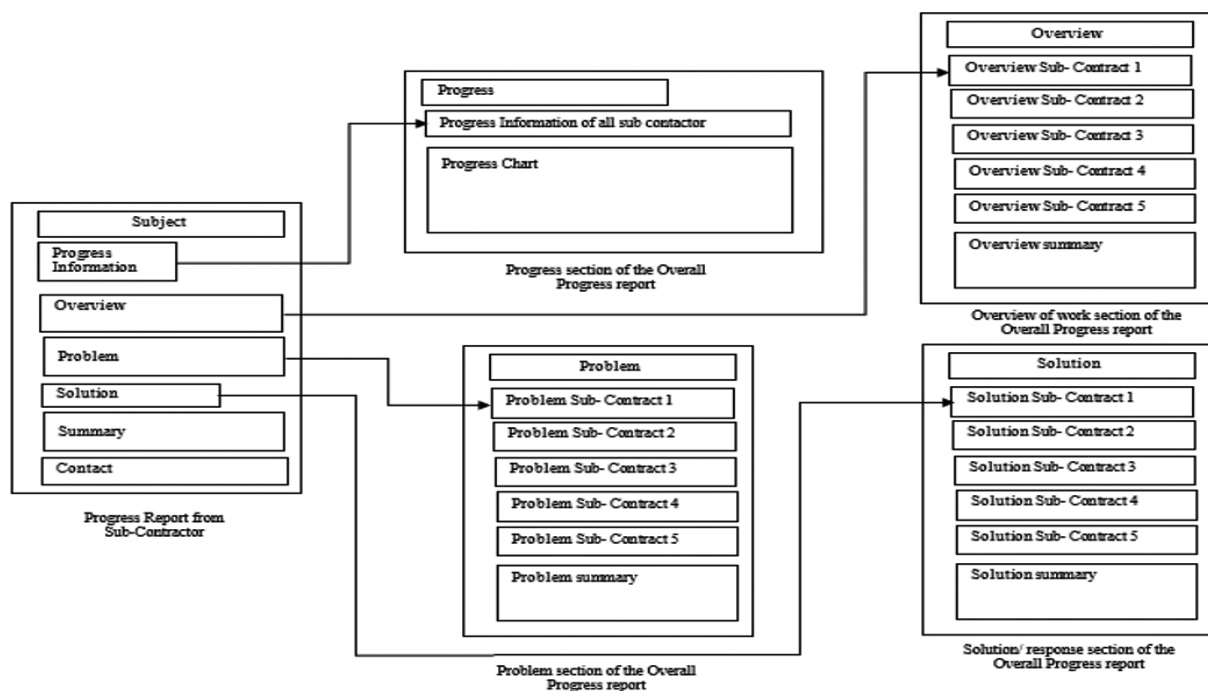


Fig. 2. Process of automatic data retrieval

The system would then take the progress inputs from all the sub-contracts to calculate the overall progress and plot the data in the graph form. This would account for how the business progresses in that month. The system would also compare the actual progress of that month to the progress planned at the beginning. This is to inform all the parties that the project is on track, ahead of the track, or behind the track. The information would show which sub-contract is behind the schedule, so the main contractor could discuss and plan to have the project back on track.

The next step is to extract content from sub-contractor's progress report and put in the correct section of the overall progress report. Since the format of the report follows the format from the project owner, the subject or title of each section could be used as a checkpoint for the system to recognize where the following content would go. For example, in the Problem and Threat section where the sub-contractors describe problems and threats during the work progress and how the sub-contractors handle the issues. The system would search the keyword "Problem and Threat", and then extract information of that section and put in the overall progress report's problem section. The same process would be repeated for the next subject/title until the whole progress report document is completed. After the completion of the first document, the system would continue to extract contents from other progress report documents

of all sub-contractors. However, only extracting and incorporating information from one document to the rest still would not support collaboration. The System would also check the contents for similarity. The purpose of similarity check is to reduce redundant data that could appear in the overall progress report. This feature aims to help the main contractor to collaborate with sub-contractors more efficiently. If the similarity of two contents reach the assigned percentage of similarity, the system would identify such similarity, so the main contractor could choose which content to put in the overall progress report. When this occurs, the main contractor would know that there are several sub-contractors possibly with similar problems, and that would allow the main contractor to collaborate to solve the problem. The system would also inform the main contractor whether such problems have occurred before and how the main contractor has chosen to solve it. This is to reduce the time and to apply the previous knowledge gained as a guideline to solve similar issues.

After the overall progress report document is generated, if there is no further change or adjustment, the user can create the PowerPoint presentation through the system. The process is the same by extracting information from overall progress report and put such information in PowerPoint presentation as shown in Fig. 3.

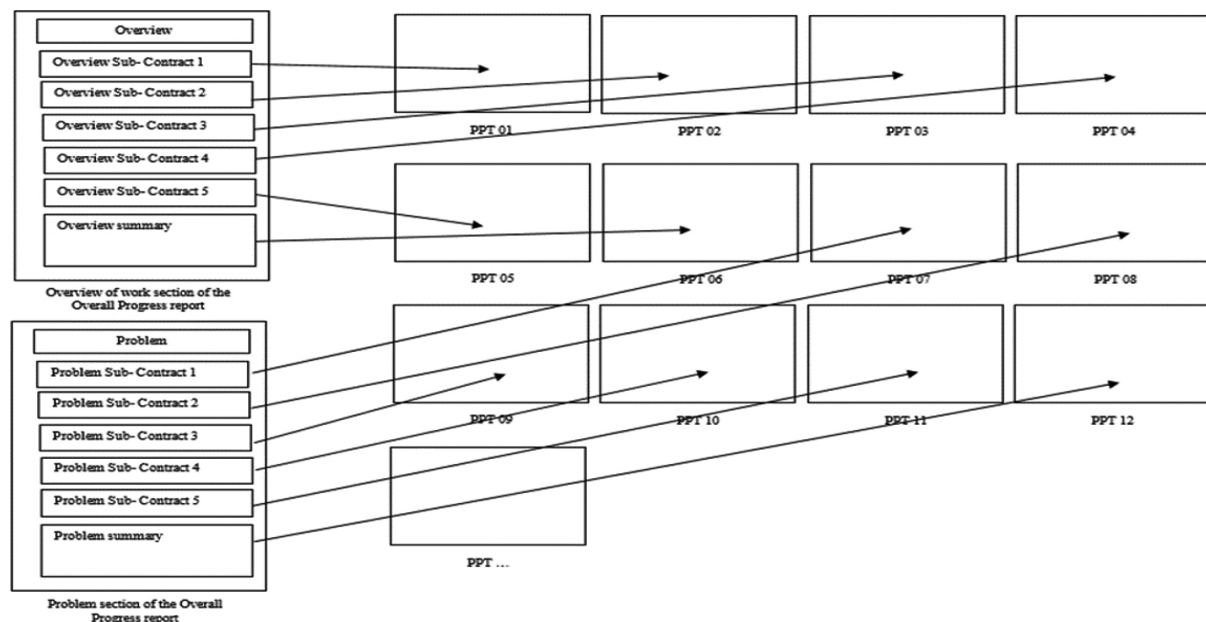


Fig. 3. Process of extracting information on the report and generate presentation file

IV. EXPERIMENT

Design and Build Business operates on a high budget scheme, for management and construction operations. However, the budget would be paid based on the performance and project progress. This would

be reported for the project owner's inspection. This would be the first problem because means any errors in the document might cause a delay of payment. The process of developing overall progress report can sometimes take a long time because all other

sub-contracts are required to submit their own progress reports to the main contractor. Then, the main contractor would inspect the report and create an overall progress report to submit to the project owner. This process of sub-contractors creating the progress report normally vary based on the nature of each sub-contractor's work. If the submission of progress report to the main contractor were late on schedule, then the main contractor would have little time to review and create the overall progress report. The second problem is that if there was a mistake or error on the progress report, then the sub-contractor would have to review and correct the information before resubmitting the progress report to the main contractor. Such process can be time consuming, in particular, when the main contractor need to make any corrections based on the revised information obtained from the sub-contractor. Any delays might result in late payment from the project owner, which might affect the work plan of the company.

In the experiment, the process started after the sub-contractors submitted their progress reports to the main contractor. The main contractor started the process by uploading the document files into the system as shown in Fig. 4.

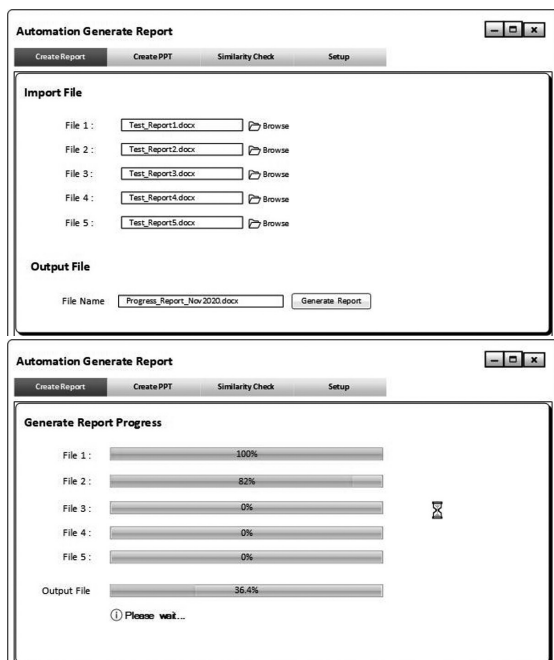


Fig. 4. Main screen for upload file

The system automatically extracted information from submitted documents and stored the information in the database for use when creating the overall progress report. The system used two-keyword search; the first keyword was used as a beginning point where the information was initially extracted, and the second keyword was used as an end for the system to stop extracting information for each section as shown in Fig. 5.

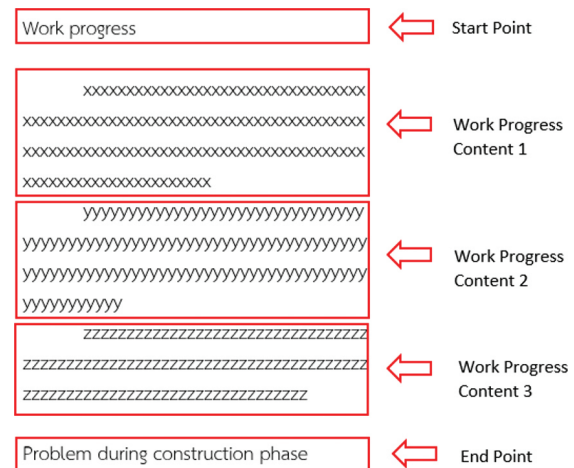


Fig. 5. Use the keyword as a start point and end point for content extraction

The System continued extracting information from submitted document until it reached the end of document. Then the system applied the process to the following documents. However, for the other submitted documents beside the first one, the system applied the keyword and the content similarity check to avoid putting similar contents in the same report. The process of this part started from separating words from extracted contents, then comparing the later contents with the content from the first submitted document. If the similarity exceeded the setup percentage, then both contents with similarity were highlighted in red to indicate the section that was similar to the previous one. The process continued until all the documents were completed as shown in Fig. 6.

