Development of Smart Mobility Platform

⑤ Understanding the actual situation of logistics MaaS and developing a strategy to build it

Proposals for improving regulations, systems, and business practices that streamline long distance transport by trucks and development of software for converting logistics information into digital

＜Report Summary＞

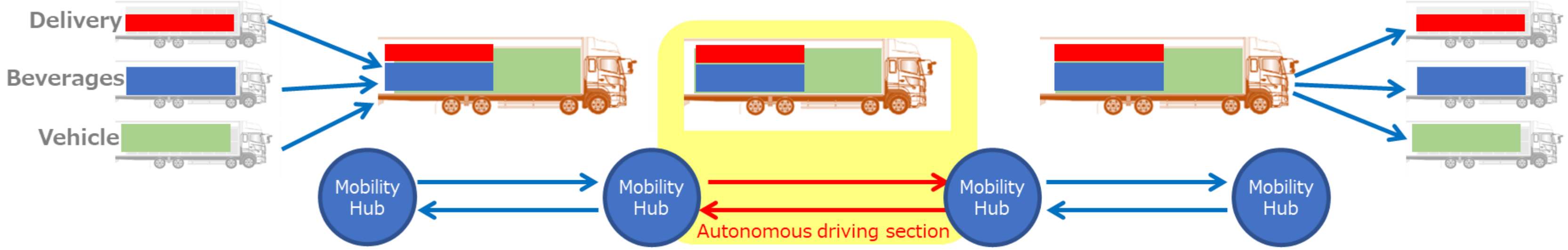
March2025

NEXT Logistics Japan， Ltd.

Overview of the initiative（英語版）

No.16 : Proposals for improving regulations, systems, and business practices that streamline long distance transport by trucks and development of software for converting logistics information into digital

SIP's vision: To achieve greater efficiency and productivity through joint transport, and to enhance the sustainability of logistics



Digitalization of logistics information

Automatic luggage allocation and loading system

Optimal operation plan

Front and rear system cooperation (TMS/WMS)

Ministry of Economy, Trade and Industry Demonstration Project

Consolidation/transfer point handling

Vehicle sharing

Joint transport and sharing

Issues for implementing logistics information standard guidelines（テーマ(b)）

Digitalization of logistics information is incomplete and fragmented (Palletized packaging information has not been digitized)

Issues in implementing joint transport（テーマ(a)）

・Advance arrangements to shorten loading and unloading times, issues with loading and unloading costs such as loading and unloading on both sides, burden of XD costs, etc.

To accelerate further efficiency improvements in joint transport, we are working on the third phase of SIP.

Theme(a)

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1. Regarding the approach to theme A (procedure)

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We have formulated an action policy as an outcome for fiscal year 2024. The policy is as follows:By utilizing actual data obtained by NLJ as it advances joint transport with its partners, we will conduct simulations for each model case of joint transport to present the effectiveness and develop efficient models (future and present) and plan measures.

procedure

Step 1 Selection of operation model

① Formulate an operation model
② Evaluate the operation model
③ Select the model to be tackled

Step 2 Identifying issues

Study and extraction of issues from data based on actual operation
- Economic issues
- Operational issues

※ Conducting simulations using actual data

Step 3 Countermeasures planning

Countermeasures planning

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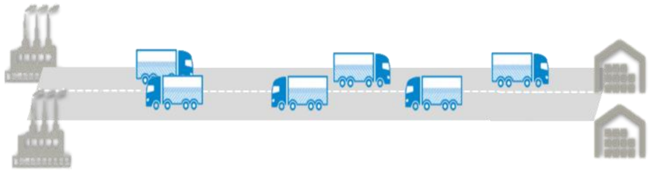
1. Regarding the approach to theme A （1）

Step 1 (Selection of operation model)

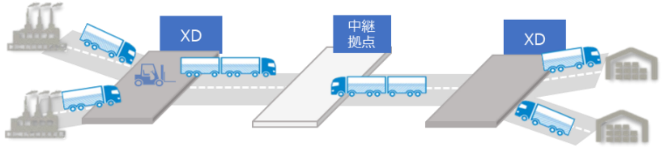
・Formulate multiple operation models from departure point to destination by setting parameters.
・Evaluate efficiency (loading rate, transportation capacity), economy (operation cost), and environmental friendliness (CO_2 emissions) to select the optimal operation model.

【Model Development】

Base



Model case 1 (example)



	Departure point	Public roads	Consolidation Center	Public roads	Express way	Relay Station	Express way	Public roads	Consolidation Center	Public roads	Arrival point
Operation model ① Base	loading	track	×	track		×	track		×	track	unloading
Operation model ② Consolidation	loading	track	mixed loading	Full tractor		Driver Change	Full tractor		Unloading and delivery	track	unloading

Parameters

Vehicle type (truck, full tractor, etc.)

Cargo handling methods, replacement of tractor coupling, etc.

[Evaluation of operation model]

1.Loading rate: weight or volume
2. Transport capacity: amount of cargo per person
3. CO_2 emissions
4. Operation costs (including labor costs, etc.)

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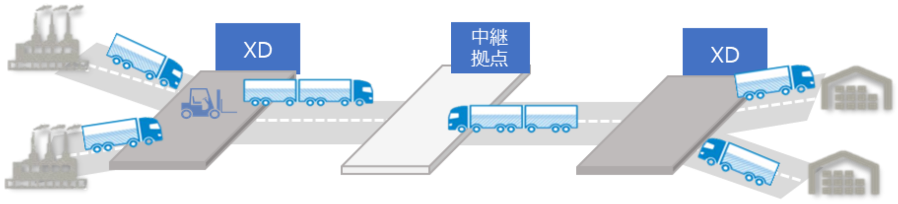
1. Regarding the approach to theme A （2）

Step 2 (Identifying issues) Step 3 (Planning countermeasures)
Use data from actual operations to simulate the planned values and actual conditions for the operation model selected in ①
Issues are then extracted and countermeasures are planned.

Operation model
(image only)



	Loading rate	Transport capacity	CO2 Emissions	Transportation costs
Evaluation indexPlanned value	**100%**	**100**	**100**	**100%**
Reality from real data	**○%**	**○**	○	**○**

Identifying issues

<Examples of actual data used in simulations to extract issues>
・Cargo information (weight, dimensions, packaging, etc.)
・Transport conditions (time of loading/unloading, temperature, mixed loading possible)
・Relay points (location, size)
・Vehicle capacity (loading weight, loading volume)
・Driver capacity (license, on-duty time, labor costs)
・Actual operation time (driving time, loading and unloading time, waiting time, etc.)