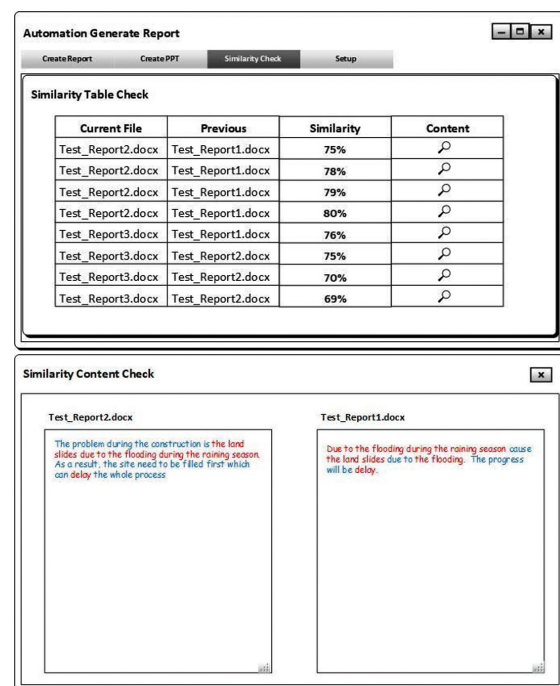


Fig. 6. Content similarity check

After overall progress report was generated, the system presented the option for the user by uploading contents in the document so that preferred contents could be chosen for a PowerPoint presentation as shown in Fig. 7. Thus, the system ran the same process of extraction, but put the information content in PowerPoint file, instead of in a Word file.

The system was also capable of creating a summary of the progress report document automatically, which helped reduce the time and workload for staff. The system Instead of staff reviewing each document and summarizing the content into the report, the system extracted the contents in the same category, putting them together and highlighting similar contents. Therefore, the time needed to perform the task was reduced. Moreover, once the content in the overall progress report was settled, the system automatically generated the PowerPoint file to reduce the process for staff.

V. EVALUATION

The system is capable of automatically creating a summary of the overall progress report. The system uses keywords to determine which sections to start extracting the contents and where the information should be incorporated in the report. The system was evaluate based of the performance whether the Collaborative technology has improve outcome performance while reducing coordination, communication, and process costs [10]. The experiment started with having the staff review five test reports and then create a summary report based on those five report. The data collected included the time for human to complete the task, the correction of contents, the correction of format, as well as ability to distinguish similar contents and to summarize it. Thus, the evaluation of this research was the outcomes of monitoring the performance of the system and data from users as shown in Table.

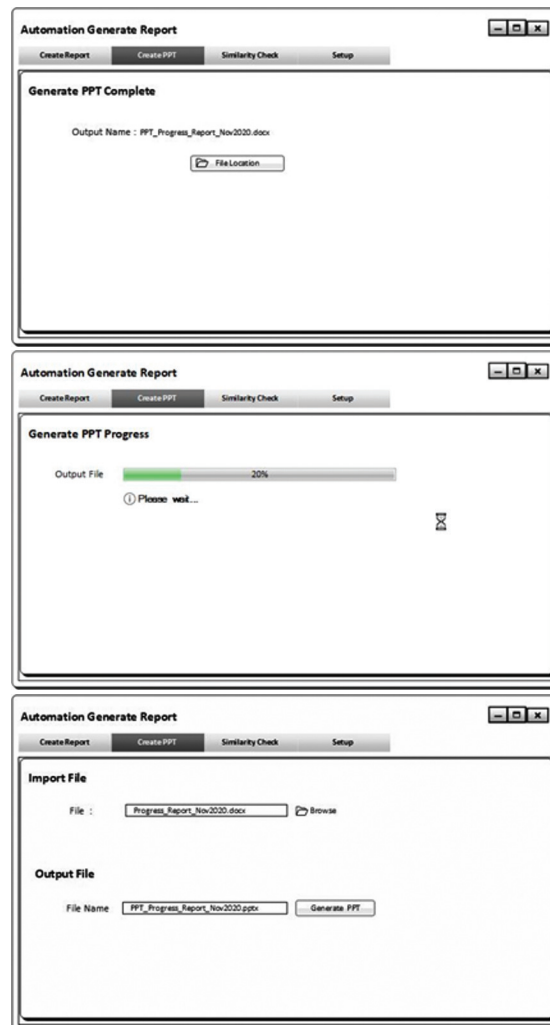


Fig. 7. Create PowerPoint file from Word content

TABLE I
THE PERFORMANCE OF SYSTEM ON AUTOMATIC DOCUMENT GENERATOR

Criteria	Traditional Process	System Process
Create Summary report from 1 document • Process Time • Format Correction • Content Correction • Similarity Check	18 Minutes 100% 95%	3 Minutes 100% 100%
Create Summary report from 2 documents by combining similar contents • Process Time • Format Correction • Content Correction • Similarity Check	42 Minutes 90% 90% 3 of 3 Similarities Found	6.5 Minutes 100% 100% 3 of 3 Similarities Found
Create Summary report from 3 documents by combining similar contents • Process Time • Format Correction • Content Correction • Similarity Check	73 Minutes 90% 75% 5 of 7 Similarities Found	18 Minutes 100% 105% 7 of 7 Similarities Found
Create Summary report from 4 documents by combining similar contents • Process Time • Format Correction • Content Correction • Similarity Check	104 Minutes 75% 70% 7 of 11 Similarities Found	33 Minutes 100% 100% 10 of 11 Similarities Found
Create Summary report from 5 documents by combining similar contents • Process Time • Format Correction • Content Correction • Similarity Check	145 Minutes 75% 70% 9 of 13 Similarities Found	47 Minutes 100% 100% 11 of 13 Similarities Found
Create PowerPoint Presentation • Process Time • Format Correction • Content Correction	55 Minutes 80% 70%	27 (+10) Minutes 100% 100%

From collected data in Table I, when working with a single file, the process time was slow because staff had to copy the contents from the submitted file and put it in the correct format of the summary report file. When working with one document, the format and content did not have to be recheck, so the percentage of correction was 100% for staff. However, as the number of submitted documents increased, the time to process increased as well, resulting in staff completing the task in more than two hours. When working with multiple documents, the format and content correction rate tended to drop because staff had to focus on many contents at one time; moreover, exhaustion could create human error. As for the system, it could still perform, as it should, even with the increasing number of documents. The processing time of content extraction, of course, increased with each additional document because there was more work to process and more similarity to recheck. As for content similarity, staff tended to have more difficulty in spotting similarity as the number of documents increased. As for the system, the similarity found rate dropped as well, in particular when inspecting the case of two similarities that the system was unable

to spot. This was because the similarity rate was lower than the setting, as the keyword was different word but had similar or relate meaning. However, the processing time was still lower than human process. As for PowerPoint file creation, the system performed with a low processing time and higher rate of correction than traditional process (human staff). However, human recheck was required to check some of the slides because the content extracted from the system might be too large to put in one slide. In the performance test, it took the system 27 minutes to create the PowerPoint file and the staff required around 10 minutes to go over the slides and make some corrections.

In addition, it was necessary to evaluate the effectiveness and benefit of the system it had for the staff and organization. This required a set of questionnaire containing two parts: the first part with a set of Likert-scale questions and the second part open for comments. The questionnaire was distributed to seven staff members involved in the progress report. The result of the effectiveness evaluation is shown in Table II.

TABLE II
THE EFFECTIVENESS OF SYSTEM ON AUTOMATIC DOCUMENT GENERATER

Criteria	Score	Level	Comment
The system reduced the process and time of creating Overall Progress Report.	4.43	Agree	<ul style="list-style-type: none"> • The System processing time should be shorter. • The System should automatically extract content-related pictures from reports and incorporated them in the report.
The format of the Overall Progress Report generated by the system was accurate.	4.71	Strongly Agree	-
The content of the Overall Progress Report that generated by the system is accurate.	4.57	Strongly Agree	-
The system helped organize the contents to reduce similar contents to appear in multiple places in the report.	4.29	Agree	<ul style="list-style-type: none"> • User still needed to check similarity contents.
The Similarity check help staff to be able to seek the solution of the same problem that appeared before.	4.29	Agree	<ul style="list-style-type: none"> • The similarity check helped find solution from other cases • The system should store content, which can be used to find solution for similar problem; this would be even more helpful.
The system reduced the process and time of creating Overall Progress Report Presentation.	4.43	Agree	<ul style="list-style-type: none"> • The system should have the capability to separate long contents into multiple slides.
Over all the system met the needs of users to complete the work.	4.71	Strongly Agree	-

From the data collected, all staff agreed on the effectiveness of the system. They all agreed that the system helped reduce the process and time in developing the Overall Progress Report. However, the staff felt that the system should complete the task much faster. However, the system generated contents in the documents without installing them in the system. If the system could save data and recall them when needed, the process could be faster. The staff strongly agreed that the format and content of report were accurate as it should be. They also agreed that the similarity function was useful in helping staff to spot similar contents and to summarize those points. The staff reported that the system reduced time and process in creating PowerPoint file from the content in MS Word file. However, the system should improve performance by separating one long contents so that several smaller content files could fit in the Slides. Overall, the staff strongly agreed that the system met their needs and helped them to complete the task more efficiently and effectively.

VI. CONCLUSION

From this research study, the prototype system can help reduce process and time, which is necessary for organizations that have to complete the task in time for withdrawing payment phase of the project. The information extraction is necessary to the task through replacing manual extraction and generating report. The system could do this automatically to reduce workload for the staff. By doing so, the system

can generate the report with the correct format and content for the staff. The process that might require more than two hours or even a day can be reduced into less than an hour. Besides helping the staffs to complete the report, the system helps notify the staff of the similar contents, such as similar problems that occur among different sub-contractors. The main contractor can spot the same problem and help resolve such problem for sub-contractors. This can also alert the main contractor if similar problems appear among multiple sub-contractors. These might be important or urgent problems that have to be solved before they can cause damage or delay to an organization.

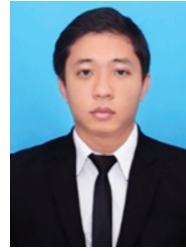
VII. FUTURE WORK

This research study has developed a prototype system to help reduce the process of developing the report, which can sometimes be time consuming. The result met the expectation of people involved in the process. However, there is still much room for improvement, in particular, how to enhance the system to extract and incorporate pictures in the final report. The system should be capable of extracting data from submitted documents and store them in database instead of extracting and creating the final report instantly. This will reduce the time of creating the final report. If there is an adjustment in one of the submitted documents, then only one document is needed to extract the information, not redoing all the documents. Storing data in the system becomes information source for staff to find the solution or

process in previous similar problems. Of course, the current system can point out the similarity of content within the documents submitted for process at the time. However, in reality, the problem that occurred in one sub-contractor report might happen in the past operation or in the future operation. So if the system is stored the database, this will enable staff and people involved to react to the problem more effectively.