Theme(b)

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Ref: Development theme
2 Development of software for converting logistics information into digital

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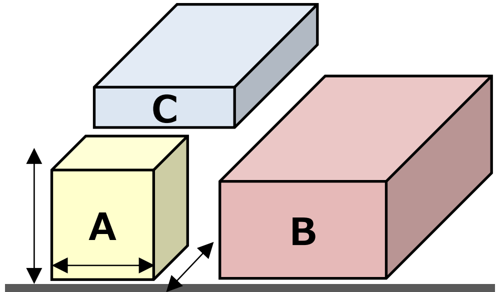
Overview :Development of software for converting logistics information into digital

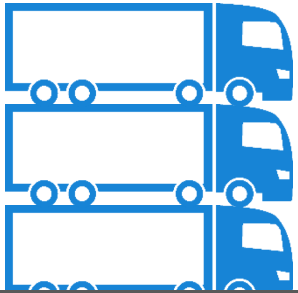
By expanding packaging information throughout the supply chain, collaboration with NeLOSS will improve truck loading rates and reduce the number of vehicles dispatched.

With packaging information



Case Packaging Master (Packaging design)

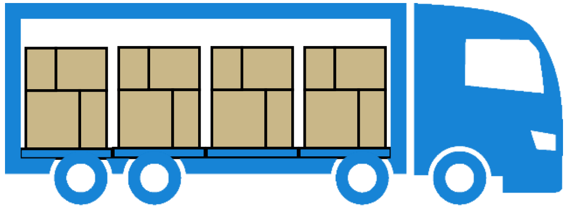
Shipping by case



Rough estimate the number of units required based on volume, weight, and capacity

Without packaging information

Ad-hoc palletizing (Mixed loads within a pallet by ad-hock)

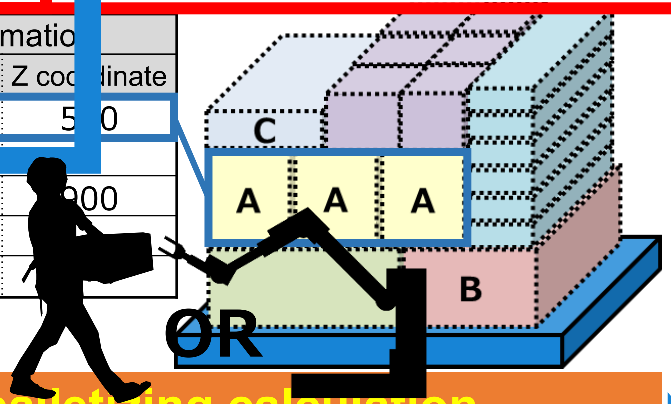


Shipping / Transportation

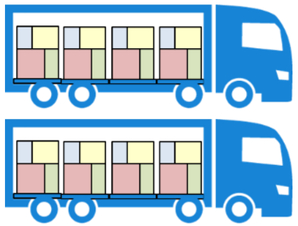
With packaging information

Image of packaging data

SKU	Q'ty	Palletizing Informatio				
		Layer	Order	X	Y	Z coordinate
A	9	2	3	0	0	5 0
[illegible]						
C	1	3	5	0	0	900
…	…	…	…	…	…	
…	…	…	…	…	…	

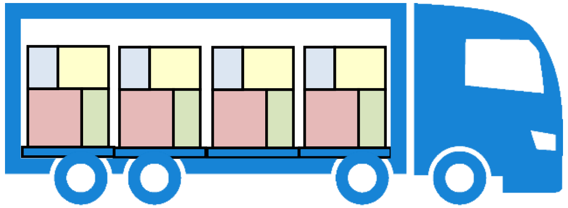


Automatic palletizing calculation
→ Work instructions or Robot instructions



NeLOSS Ver.1.0

Automatic calculation of optimal number of vehicles for goods allocation



Transporting goods while maintaining traceability of packaging information and loading position

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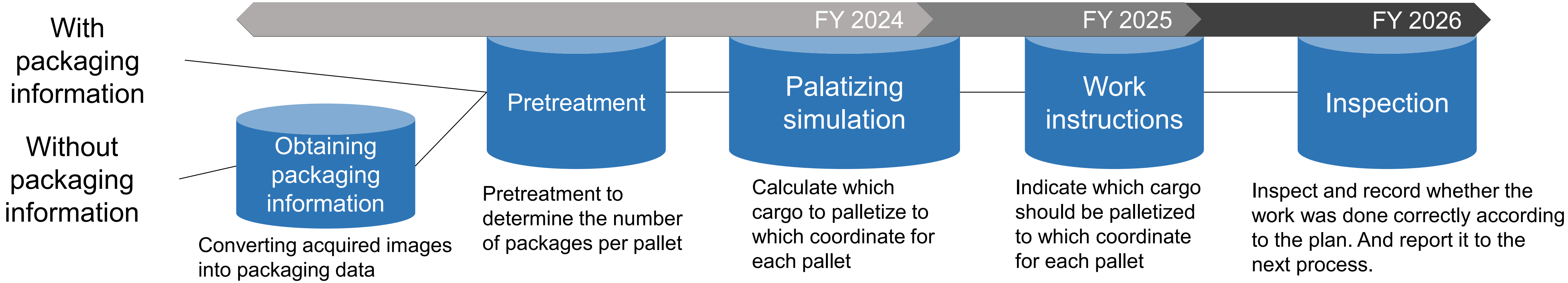
全体取り組み計画

FY2024 Goals

・On-site inspection of mixed palletizing,Identification of the characteristics and requirements of mixed palletizing.

・Conduct functional verification of the first development system using actual data at one or two demonstration sitesIdentify issues necessary for second development.