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Let-It-Cold Design Concept for Supporting Temperature-Sensitive Products

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Abstract—Various factors cause fruits and vegetables spoilage. Sufficient ventilation, heat, light, humidity or temperature may affect both safety and quality of those fruits and vegetables.

To prevent the situation that the fruits and vegetables are unsuitable for consumption or they decay or go bad quickly, keeping sensitive items in proper temperature-controlled storage system is recommended. *Let-It-Cold* design concept has been introduced in this study where the space and layout between containers used for keeping fruits and vegetables fresh and crisp are the key considerations. For small-sized cold room, arranging containers/crates properly to keep produce fresh much longer than other traditional ways will be reported and analyzed. Three layout designs for positioning and stacking a crate containing 25 kg tomatoes are considered and compared. Ergonomic design for people at work; depalletizing operation was applied in this study as the guideline to design the proper height of the stacked crate in column. For each storage shape, computer fluid dynamics (CFD) has been applied as the tool for cold room analysis. Then, a newly proposed performance index is used to compare and choose the optimum design layout from the simulation result.

Index Terms—Design and Development, Stacked Crate Design, Depalletizing Operation, and Cold Room Configuration

I. INTRODUCTION

Many questions have been raised and needed to be revealed for transporting temperature-sensitive products, such as fresh produce, medicines or cosmetic items, in practice, for the largest wholesale fresh market (Talaad Thai in Pathum Thani province, Thailand), a crate is applied as the main container to keep produces in place as illustrated in Fig. 1.



Fig. 1. Applications of crates in wholesale fresh markets

When loading a moving truck; a large number of crates are carried and stacked as layers, the heaviest crates are placed in first, and the experienced workers have tried to apply their gut feelings or perceptions to make sure that the load is evenly balanced (Fig. 2) before transporting to the retail markets, the urban regions surrounding the metropolis of Bangkok, Thailand.



Fig. 2. Traditional style to carry and load crates to the truck

High Density Polyethylene (HDPE) crates are being used in storage and transport of fruits and vegetables like tomato, apple, orange or cucumber. Good crate should provide good ventilation and smooth interiors with sturdy exteriors (i.e., strongly and solidly built) to protect the surface of fruits or vegetables from scratches and bruises during transportation. Since the cost of high-quality crate is very expensive, the sellers prefer to apply use plastic

bag (Fig. 3) or foam plate to wrap or cover for keeping produce fresh, crisp, and tasty all week long before putting them into the recycled plastic crates. Plastic bags are made from a ubiquitous polymer substance known as polyethylene (PE). In general, a bag does help keep produce fresh; however, it is not good since it builds up much more moisture since lots of fruits and some vegetables release the hormone as a gas. (Fig. 4).



Fig. 3. Applications of polyethylene (PE) saver storage bag for fruits and vegetables



Fig. 4. The drawback of PE storage bag-moisture and gas found

In practice, the sellers need to launch the fresh produces to the customers as much as possible per trip to minimize transportation cost. Stacking crates with 4 to 5 layers is very popular as shown in Fig. 5. HDPE crates are carried by human (Fig. 6) where a 2-wheel cart is used as the main supporter for reducing physical effort that is required to accomplish a task; *lowering, pushing, pulling, carrying, restraining* or *holding* crates manually using human. Delivering heavy packages, pushing a heavy cart, or moving a pallet as manual handling activity is identified as one of the main causes of back, legs, and shoulders injury.

In order to solve those health problems, the developed design of cart has been introduced where the motorcycle-platform function is adapted and modified to be 3-wheel cart as shown in Fig. 7. The bright colors and shapes of tropical fruits and leafy green vegetables will attract customers' attention and urge them to stop for purchasing; however, those fruits and vegetables have reported losses as high percentage during cultivation and postharvest storage, especially during the rainy season that presents the spoilage.



Fig. 5. Carrying and stacking a large number of crates



Fig. 6. 2-Wheel cart designed to satisfy fruit & vegetable markets necessity



Fig. 7. Application of 3-wheel cart

Sometimes, produce is applied and mentioned as the generalized term for many farm-produced crops, including fruits and vegetables (grains, oats or tomatoes). In order to keep delicate produce fresh (e.g., herbs, tomatoes or lettuces) longer, mobile cold room is introduced (Fig. 8). Applying cold storage room and selecting paper box container have become world-wide solutions recently.

In general, from counter-depth refrigerators, door-in-door and side-by-side refrigerators to mini fridges or bottom freezers, the refrigerator humidity effects on produce quality where its components such as crispers (i.e., drawers) can keep fruits and vegetables in good condition longer when the amount of humidity they are exposed to is well controlled.

However, using this cold room practiced method is quite expensive [1]-[5].

The main purpose of this study is to introduce an alternative design of a cold room system by using the simulation application; *computational fluid dynamic (CFD)*, to define optimal condition of products layout according to the physical characteristics and properties of the fresh produce, air ventilation, humidity, physical shape of packaging or crates, temperature, layout of stacking crate inside the cold room, and comfort zone for working area.



Fig. 8. Mobile cold room for keeping produce fresh and crisp

II. RESEARCH BACKGROUND

Presented in this section are the background of the research for identifying and recommending the proper conditions for *Let-It-Cold* storage room where the customer's requirements and perceptions towards the fresh produces and how to keep them fresh are the keys for this study. The interviewed results from the sellers and the business owners who are accounted as the target group and they work in the wholesale-market environment are firstly recorded and analyzed. The processes of translating customer's requirements and perceptions about cold room for storing temperature-sensitive products to be design layouts are taken into consideration in this study before designing process attempts.

A. Product Design and Development

In this study, applying product design and development (PDD) concept can help ensure better forecasts and suggestions about the proper design layout of cold room for storing fresh produce where the air-ventilation and temperature inside the specified area are simulated with various environmental conditions.

Applying PDD can develop general models as well as improving the existing design layout to be competitive with the continuously shifting market needs [6], [7]. In order to serve and satisfy the needs of end users, translating and revealing the hidden perception issues by 5-steps PDD (Fig. 9) can help

designers and manufacturers to quickly create a new design or develop an existing product.

- The first stage of PDD is *concept development (CD)*. Concept development consists of various activities to determine the core concept of the product, which satisfies the needs of the customers and markets.
- The second stage is *system-level design*, this is the stage where the components have been identified and classified; the stage continues to detailed design where the classified groups were used to build the virtual model or prototype.
- The next stage is *testing and refinement* where the prototype is tested or checking its physical characteristics.
- The last stage is production ramp-up; the prototype is now entering production in the manufacturing.

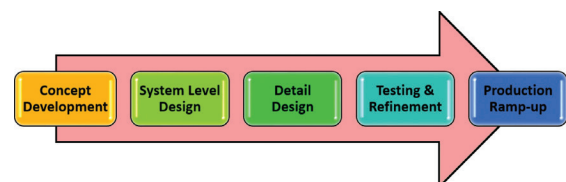


Fig. 9. Product design and development diagram

B. Human Error in Product Design and Development

Before constructing the platform or production planning structure to satisfy customer's requirements, understanding and revealing the employees' experiences and perceptions through their working behaviors when the tasks assigned (i.e., routine tasks) need to be done first. When the workers lack work experience, it should have a mitigating effect on the frequency of minor events; or simply say, this mentions about having the effect of making something bad less severe, serious, or painful. The requirements of *human factors* (HFs) have been considered and identified as the key assisting tool where human factors and ergonomics is the application of *psychological* and *physiological* principles to the engineering activities and design of products, processes, and systems [8]. Understanding human factor in design phase can help the manufacturers and companies to reduce working load, decrease human blunder, time and ensure safety in working environment [9]-[13] where the compliance with deterministic rules shall be shown, and probabilistic analyses where the compliance with risk criteria shall be shown. Human reliability analysis (HRA).

To address human errors in working environment the following human failure activities are mentioned and taken into consideration [12]:

- Poor hazard identification
- Poor design and lack of feature assessment
- Lack procedure
- Lack or poor training

- Workload and overload
- Unclear duties and less responsibilities
- Lack of rest and stress at work

Non-traditional technologies such as an automation system, robotics or smart controlling unit have been become vital and considered to replace human to reduce human error and increase productivity in manufacturing sector [10], [11].

Moreover, understanding the human factor analysis and its concept can help the business owners to create the guidelines for improving the facility or working layout where the equipment is used and maintained correctly to reduce the risk of accidents or damage to health.

In the initial stage of this study, the researchers tried to observe and visit the fresh produce markets and companies around Bangkok metropolitan region for interviewing the business owners about employee strategy to increase profitability. The results presented that, in the business owners' viewpoints; hiring costs generally increase with skill requirements for job applicants.

In their perceptions, placing young people in jobs that require repetitive movements, heavy workload and difficult positions might be the good solution for solving the risk of radiating low back pain that is found in older adults (i.e., high-skilled workers). Moreover, the business owners prefer to work with young generations in the workplace due to the fact that the cost of generating skills from the assigned tasks inside the workplace is lower than that of recruiting skilled workers. So, "in-house skill" is recommended.

However, some questions were raised and considered as the problems in recruitment and selection:

- *Ability to make decisions and solve problems?*
- *Ability to plan, organize, and prioritize works?*
- *Ability to obtain and process the information?*
- *Different backgrounds have the potential to produce violent behavior?*

In order to increase the level of employee's performance, the safety considerations such as the materials' height (i.e., stacking height) and weight, design of the box or crate, and inventory layout should be identified and recommended.

C. Ergonomics Design for Engineering Activities

Human power is mentioned in various activities to support loading or supporting which incorporate pushing, lifting, carrying, lowering, holding and restraining. Currently, many workers are suffering from their work places related to forceful exertion, self-retracting, repetitive motion, discomfort, and injuries with working tools. Those issues affect to their working mood, safety, health, production bottleneck, and product quality and company profit. Ergonomics

principle analyses is joining in manufacturing processes and maintenance engineering activities to increase work-welfare and productivities as five principle below:

- *Safety*: reduce human error, however it is intentionally or not would cause to a serious injuries or serious safety violations which lead to loss life.
- *Health*: over exertion may affect to physical health such as chronic symptoms or muscle fatigue.
- *Work comfort*: limitation of work capacities to enhance the comfort zone for employee to eliminate risk and allowing employee to work longer with less fatigue.
- *Efficiency*: to reduce stress on back, shoulder, effort, force, and bending by replacing working tool to increase work productivity.
- *Quality*: ergonomics gives employees a better working environment by minimizes physical fatigue and mental fatigue to replace with overall working performance also increases productivities, service quality, and worker morale.

The fundamental concepts of "Ergonomic design" have been considered and applied for supporting the concept development phase of the new layout platform where the height of stacking crate or container will be revealed and designed. Moreover, in order to achieve a low cost, efficiency and comfortably for worker, which is important for productivity.

To eliminate working hazard, ergonomic studies have to be applied into design process to reduce health concern and increase safety to achieved injury free in working place [13], [14]. Several studies and guidelines were proposed for lifting objects [15]-[17]. Muscle pain can be caused by lifting heavy objects or bending forward in an awkward position. The pain that muscle strain produces is usually right around the lower back. The 50th percentile of Asian male is 164 cm which is just a bit more 5 feet 4 inches [18]; according to Ministerial Regulation of the Ministry of Labour, B.E. 2547 [19], the maximum weight that a female labor and male is allow to lift is 25 kg and 45 kg, respectively. The proper amount of crates/containers carried by one worker per shift and the height of stacking crates should be considered and identified, at the same time, air ventilation inside the workplace or storage areas should be recommended for reducing human error and maximizing work performance.

Fig. 10 presents about the depalletizing operation where a stacking column is made of a total of 5 boxes; the height of each box should be around 40.5 cm. per box, this means the total height of the 5-layered boxes is around 202.5 cm [20]. This related article mentioned about the proper height for a worker to carry and lift the container in stack. In conclusion,

the *ergonomic design* is aimed to provide user with great working atmosphere and working posture to promote well-being also work performance.

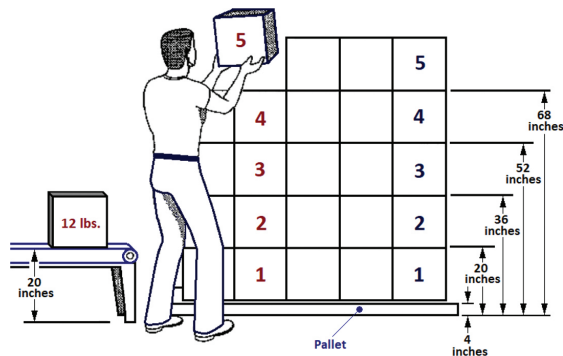


Fig. 10. The proper height and number of boxes recommended for saving health-problem issue [20]

This job consists of a worker inspecting compact containers for damage on a low shelf, and then lifting them with both hands directly in front of the body from shelf 1 to shelf 2 at a rate of 3 per minute for a duration of 45 minutes. For this analysis, assume that (1) the worker cannot take a step forward when placing the object at the destination, due to the bottom shelf, and (2) significant control of the object is required at the destination. The containers are of optimal design, but without handles.

III. RESEARCH CONCEPT

Let-It-Cold is introduced in this research as the name of a design concept for smart cold room system that consists of, *crate design unit*, and *crate-stacking layout simulation*. The input parameters which are *product weights and dimensions*, *types of fresh produce or temperature-sensitive product*, and *acceptable range of storage temperature/moisture conditions* can be easily assigned into the developed system.

For the crate-stacking layouts considered in this study, *three configurations* which are *A, B* and *C* are considered and compared in the testing and simulating section. When the door of a cold storage room is opened for loading the crates in/out, the environmental conditions (e.g., level of humidity, temperature, and air ventilation) might be varied and have direct effects to the quality of the fresh produce. A good design for layout configuration that is a part to contribute for improving cold storage condition can help to reduce post-harvest loss, food waste, reduce energy consumption (air-conditioner can be well controlled) and improve the shelf life of the products.

A. Case Study: Tomato

In this research, “*Tomato*” is used as a sample type of fresh produce for demonstrating the proposed concept. After interviewing the sellers and business

owners about “*cold room*” and “*how to keep the fresh produce crisp*”, the answers were translated and taken into considerations for applying as the input parameters or criteria in the design phase:

- **25-kg-tomatoes** are stored and kept inside the crate.
- Three layouts of stacking crates; **A/B/C design layouts** are considered and compared to find out a suitable cooling condition and configuration to preserve fresh-and-crisp produce.
- **3D-modeling software** is used to design packaging which is “*crate*” for storing tomatoes.
- **Simulating the airflow** in cold storage is done by CFD application.
- The **suitable temperature** for tomatoes should be $15 \pm 2^\circ\text{C}$.
- The **results** obtained from the simulation; *the amount of storage space, load capacity, and suitable configuration* can be applied as the guidelines for designing the specific dimensions of the cold room.

B. Packaging Design: Crate

The packaging material is using in this study has been developed by using *SolidWorks*, a 3D modeling software to create the geometry and dimension to follow the most exiting popular packaging design for horticulture products. The packaging is one the most influencing factors for food waste [21], food quality, and food protection [22]. The packaging designed nowadays is very famous for any product in every manufactory. The functions of packaging are separated into four important parts such as convenience, protection, signature, and product advertisement. In Thailand, several packaging designs are used during transportation and storage of fresh produce. In this research, one type of packaging was selected to use in our case study for cold storage simulation. Illustrated in Fig.11 is the crate design that is available and very popular in the markets. The specific characteristics of this crate style are listed as:

- Length: 375 mm
- Breadth: 570 mm
- Height: 308 mm
- Capacity loaded: 25 kilograms

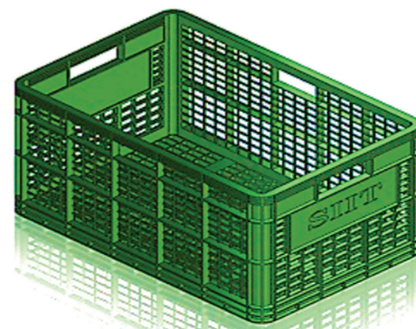


Fig. 11. Packaging design by 3D-modeling software

C. Characteristics of “Tomatoes”

Tomatoes are known as *Lycopersicon esculentum* in scientific names. Fresh cut tomatoes are popular for consuming in any country and provide many nutritional values. Tomato is having many bioactive components such as vitamin C, vitamin E, antioxidant, carotenoids, and phenolic compounds [23]. The redness color is one of the most important colors, which received highest number from selling [24]. Physical qualities of tomatoes come from harvesting, poor postharvest handling, postharvest techniques, and storage condition have effect to the quality of product.

Good postharvest handling is very important to maintain tomatoes qualities and ensures product safety along the process from farm to buyer. Physical losses of tomato would decrease in quantities and qualities of fruit between harvested through consumer according to the majority, mechanical damage, bad packaging, poor harvesting methods, over-ripening and immaturity. Therefore, most of the consumers buying only good appearance of tomatoes according to fruit have to be in a uniform shape, uniform color, and smooth appearance.

Normally any fruit is turning from green maturity to ripen maturity and change till dark red in full of maturity. Tomatoes firmness most of many researchers assumed as an important part of the quality of tomato because it is correlated with eating quality and length of storage condition. Moreover, tomato-eating quality could contribute to consumer feeling also acceptability to select tomato color and firmness measurement. From this, color and physical quality are one of the most important factors that can be influenced to the quality of fruit during storage and transport [25].

D. Traditional Technique of Harvesting, Storage, and Transportation

Harvesting methods by handpicking or using traditional methods normally is happening in a developing country; as shown in Fig. 12. The poor technique of harvesting is often happened by the farmer using a nail finger to cut and pull from the tomato stem. Presented in Table 1 are the traditional transportation techniques applied.

Moreover, the researcher observed that farmers they do not follow good personal hygiene while they are harvesting at the field. Harvested tomatoes should be at a low temperature and high humidity periods like in the early morning and evening. Besides that, fruits have to be place in a clean container and smooth surface to prevent damage during handling. Those poor handling practices could give a result later in both visible and non-visible damages.

The visible damage could happen such as picking, throwing, and dropping tomatoes into containers.

Invisible damage can happen inside the fruits like internal bruising. According to this traditional technique of farmer could affect to the physical qualities of tomato and reduce the shelf life of fruit as well.



Fig. 12. Traditional technique of harvesting tomatoes

Presented in Table I are the examples of improper transportation for sensitive products where the local workers are hired and they usually perform the tasks by using their personal perceptions and experiences. Some problems as the aforementioned situations might be occurred when the worker is hired and paid one day at a time, with no promise that more work will be available in the future. They have less access to resources than mid-to-high skilled routine workers.




TABLE I
TRADITIONAL PRACTICE OF POSTHARVEST

Improper Transportation of sensitive products	
Picture	Description
<p>A</p>	<p><i>Loading A</i></p> <ul style="list-style-type: none"> • Sitting on the vegetable • Bad packaging • Effect to physical damage
<p>B</p>	<p><i>Retailer B</i></p> <ul style="list-style-type: none"> • Can not be stacked from bottom to top • Difficult for air ventilation • Cause injuries on fruit
<p>C</p>	<p><i>Fruits damage C</i></p> <ul style="list-style-type: none"> • Fruit loss • Effect to food waste • Surface of fruits is compress

E. Tomatoes Harvesting, Storage and Transportation in good practice

Harvests in good management practices have four important elements which are applied and considered during harvest seasons such as maturity of fruits, time of harvesting, harvesting technique, packaging materials, and storage condition. Tomatoes can be harvested in any stage of maturity depending on the logistics condition from the production area to the consumption area. The fruits farmer and buyer select the level of maturity based on distance of transport from the field until selling desk. The mature green of tomatoes is important for keeping and loading during harvesting and transportation because dark red tomatoes are easily affected by physical damage causing loss of the product during operation. Time of harvesting also has to be put in consideration because when farmer harvest in a wrong time would strongly make invisible damage to the fruits [26], [27]. Harvesting fruits in hot duration is increasing the mechanism of maturity and increasing dehydration of fruits itself as well. On another hand, the harvesting technique also considers as critical method to prevent fruit loss and fruit waste. Presented in Table II are the proper transportations for sensitive products. The processes shown were captured from the wholesale (fresh) market in Pathum Thani province, Thailand.

TABLE II
GOOD PRACTICE OF POSTHARVEST

Proper Transportation for sensitive products	
Picture	Description
<p>A</p> 	<p><i>Loading A</i></p> <ul style="list-style-type: none"> • Rack can stack from bottom to top • No compress to the fruits • Good air ventilation • Easy to swap from location A to B • Fast moving
<p>B</p> 	<p><i>Retailer B</i></p> <ul style="list-style-type: none"> • No damage or injuries • No fruits loss • No fruits waste
<p>C</p> 	<p><i>Storage C</i></p> <ul style="list-style-type: none"> • Easy to load to cold storage • Convenient • Time saving • Reliable of product quality

Normally, tomatoes are loaded in three different places such as field, packinghouse, and supermarket in order to reduce damage during this main three-operation farmer need to consider a good operation practice during supply chains such as good picking method, hygiene operation, and smoothly preparation. Packaging materials are using to protect fruits from any damage that simply happens during harvesting operation; especially providing space in between plastic bin from bottom to the top for giving an air pass through the stacks.

However, storage facilities are so important for properly protect crops, raw materials, semi-finish products, and finish products [28]. Storage techniques for tomatoes are a main big impact to tomato quality according to storage temperature that would effect to lycopene content and color quality [29]. Since the amount of space of warehouse or the storage area is necessarily required first for determining the layout design where the proper workflow areas and equipment needed to receive and dispatch products are identified.