項目	2024		2025			
	3Q	4Q	1Q	2Q	3Q	4Q
Technical research						
Understanding the actual situation						
1st requirement definition						
1st development						
1st test						
1st demonstration						
Identifying issues and planning countermeasures						
2nd requirement definition						
2nd development						
2nd test						
2nd demonstration						



Technical/ Methodology	Image recognition	Visualization of know-how	Mathematical Optimization	UI/UX	Image recognition

Gradually expand the target industries and aim to mature the application into one with general-purpose capabilities

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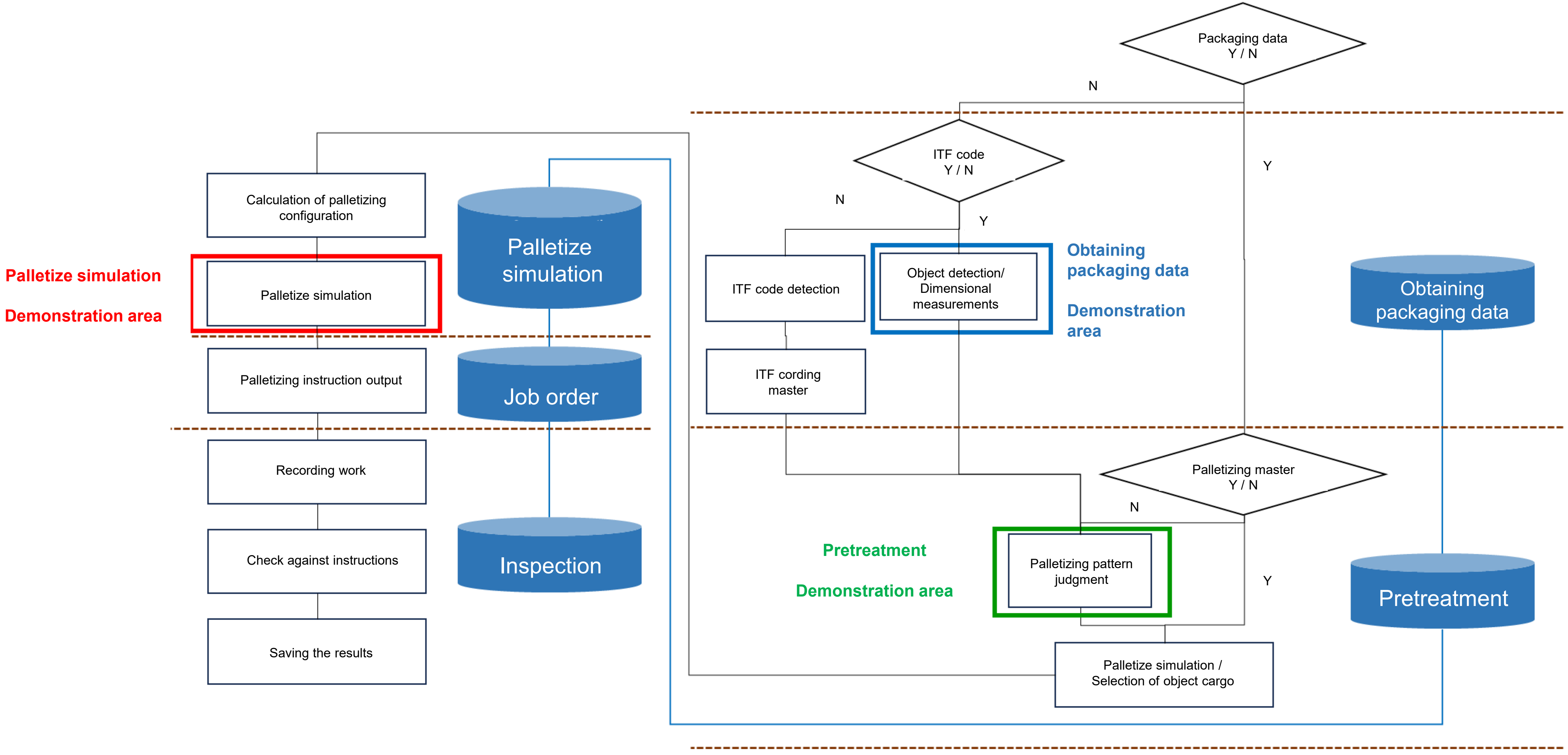
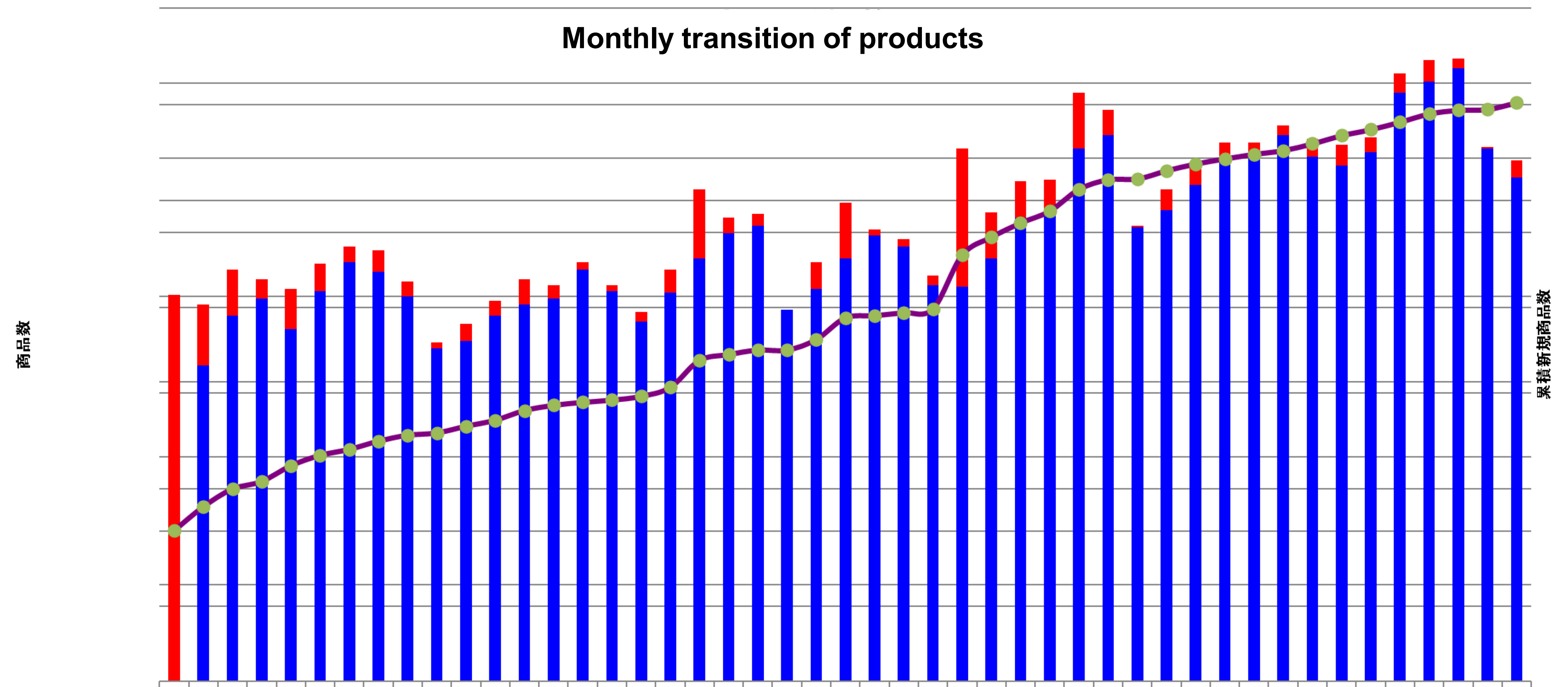
Palletizing Planning System Data Flow