For setting workstations and storing items inside the warehouse or storage room, two methods are introduced; *clustering or grouping by type*, and *storing in aisles as a grocery store design*. In clustering method, workers feel comfortable to access the area of interest to find items. Applying the aisles in the back and production and workflow in the front can increase the storage capacity and maximize the amount of the current space, since the vertical space as stacking items is applied [30].

F. Cold room Design Concept and Configuration

The cooling system is the one most commonly practiced method to prevent contamination and spoiled between the production and supply chain processes. It is one of the effective methods of perishable commodities in fresh and whole supply chain states for a longer period by humidity and controlling temperature within the storage system [31]. The relative humidity of the storeroom should be kept as high as 80-90% for most of the perishables, below or above; detrimental effect on the keeping quality of the produce [27]. Most vegetable and fruit have a very limited life after harvest from the field if happened at conventional harvesting temperatures it would decrease more on the quality.

Cold storage can be added to some chemicals in storage environment with added carbon dioxide and sulfur dioxide according to the natural product to be preserved. The cold room is designed to access horticulture products such as tomato, cucumber, cabbage, bok choy, eggplant, onion, and fruits. Illustrated in Fig. 13 is about the virtual design of cold room that is considered and applied in the real markets (i.e., small to medium-scaled fresh markets).

The dimensions and shape of the room were obtained from the interviews/self-administered questionnaires from the sellers.

To set up a new cold room normally every factory would like to get a large capacity of a cold room and optimal location to reduce labor costs and transportation costs [32]. That is why the design of warehouse or cold storage is very important to the firm of companies and the overall cost of the logistics supply chain. The overall process of setting up a new warehouse needs to be study such as labor cost, machine configuration, rack configuration, location, capacity of storage, and transportation cost; anyway it could happen a big loss at the end [33]. Warehouse and cold room materials handling plan, operation plan, and configuration plan are the most concerned three factors affect the warehouse configuration design. There are many kinds of factor to involve for warehouse configuration but only three are important factors such as:

- Warehouse *operations* plan includes placement, picking policies, and assignment policies.
- The warehouse *material-handling* plan includes materials handling equipment plan and personnel plan.
- Warehouse *configuration* includes storage area, size, capacity, aisle, rack, location, and sizes of docks.

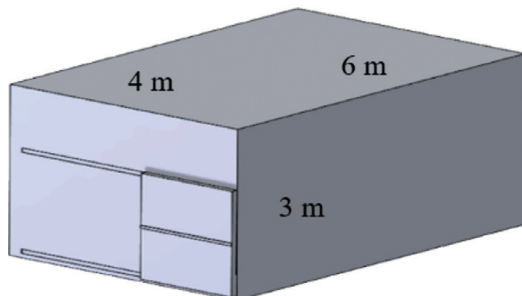


Fig. 13. Cold room concept design for CFD prototype

G. Three-shaped Patterns of Product Flow

Three popular warehouse configurations will be mentioned and analyzed in this study; *I-shaped*, *U-shaped* and *L-shaped* patterns [34], [35]. The U-shaped configuration in warehouse product flow is the most popular type of configuration. The brief descriptions of these three shape designs or flows are presented in the following three sub-sections below with pictures (Fig. 14-16).

• I-shaped design

The concept of this design is about the way to receive and dispatch products; receiving at one end and dispatching from the opposite end. The motion is considered as the flow-through

or 'I'-shaped layouts as shown in Fig. 14. This pattern is commonly found and applied for "high-volume operations" where the complete separation of receiving and dispatch operations is required. I-shaped design is widely used; however, this design requires greater hardstand areas than the "L" or "U"-shaped designs.

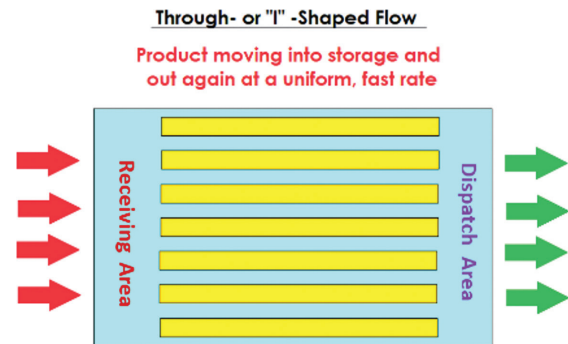


Fig. 14. I-shaped design layout

• U-shaped design

The key characteristic of this design is about receiving and dispatching operations that are adjacent, on the same side of a warehouse are known as "U" shape designs. The majority of distribution centers are designed as U-shaped (Fig.15). The benefit obtained by this design is minimizing space because U-shaped flow is a one-way in and one-way out option where the shipping and receiving vehicles (e.g., trucks) can share the same side of the building, each having its own dock. A receiving truck pulls up to the dock, the employees pull the items off the truck and move it the central inventory location for sorting. Meanwhile, on the other end of the "U," the shipping truck gets loaded with goods to head out to their destination.

The strength of this pattern is that,

- This layout offers the optimal solution for minimizing the amount of a paved or stabilized area required where vehicles.
- Work is occurring simultaneously.
- Shipping and receiving within close proximity to one another means employees can easily move goods from one truck to another with ease and speed.
- U-flow layout can minimize staffs for moving production and inventory even a small production team.
- With this style of warehouse layout optimization, the storage and inventory are taking up the least amount of space in building as possible.

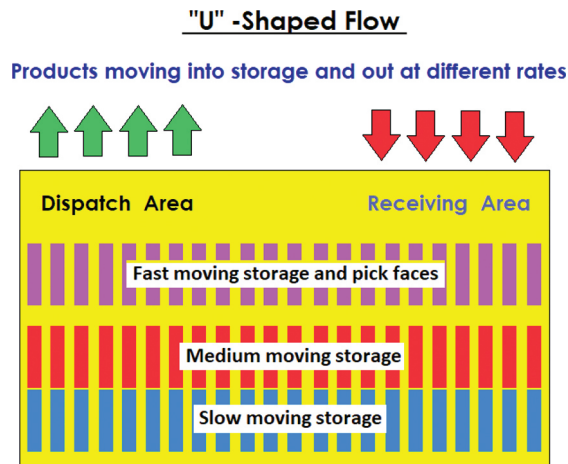


Fig. 15. U-shaped design layout

- *L-shaped design*

The definition of “L-shaped design” is about receiving on one side and dispatching on an adjacent side at 90 degrees from the receiving side. In practice, some warehouses or docking operations apply an L-shaped design for receiving products in large trailers but dispatching in smaller vehicles as shown in Fig. 16. For some contemporary distributions, the combination between/among two or three of I, U and L-shaped designs is recommended. Currently, various storage systems require multiple rooms or spaces to store temperature sensitive goods such as fresh produce, medicines or cosmetic items. Thus, the key design components are considered on the ways to load/unload parts, air flow inside the room, vehicle types accessing the site, and product capacity.

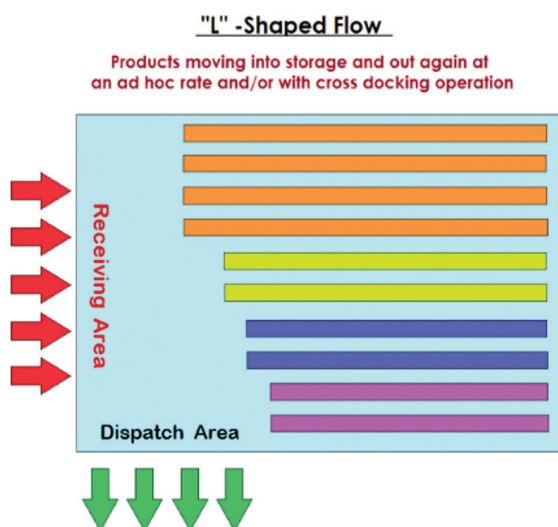




Fig. 16. L-shaped design layout

In this research, three configurations of design layout for supporting cold room system are compared where the air ventilation and temperature inside the

room are listed as the main set of considerations to simulate the fluid motion and heat transfer by using numerical approaches; *Computational Fluid Dynamics (CFD)*. The results are reported as the quantitative predictions of fluid-flow phenomena based on the conservation laws (conservation of mass, momentum, and energy) governing fluid motion. Since the average height for Thai male and female population is 168.6 cm and 157.5 cm, respectively [36].

This might imply that the appropriate stacking height of the crates should not exceed 5 layers to avoid overhead lifting action. Presented in Table III is the arrangement of pallet design five layer per one pallet that is widely used in the warehouse and storage room.

TABLE III
THE ARRANGEMENT OF PALLET DESIGN FIVE LAYER PER ONE PALLET

Product stack and Pallet design	
Pallet top view	Packaging arrangement
	
Top view of packaging 25 kilograms	Front view of packaging stacked from bottom to top

IV. METHODOLOGY

A. *Computational Fluid Dynamics (CFD)*

Appropriate controlling a uniform cooling and cold storage of fresh produce are quite difficult to provide because of an uneven distribution of the airflow; the airflow distribution inside the area of interest depends upon the product, the cooling medium, the geometry, and the characteristic of the cooling room. Ho [37] mentioned that the increase of development of computers and the field of Computational Fluid Dynamics (CFD) in recent years has opened up the possibilities of a low-cost and effective method for modeling and simulation of airflow and heat transfer in the refrigerated warehouse with fewer experiments required.

The model was subsequently applied to predict the condensation in bulk-stored; CFD was used to investigate the airflow in a cold stored as well as to modify the airflow distribution system in the storage room. Airflow, heat, and mass transfer in cold storage was modeled to predict the velocity distribution, temperature profile, and moisture loss in

stored product. CFD was also proven to be a suitable technology for predicting the effect of various design parameters on the flow and temperature fields of cold stored [38].

Fig. 17 and 18 show examples of air velocity and temperature distribution from CFD simulation results of forced airflow over three crates of product positioned in the middle of the cold room. The inlet temperature from the air conditioner was set to 15°C. The inlet air velocity was approximately 4 m/s.