This year, we will carry out a standalone functional demonstration of key elements on the flow.

Considerations from actual transportation data



年月	2021-04	2021-05	2021-06	2021-07	2021-08	2021-09	2021-10	2021-11	2021-12	2022-01	2022-02	2022-03	2022-04	2022-05	2022-06	2022-07	2022-08	2022-09	2022-10	2022-11	2022-12
New	201	32	24	10	21	14	8	11	8	3	9	8	13	7	4	3	5	12	36	8	6
Existing	0	164	190	199	183	203	218	213	200	173	177	190	196	199	214	203	187	202	220	233	237
Cumulative new	01	233	257	267	288	302	310	321	329	332	341	349	362	369	373	376	381	393	429	437	443

年月	2023-01	2023-02	2023-03	2023-04	2023-05	2023-06	2023-07	2023-08	2023-09	2023-10	2023-11	2023-12	2024-01	2024-02	2024-03	2024-04	2024-05	2024-06	2024-07	2024-08	2024-09	2024-10	2024-11	2024-12	2025-01	2025-02
New	0	14	29	3	4	5	72	24	19	16	29	13	1	11	9	7	6	5	9	11	8	10	11	5	1	9
Existing	193	204	220	232	226	206	205	220	241	245	277	284	236	245	258	273	274	284	273	268	275	306	312	319	277	262
Cumulative new	443	457	486	489	493	498	570	594	613	629	658	671	672	683	692	699	705	710	719	730	738	748	759	764	765	774

年月

既存商品数 新規商品数 累積新規商品数

Since there was no integration of packaging data, the number of types increased over time.
→ Even create a master, it is needed to maintain it frequently.
→It is necessary to supplement the packaging data by taking pictures of the goods when they are received.

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Implementation details of each function

NEXT LOGISTICS

Obtaining packaging data

Demonstaration contents : Photograph the actual pallet packaging and estimate the case packaging dimensions
Expected Effects : After identifying imaging issues in the actual process, the accuracy of dimensional estimation is analyzed and the causes of accuracy fluctuations are identified


Detects boxes from pallet packing

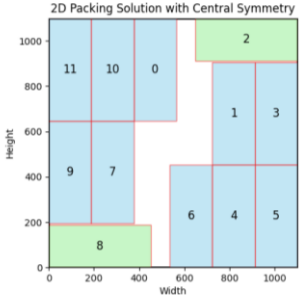

Identify the vertices of the box

Estimate case packing

Dimension estimation of cardboard boxes on a pallet is an unprecedented endeavor

Pretreatment

Demonstaration contents :Palletizing master is generated from case packing data
Expected Effects :Reanalyze the generated master and actual packaging, and extract correction issues



Generation Master

Palletize simulation

Demonstaration contents :Extract mixed palletizing data from actual data, and perform palletizing simulation
Expected Effects :Analyze the difference with the palletizing results, and extract correction issues

The aim is to achieve the current progress of each function and reap the benefits that will lead to the definition of development requirements for the next year.

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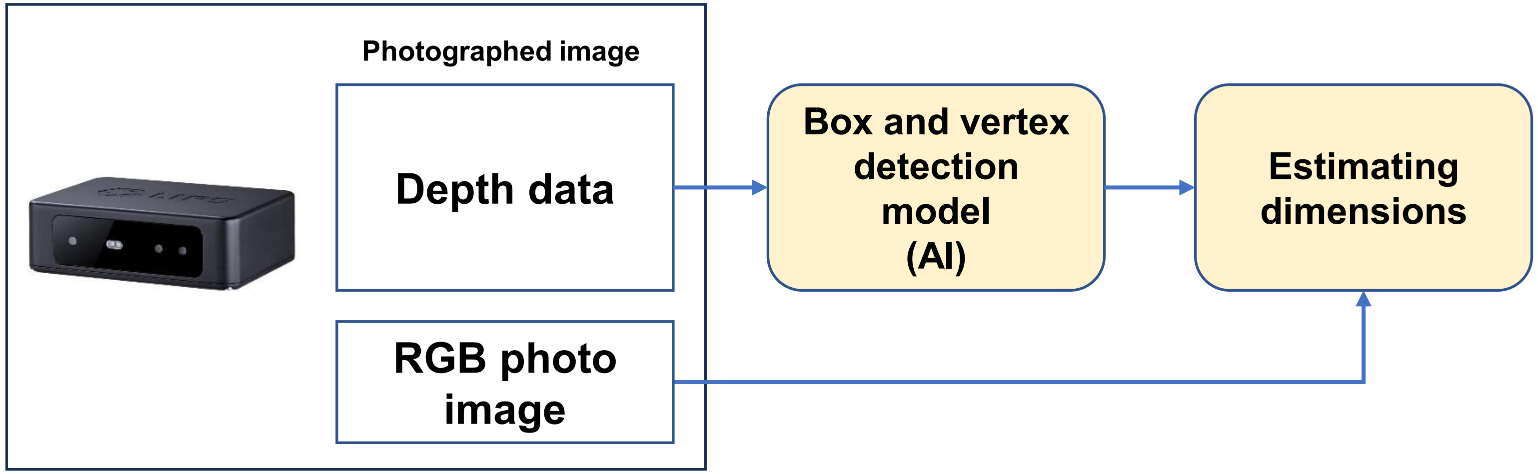
Contents of obtaining packaging data demonstration

Method of estimate case packing dimensions

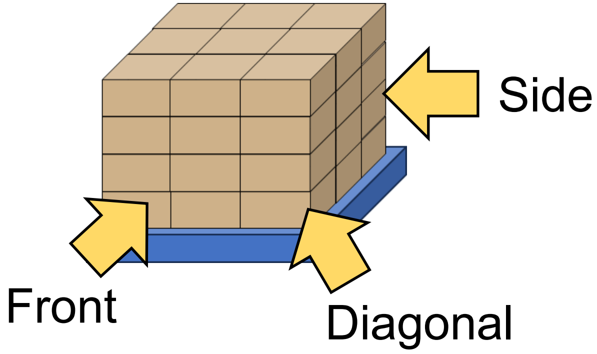
- A stereo-type depth camera is used to obtain two types of data (depth, RGB).
- By combining these, It is could be estimated the dimensions.



Demonstration details

- Estimate for the performed size by took photo image at intermediate warehouse for local delivery (Manufacture → Wholesaler, Store) of a food transport company.

- Images were taken from the front, side, and diagonal, and accuracy was compared according to the following classification:
  1_Front/Side
  2_Diagonal



1_Front/Side :Estimate boxes across an entire pallet using both sides
2_Diagonal :Estimate the entire pallet with one image

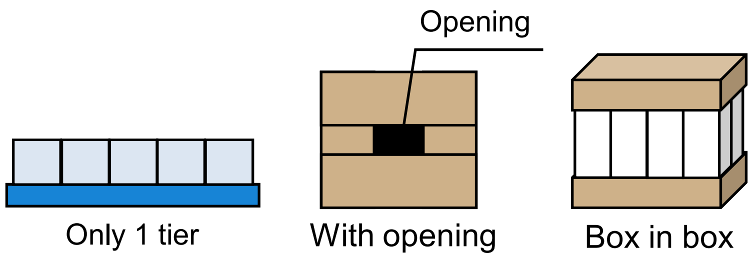
Demonstration results – Obtaining packaging data_1

Item	Angle	Box color	Stretch film	Special factor	Mixed loading	Accuracy: Box detection rate	Accuracy: Ave. error of estimated dimensions [mm]
Whole	Total					**60.8%**	**21.9**
	Excluding special factors					**81.6%**	**12.0**
	Total (Front/Side)					**73.3%**	**14.3**
	Total (Diagonal)					**42.6%**	**32.8**
breakdown	Front /Side	Brown	Yes	With opening		**82.5%**	**12.3**
		Brown	No	With opening		**100.0%**	**7.7**
		White	Yes			**100.0%**	**13.5**
		White	No		○	**86.8%**	**15.2**
		Brown	Yes		○	**38.5%**	**11.2**
		Brown	No	Only 1 tier/Box in Box		**56.3%**	**37.7**
		Other	No	Only 1 tier/Box in Box		**0.0%**	**-**
	Diagonal	Brown	Yes	With opening		**37.1%**	**32.4**
		Brown	No	With opening		**76.5%**	**30.3**
		White	Yes			**60.4%**	**33.8**
		White	No		○	**48.4%**	**42.4**
		Brown	Yes		○	**16.7%**	**22.0**
		Brown	No	Only 1 tier/Box in Box		**37.5%**	**35.7**
		Other	No	Only 1 tier/Box in Box		**0.0%**	**-**

Box detection rate
= Number of boxes detected /
Total number of boxes on a pallet

Size error average
= Average absolute value of LWH estimation error among detected boxes

Causes of accuracy degradation
- With stretch film
- Types of boxes outside the learning pattern
(Special loading patterns included)



Accuracy Comparison : Front/SIde > Diagonal
Results excluding special factors : Box detection rate → 81.6% / Estimated Dimension Error → 12.0mm

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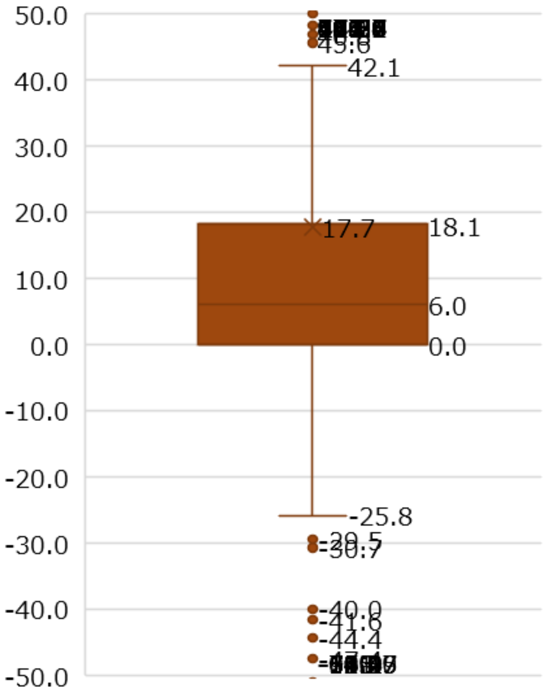
Demonstration results – Obtaining packaging data_2