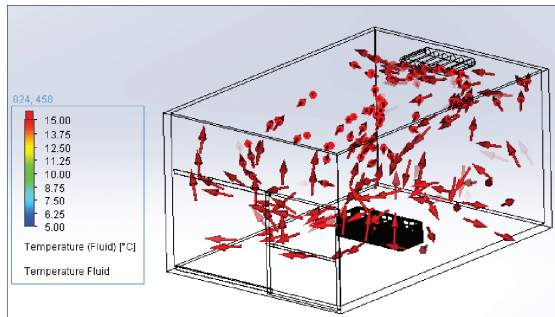


Fig. 17. Temperature-CFD testing by using SolidWorks

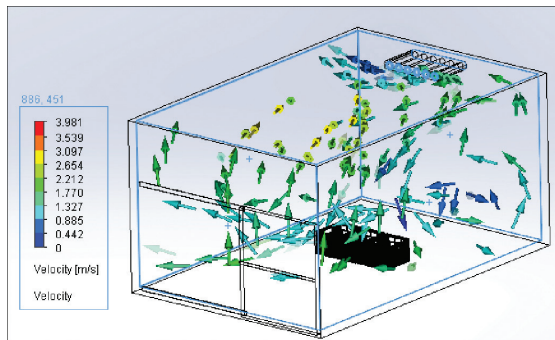


Fig. 18. Velocity- CFD testing by using SolidWorks program

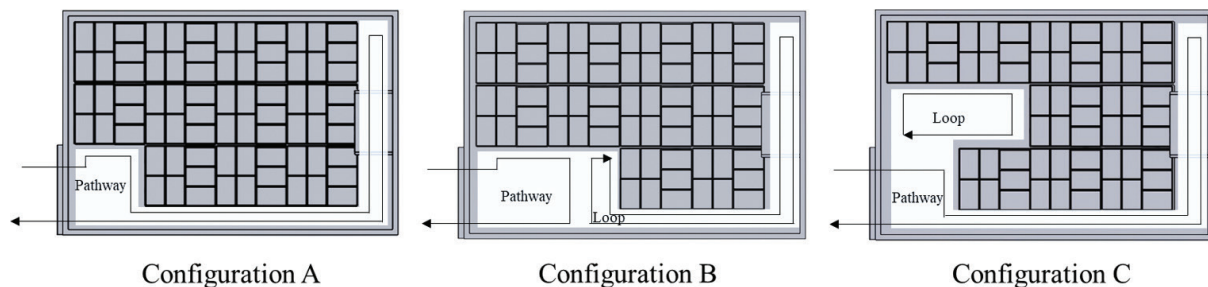


Fig. 19. The three configurations of the cold room layout used in the CFD simulation

Configuration A fills most of the room with the product except the bare minimum space needed for access of the workers. Configuration B removes one pallet out to allow more room for two workers to work in a two-loop workflow.

Configuration C sacrifices more of the storage capacity while gaining more access to the inner area of the cold room. The total number of crates for configuration A, B, and C are 385, 350, and 315 crates, respectively, as mentioned in Table IV.

B. Detail Design

The computational fluid dynamics are used in a cold storage system to evaluate airflow to the right location of product needed. This part of the research study is an answer to customer needs such as improved quality of fruit/vegetables; reduce cost through minimize electricity consumption and improving shelf life of products. Moreover, this concept designed is truly applied in commercial cold storage and small scale cold storage based on the capacity of cold storage and CFD system to identify the good configuration of product rack to be fit and efficient. The CFD is used to design and study different product arrangement to evaluate the space, airflow, and temperature distribution inside cold storage.

In this study, cold room size with dimensions of 6.0×4.0×3.0 meter was selected as a case study of small cold room for retailers. The room can hold products up to 16 tones (640 bins of 25 kg bins) of tomatoes if filled without space. However, product accessibility and distribution workflow must also be considered in the detail design of the layout.

With many concepts from the literature review, this design would like to design pallets into three different configurations which varies in storage capacity and accessibility with ergonomics considerations. The three configurations are shown as A, B, and C in Fig.19. Five layered stack of 25 kg plastic crates was applied to the simulation.

TABLE IV
THE THREE CONFIGURATION SPECIFICATION

Description	Config. A	Config. B	Config. C
Plastic Bin 25KG	9625 KG	8750 KG	7875 KG
Total number of crates	385	350	315
Number of layer	5 layers	5 layers	5 layers
Number of pallets loaded	11 pallets	10 pallets	9 pallets

This simulation experiment was designed to compare the result of the flow and temperature distribution at the product crates among the three configurations. Since the quality of the product stored depends on the appropriate temperature of the crates, a performance index is defined such that the three configurations can be compared even if the amount of product inside is different.

$$e = C / b$$

Where e is cold room efficiency. C refers to the total capacity of the configuration in number of crates, b is the number of crates that has bad temperature distribution either too warm or too cold for the specific product.

C. Ergonomic Design

The guidelines for creating and designing cold room layout proposed in this study focus on how to locate/form the crates into a proper layout for maximizing profits while maintaining comfort of the workers; the key components for this ergonomic design are *simplicity*, *accessibility*, and *storage capacity*. In order to achieve the optimal reachability at working area, these following assumptions are taken into considerations:

- Five stacking layers is recommended to prevent overhead lifting (stacking 5 boxes; the total height is around 150-160 cm).
- Providing spaces for a worker to easily move in and out.
- Applying CFD to simulate the proper conditions required for cold room to store temperature sensitive products.

D. Heat Load Calculation

Temperature is a key component to make changes in the quality of products. The range of temperature is very important for any kind of product to maintain

both their nutrient and physical qualities. Moreover, the temperature range is one of the most concerns for many researchers to study and evaluated to find a good way to empower cold storage and products. Therefore, to ensure product quality cold storage room could be researched more on temperature, capacity, storage condition, relative humidity and, velocity has to be done to keep as guidelines during operation design.

The cold room conditions have to involve the average of maximum outside cold room temperature and the maximum amount of product cold in a day and the maximum temperature of the product to be cooled. The total heat load produce by products itself and from materials inside the refrigeration system so heat which comes from every part of cold room must be removing from the cold room is called the heat load. The heat load can be produced by product respiration, people, leaking parts and, packaging [39]. The leaks and splashes of heat entering a cooling room come from several sources:

The heat of respiration: heat comes from naturally of product respiration.

Service load: heat from many parts of the cold room such as equipment, lights, people, moist, packaging, and air entering through cracks or the door when opened [40].

E. Vegetable Respiration

Vegetable respiration usually comes from fruit, vegetable, and other horticulture products. The respiration is starting after harvesting from the growing field. Vegetable respiration rate is depending on external and internal factor such as harvesting time, temperature, packaging, oxygen and carbon dioxide [41]. The number of respiration from vegetables is calculating according to the level of CO_2 produce from the product itself.

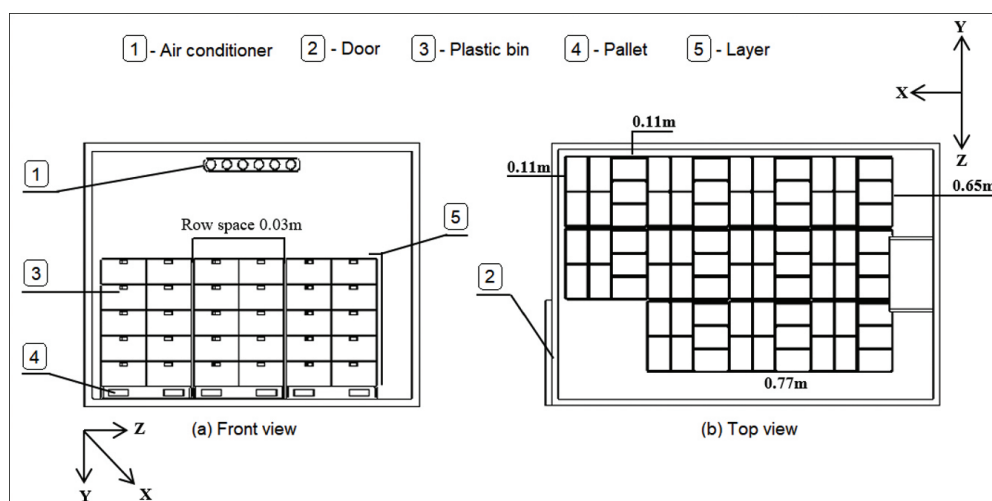

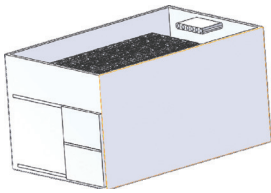
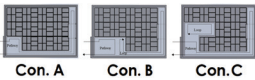
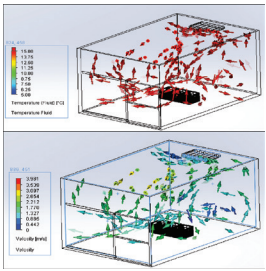
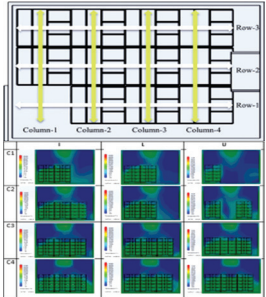
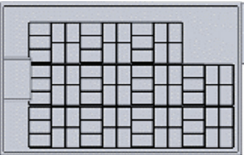


Fig. 20. Schematic of cold room for CFD simulation

The calculation for vegetable respiration normally heat respiration convert glucose ($C_6H_{12}O_6$), and transformed glucose to carbon dioxide (CO_2) and water (H_2O) by using oxygen (O_2) in a cold chamber (1 kg of tomatoes equal to 3.81 BTU per hour) [42], [43]. Heat respiration for every vegetable, fruit and root vegetable were calculated by how much carbon dioxide produce in a single day and convert into calories [44]. Illustrated in Fig. 20 is the Schematic of cold room for CFD simulation applied in this study. The steps required for the proposed research are presented in Table V.

TABLE V
RESEARCH STEPS REQUIRED IN THIS STUDY

Illustration	Description
	Step 1 Packaging design: <ul style="list-style-type: none"> Length: 375 mm Breadth: 570 mm Height: 308 mm 25 kilograms
	Step 2 Dimension of cold room: <ul style="list-style-type: none"> Length: 6 m Breadth: 4 m Height: 3 m Air conditioner types 42PST1U6 (39000BTU/hour)
	Step 3 Configuration of study <ul style="list-style-type: none"> I shape L shape U shape
	Step 4 CFD design: <ul style="list-style-type: none"> Temperature (15 ± 2 °C) Velocity (4 m/s) Relative humidity (90-95%)
	Step 5 Compare the three configurations using performance index e <ul style="list-style-type: none"> Plot sectioned view of temperature distribution Count crates that has out-of-range temperature
	Step 6 <ul style="list-style-type: none"> Model selected Give conclusion Provides suggestion

F. Boundary and Initial Condition

The model each simulation is using Flow Simulation in SolidWorks to analyzed and solved by applies finite elements to testing the model. For each time to test the model by using full flow simulation in SolidWorks it took 2 or 3 hours on a 64-bit, Intel[®] with Six-Core Processor 3.60 GHz, 8 Gb RAM, Windows 10 PC. This cold room simulation study is assumed the room condition is completely isolated from outside environments such as walls, floor, ceiling, and door. In the room are containing differences number of bins loaded into cold storage (Table VII).

Based on fluid simulation x, y, and z direction to the contour plot of simulation results. The air simulation in the room is defined by adding a momentum source term in the fluid domain. Airflow is using the main parameter of temperature fluid, velocity (X, Y, and Z) and relative humidity. In boundary condition, air velocity is adding 4 m/s with temperature 12 to 15 degrees Celsius with assume relative's humidity 90 to 95 percentage in cold storage.