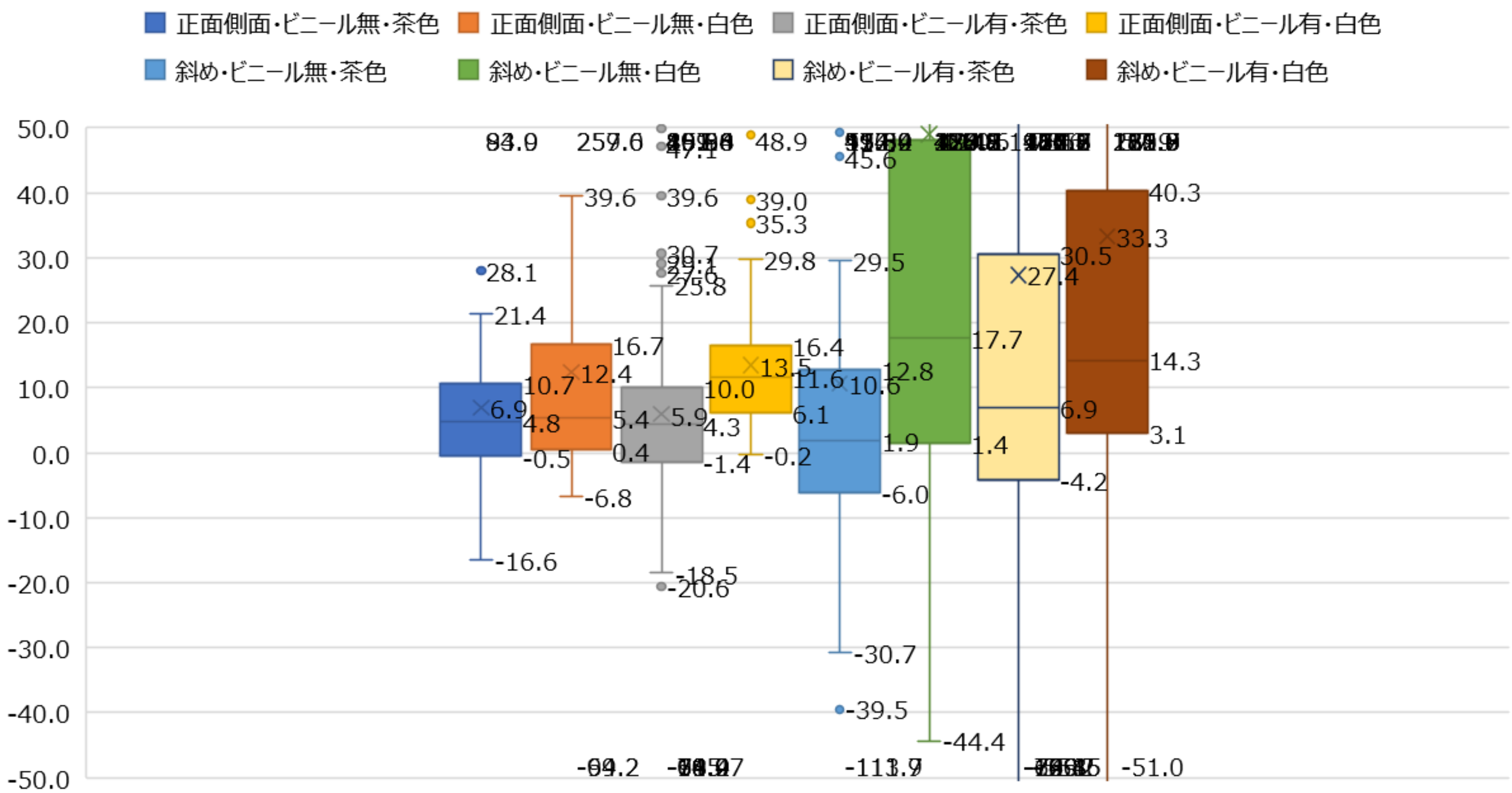
Visualize estimated dimensional errors (simple errors, not absolute values) by shooting angle, presence or absence of vinyl, and box color

Size Estimation Error Distribution (whole)



TTL number of boxes :313
TTL number of sides:788

Size Estimation Error Distribution (breakdown)



Overall, there is a large variation in error for upward deviation errors and oblique shooting.

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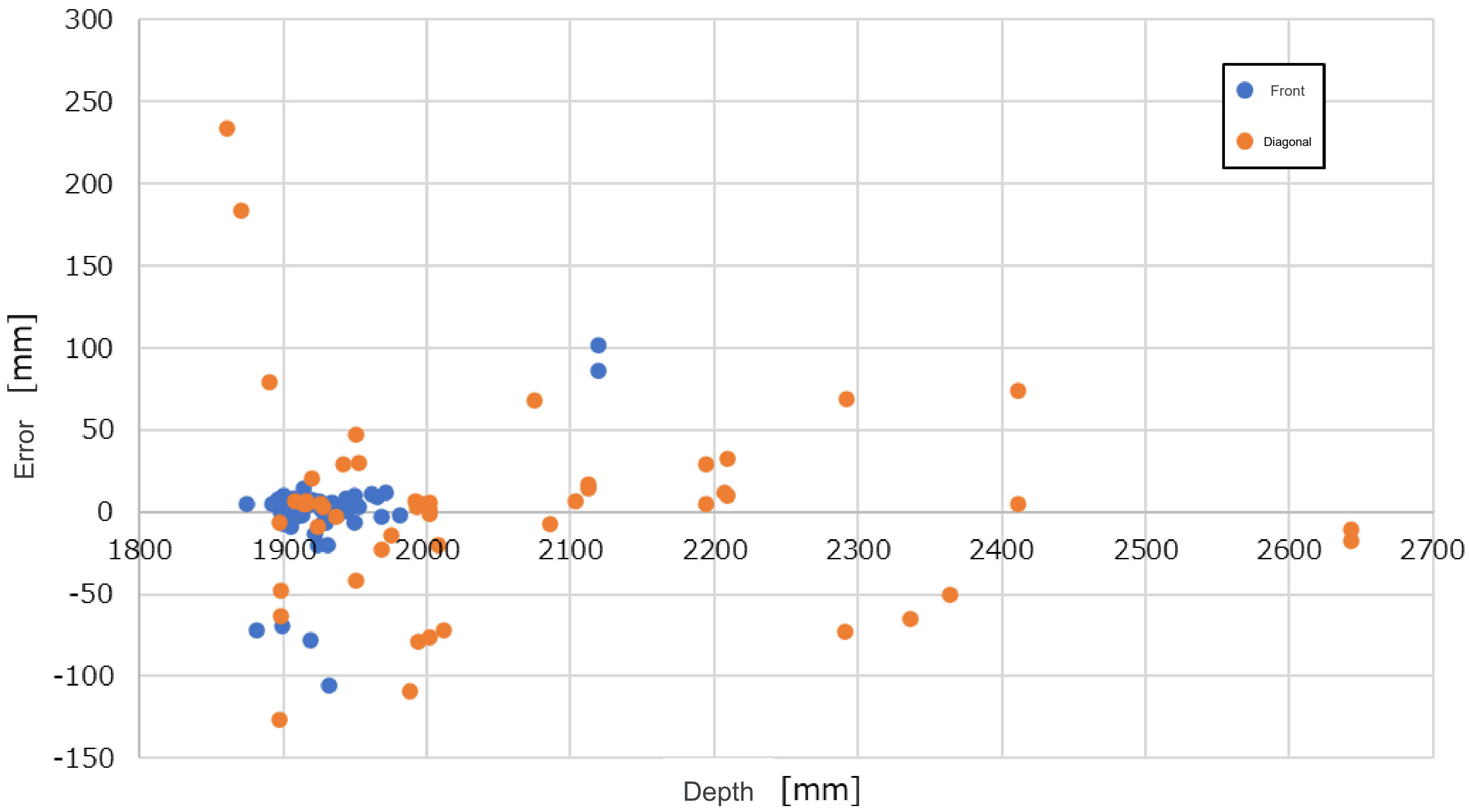
Demonstration results – Obtaining packaging data_3

Correlation between size estimation error and dimensions for the same package



No correlation was found between estimated dimensions and errors.