1) Constraint.

- Number of products loaded with specific configuration
- Manual lifting
- Temperature in the range

2) *Target set up.* The boundary conditions were used cold room wall to define the airflow direction (Table VI). The airflow velocity, relative humidity and inlet flow temperature were set at the experimental designed.

- Air velocity 4 m/s.
- Room assumption well-isolated.
- Relative humidity assumption in good range from 90-95%.
- Capacity loaded and heat load.
- Temperature 15 ± 2 °C.

3) *Inlet mass flow.* The inlet mass flow set up was use air conditioner to set up flow direction from air conditioner to cold room and product loaded. Optimization product loaded to get a rage temperature 15 ± 2 °C.

IV. RESULTS AND DISCUSSION

A. Air Velocity and Temperature results

For configuration A, the air velocity profile inside cold storage is shown in Fig. 21 (a,b). The airflow pattern from air conditioner flows directly to cold storage with a maximum air-speed in 4.0 m/s and velocity decreases the speed from 4.0 m/s to 0.004 m/s when reach into every surface of the packaging inside cold storage. There is also flow create circulation zone at Fig. 21 (b) the front part of cold storage next to the entry door of the stack which is a free space for the forklift to loading product.

According to the number of air-speed from the result of velocity shows in 0.2 m/s to 0.86 m/s that in a good range for horticulture products [37], [45], [46]. In addition, from velocity characteristics inside cold storage. Fig. 21 (c, d) show temperature distribution from the air conditioner which flows directly to cold storage with a maximum temperature of 21°C. The temperature measurement range were derived from a stable condition after sixty minutes when the temperature around the crates reach a stable point of 15°C. The total range of temperature was found to be from 33°C to 2°C. Some crates positioned at the outer layer experienced very low temperature and may cause issues to the product quality while the majority of the storage gets appropriate temperature range of $15 \pm 2^\circ\text{C}$.

For configuration B, similarly, the air velocity and temperature profile inside cold storage are shown in Fig. 22. The air speed pattern from air conditioner flows directly to cold storage with a maximum airspeed in 4.0 m/s and velocity decreases the speed from 4.0 m/s to 0.004 m/s when travel to every parts

in cold storage. There is also a non-uniform flow create circulation zone on the top which is influence by a free space next to the entry door. This may cause better flow of air as compared to configuration A. According to the number of air-speed from the result of velocity, it also provides 0.28 to 0.86 m/s which is a good range for horticulture product [26], [27], [35], [36]

The temperature pattern from the air conditioner flows directly to cold storage with a maximum temperature of 21°C.

For configuration C, the simulation results are shown as the velocity profile (Fig. 23 (a, b)). It shows more air flow upward through the center of the room, creating a wide area circulation zone on the top. This should be the influence of the free space in the middle of the crate arrangement in *configuration C*.

The velocity is also in the suitable range required for horticulture storage as the *configuration A* and *B*. The temperature range is also listed with 33°C to 2°C where some minor parts of the crates are too cold for the target temperature.

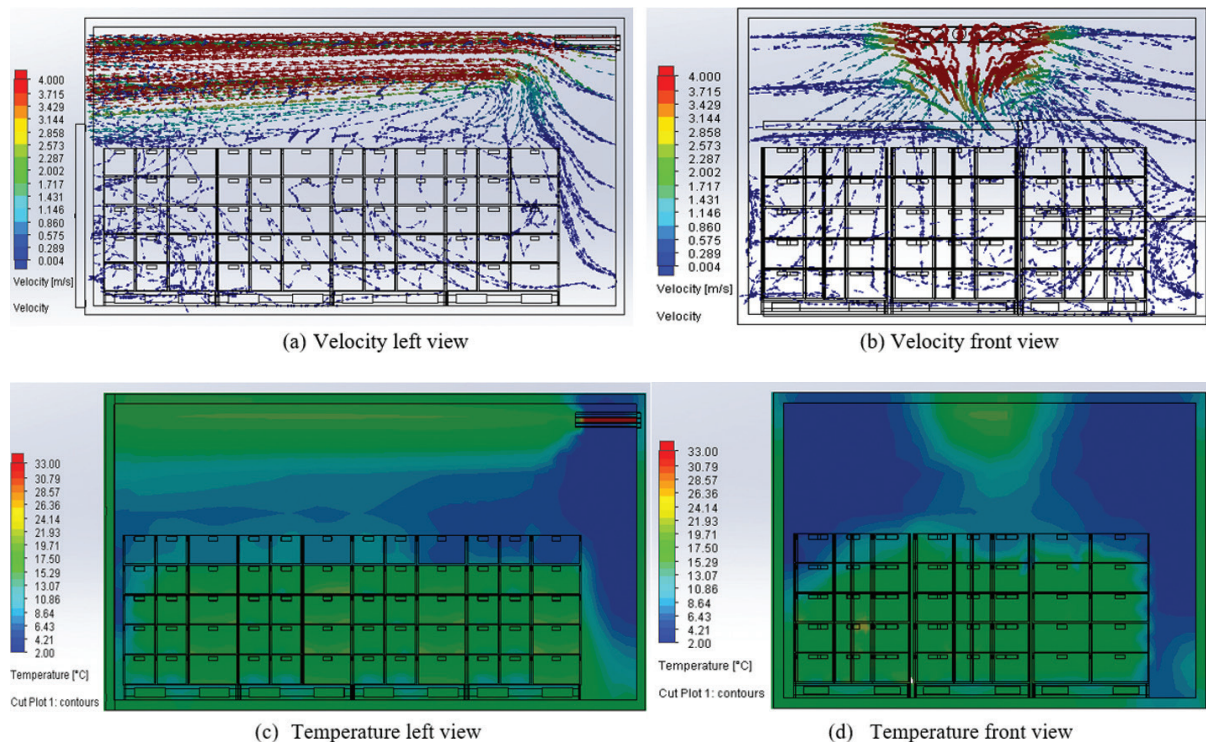


Fig. 21. Simulated contour of temperature in the middle of cold storage with configuration A with 385 boxes loaded. (Middle row and column)

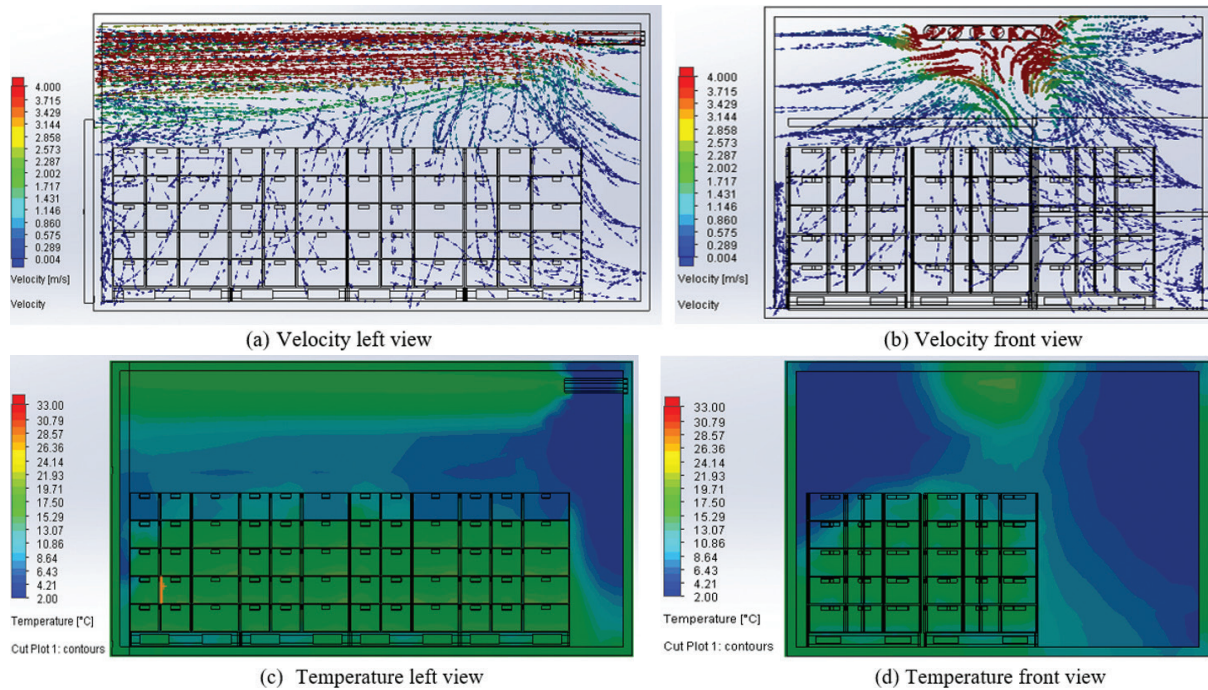


Fig. 22. Simulated contour of temperature in the middle of cold storage with configuration B with 350 boxes loaded. (Middle row and column)

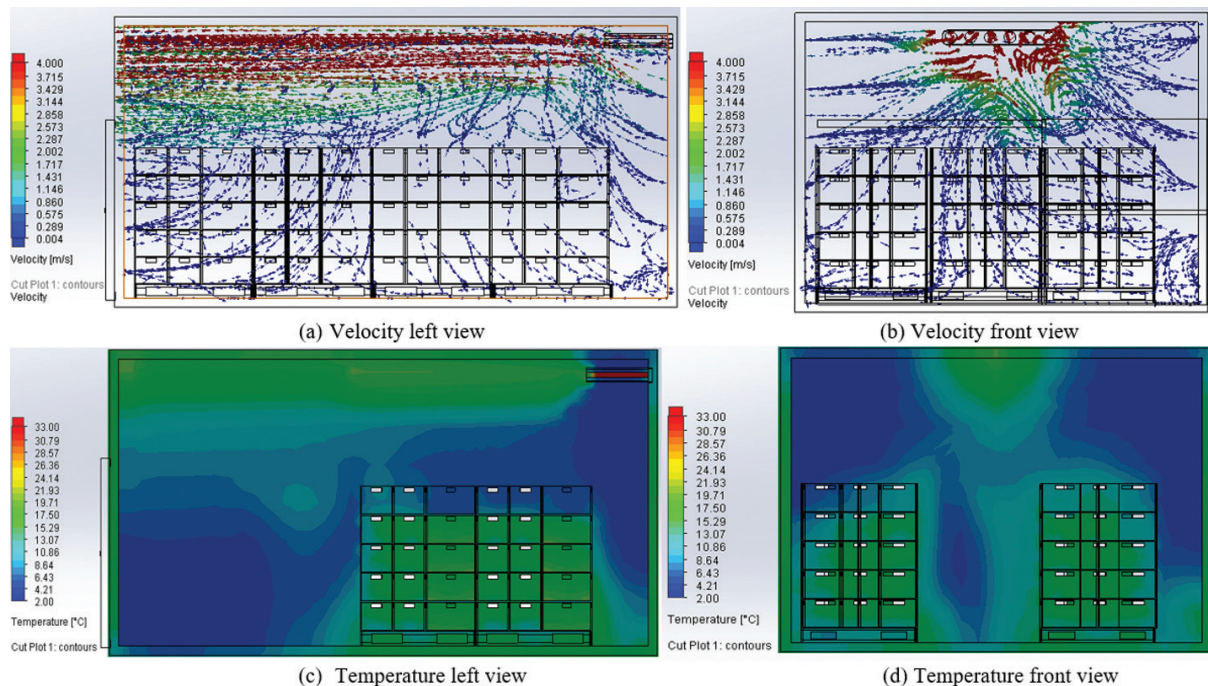


Fig. 23. Simulated contour of temperature in the middle of cold storage with configuration C with 315 boxes loaded. (Middle row and column)

B. Cold room Efficiency

As mentioned before, the *three configurations*: *A*, *B* and *C* have different loading capacity and each has its own advantage/disadvantage when it comes to cold-room design. This leads to the need to create a comparable performance index defined as cold room efficiency, where *C* refers to the total capacity of the configuration in number of crates, and *b* is the number

of crates that has bad temperature distribution either too warm or too cold for the specific product. “*b*” can be approximated using sectioned plot of the CFD result in all column and rows of the pellets as shown in Fig. 24. One of the sectioned plots of *configuration A*, Row 1 is shown in Fig. 25. The circles mark the crates that have too low temperature for tomatoes storage.

After the same method has been applied to all available sections, the total number of bad crates across all sections are summarized to b for the calculation of the cold-room efficiency. Table V displays the calculated values for all configurations.

The cold room efficiency works as a quantitative comparison tool to help the designer select a layout of the crates to maximize the capacity in the room while having the least number of crates that has out-of-range storing temperature for the specific fresh produce, which is tomato in this case study.

The result shows that while *configuration A* has the highest loading capacity, the configuration B would be a better choice of layout according to the highest performance index (cold room efficiency e) of 9.46 among the three configurations. Additionally, *configuration B* provide moderate accessibility and two loops pathways for better task management between workers.

TABLE V
PERFORMANCE COMPARISON BETWEEN LAYOUTS

Description	Config. A	Config. B	Config. C
Column 1	5	4	3
Column 2	4	3	7
Column 3	7	7	6
Column 4	7	5	7
Row 1	9	4	5
Row 2	11	7	5
Row 3	11	7	10
Number of bad crates b	54	37	43
Cold room efficiency e	7.13	9.46	7.33

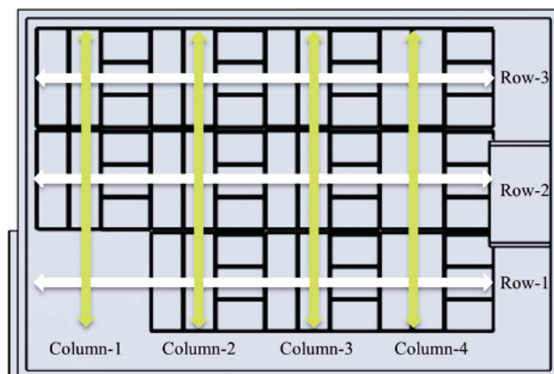


Fig. 24. Section planes for counting the bad crates using sectioned temperature plot technique

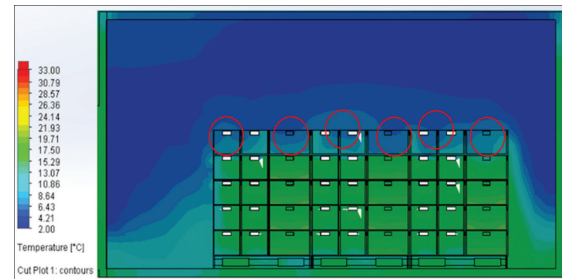


Fig. 25. Sectioned plot of temperature profile (Config. A, Row 1)

V. CONCLUSION

This research study and suggest a design guideline for storage layout of small-sized cold room. Firstly, workflow analysis, ergonomics standard and regulations were used to suggest three basic configurations of crate and pellet layouts. Then, CFD simulation was conduct to analyze the velocity profile and temperature distribution within the room and product area. The simulation result provides beneficial clue to choose the optimal configuration for a specific room size and reduce waste time trying to improve the layout using trial-and-error methods. Additionally, this research propose a performance index called cold room efficiency to be used as one of deciding factors in cold room design.

For the case study of “tomato cold storage room”, the **configuration B** was suggested to be the optimum layout because it gives the least defective crate for the loading capacity among the three configurations.

The design method and guideline presented in this study can be extended for other types of product that require different packaging, temperature, velocity, and relative humidity range. Because some products can be placed in a warmer or colder area than others, mixed storage with different product appropriately stored in the same room is also possible with the help of CFD simulation.

For future works, the research should bring this result to do a real experiment for cold room to see how different of layout could give effect to the quality of tomato in term of firmness, color change, and weight loss. Also, the accuracy of the performance index could be improved by changing the approximation method to use a full 3D result and image processing software to count the number of bad crates. However, this improvement would take a lot of computation time unless a high performance computational machine is available.

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- [1] G. O. Young, "Synthetic structure of industrial plastics," in *Plastics*, 2nd ed., vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15-64.
- [2] W.-K. Chen, *Linear Networks and Systems*. Belmont, CA: Wadsworth, 1993, pp. 123-135.

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- [3] J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility," *IEEE Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34-39, Jan. 1959.
- [4] E. P. Wigner, "Theory of traveling-wave optical laser," *Phys. Rev.*, vol. 134, pp. A635-A646, Dec. 1965.
- [5] E. H. Miller, "A note on reflector arrays," *IEEE Trans. Antennas Propagat.*, to be published.

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Examples:

- [6] E. E. Reber, R. L. Michell, and C. J. Carter, "Oxygen absorption in the earth's atmosphere," Aerospace Corp., Los Angeles, CA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.
- [7] J. H. Davis and J. R. Cogdell, "Calibration program for the 16-foot antenna," Elect. Eng. Res. Lab., Univ. Texas, Austin, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

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- [10] J. Jones. (1991, May 10). *Networks*. (2nd ed.) [Online]. Available: <http://www.atm.com>

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- [11] R. J. Vidmar. (1992, Aug.). On the use of atmospheric plasmas as electromagnetic reflectors. *IEEE Trans. Plasma Sci.* [Online]. 21(3), pp. 876-880. Available: <http://www.halcyon.com/pub/journals/21ps03-vidmar>

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Example for papers presented at conferences (unpublished):

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- [18] G. Brandli and M. Dick, "Alternating current fed power supply," U.S. Patent 4 084 217, Nov. 4, 1978.

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- [19] J. O. Williams, "Narrow-band analyzer," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.
- [20] N. Kawasaki, "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

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- [21] A. Harrison, private communication, May 1995.
- [22] B. Smith, "An approach to graphs of linear forms," unpublished.
- [23] A. Brahms, "Representation error for real numbers in binary computer arithmetic," IEEE Computer Group Repository, Paper R-67-85.

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- [25] Letter Symbols for Quantities, ANSI Standard Y10.5-1968.



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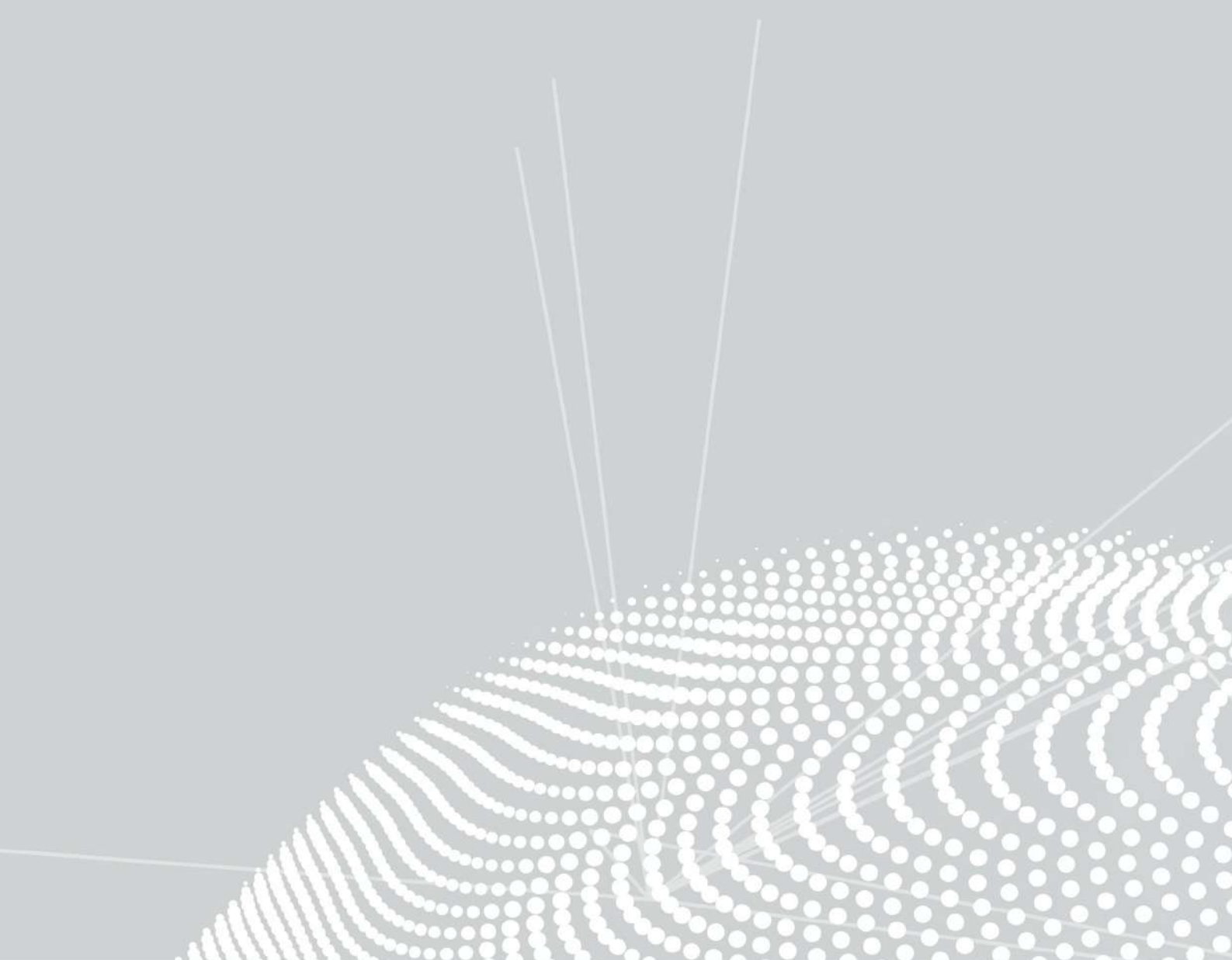
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