Demonstration results – Obtaining packaging data_4

The effect of errors on multiple factors such as box color and plastic packaging is summarized below.

Item	Factor					Special factors	
	Box color	Stretch film	Box exterior	Shooting angle	Focal length	Only 1 tier	Box in box
Box detection	- No significant impact	**Small impact** There is an impact if reflection or visibility is reduced.	**Large impact** The accuracy of edge detection decreases for untrained boxes (openings, etc.).	**Large impact** -Accuracy decreases when shooting obliquely -Case that is outside the viewing angle can also cause false detections.	- No significant effect within 1.5 to 3m	**Large impact** The detection accuracy of the box at the back is decreased	**Large impact** Undetectable In currently
Size Measurement	- No significant impact	**Small impact** There is an impact if reflection or visibility is reduced	**Large impact** The accuracy of edge detection decreases for untrained boxes (openings, etc.).	**Large impact** -Accuracy decreases when shooting obliquely -Case that is outside the viewing angle can also cause false detections	- No significant effect within 1.5 to 3m	**Large impact** Edge detection accuracy is decreased	Unverified as box not found

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Demonstration results – Pretreatment

NEXT LOGISTICS

Demonstration contents

- Extract packaging data from the palletizing masters of six manufacturers, mainly of food and miscellaneous goods, and apply it to the developed palletizing pattern judgment logic to generate a palletizing master.
- Verify that the quantity per layer matches the actual master data

Demonstration results

- Q’ty match rate : Less 10%

Extracted task

- Special patterns must be supported (split, double pinhole, etc.)
- Introducing a pattern approach based on the characteristics of cargo

Lightweight : The main aim is to use up the volume, so a pattern that allows for overhang from the pallet is adopted.

Heavyweight : Since it is not possible to use up the capacity of the truck cargo space, a pattern that will result in the highest quality of transportation will be adopted, rather than the most efficient quantity.
(Deliberately reduced the quantity per layer and selected a stable pattern.)

Different manufacturers have each ideas about palletizing, so it is necessary to organize them.

Demonstration results – Palletize simulation_1

Demonstration contents

- Extract detailed transport data on actual transport where mixed loading occurred within a pallet, and conduct a simulation.
- Comparison of volumetric efficiency and separation number of the same product for each palletizing method between simulation and actual results

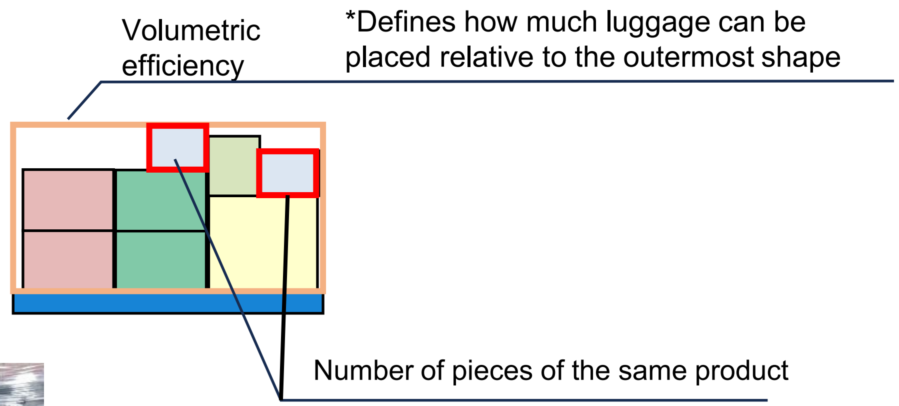
Volumetric efficiency :Defines how many packages are placed within the volume defined by the top of the pallet and the pallet outline.

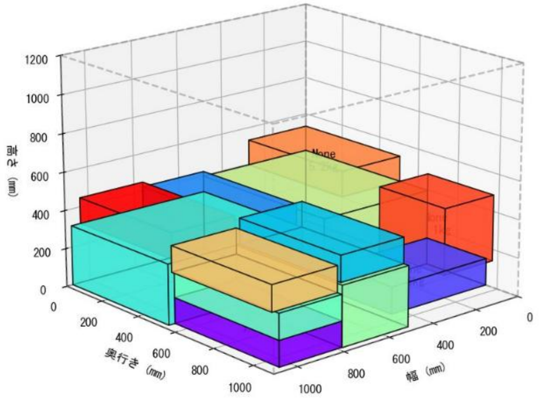
Number of pieces of the same product :Defines how closely packed the parcels are when there are multiple identical items

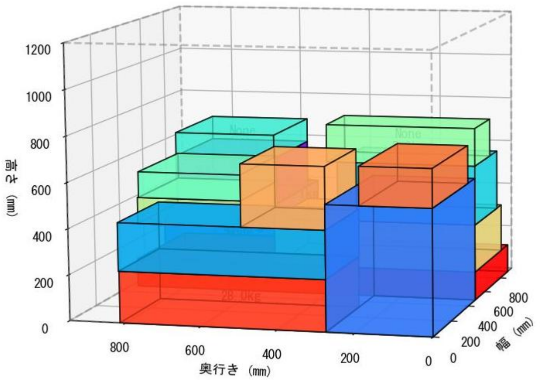
Demonstration results

*par pallet

	Volumetric efficiency	Number of pieces of the same product
3D simulation	49.8%	2.0
Achievments	57.8%	0.0







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Empirical results – Palletize simulation_2

Extracted task

1. Efficiency

The need to use the top surfaces of multiple boxes arranged at the same height as one surface for calculations

2. Operational feasibility

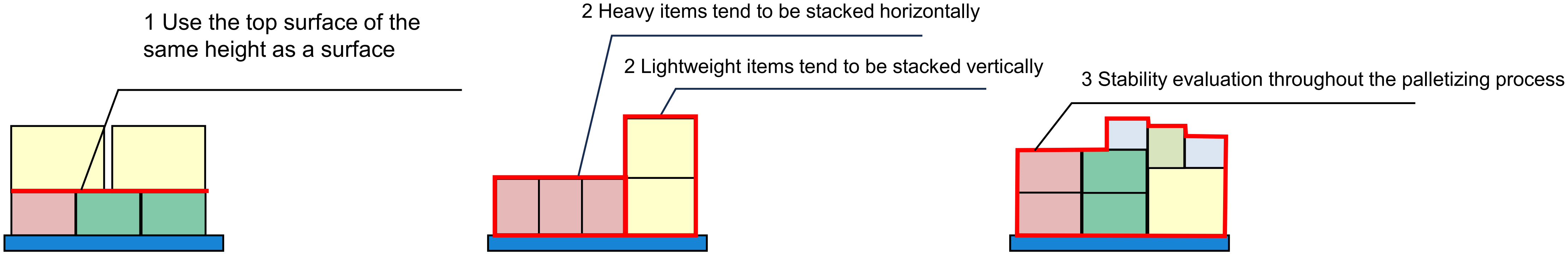
The need to consider groups of the same products in simulations

→It is necessary to take into consideration that there are trends in how products are packaged depending on their characteristics.

3. Transportation quality

Although it is possible to consider stability for individual stacks, a logic for evaluating stability for the entire palletizing process is required.

→ It is necessary to evaluate the stability taking into consideration the final wrapping in stretch film.



The following issues need to be addressed:
1.Establishment of palletizing evaluation index 2.Development of calculation methods for converging evaluation indices

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Summary of functional issues in each demonstration

NEXT LOGISTICS

Obtaining packaging data

-Technical issue : Although it is possible to estimate dimensions from pallet images, it is necessary to increase the number of actual packaging data to improve accuracy.
-Operational issue : It is necessary to consider how to match with product master data and how to capture images during the actual process.

Pretreatment

-Technical issue :Need to improve accuracy in palletizing pattern judgment
-Operational issue : Since each manufacturer has a different approach to palletizing, it is necessary to develop a user interface that allows users to select and execute the prerequisites for calculation.

Palletize simulation

-Technical issue :The following initiatives are necessary to achieve a balanced result of efficiency, operational feasibility, and transport quality
1) Establishment of palletizing evaluation index
2) Development of calculation methods for converging evaluation indices
-Operational issue :Developing a user interface to translate simulation results into work instructions

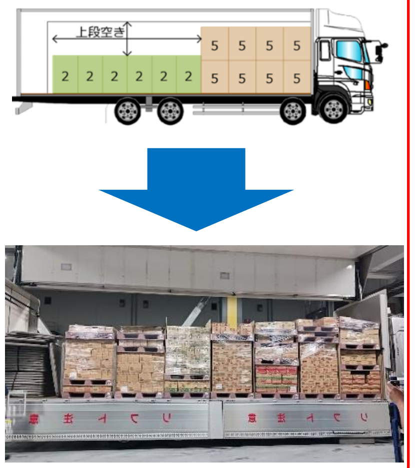
Palletizing planning system operation image

Ideal image → Data flows seamlessly throughout the facility, and operations are completely no human resources

Transportation plan

Loading

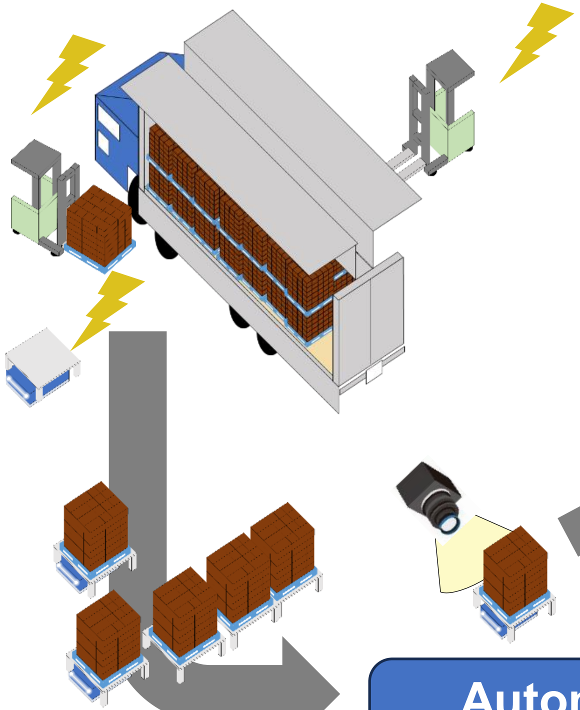
Loading plan fig.
NeLOSS



Warehouse work

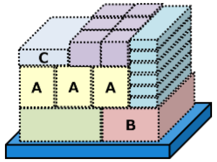
Unloading | **Inspection** | **Palletize** | **Loading**

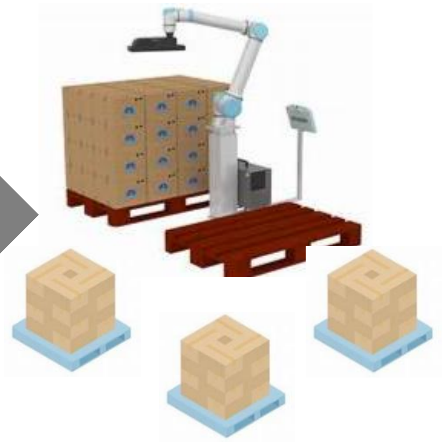
Automated cargo handling by
AGF(Automated Guided Forklift), AMR（Autonomous Mobile Robot）



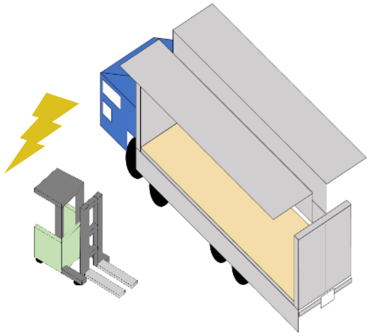
Automatic inspection

Palletize plan





Automated palatize



Loading plan fig.
NeLOSS