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Quantity Matters: Packaging and Pallet Design for Core Relief Items Used for Humanitarian Aid Operations
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Quantity Matters: Packaging and Pallet Design for Core Relief Items Used for Humanitarian Aid Operations

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Summary: This thesis identifies and analyzes opportunities to optimize package density and cube utilization through improved package and pallet design for seven core relief items used by the United Nations High Commission for Refugees throughout the world.



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KEY INSIGHTS

1. The recommended set of potential packaging and pallet (P&P) design improvements, if implemented, could yield annual savings of ~\$5 million in international transport costs.
2. A fully developed P&P Design Evaluation process will uncover necessary changes in the UNHCR CRI end-to-end supply chain
3. Package density and cube utilization are vital measures to continuously monitor for each CRI in order to achieve optimal unit and transportation loads.

Introduction

Space efficiency has multiple benefits for humanitarian operations. First, it allows a greater quantity of product to be shipped per sea container, truckload, or aircraft, significantly reducing transport cost. Second, when pallets or boxes are packed tightly, goods do not move around and stacks don't fall over as much during transport, reducing damage and thus improving quality of goods. Last, loading and unloading times are decreased, enabling faster receipt and dispatch. Quantity, product quality and protection, and speed are some of the most important factors to consider within humanitarian logistics operations.

Fitting more items into the package or making the package smaller increases the packaging density (PD) – the number of packaged items per cubic meter (cbm). Fitting more packaged items onto pallets and/or more pallets into containers increases container cube utilization (CU). Together they improve use of space during transport.

This thesis identifies and analyzes opportunities to optimize PD and CU through improved package and pallet design for seven core relief items (CRIs) used by the United Nations High Commission for Refugees (UNHCR). These items – tents, high and medium thermal blankets, plastic sheets, plastic rolls, jerry cans, kitchen sets, and so on, comprise the basic relief package for refugees across the globe.

UNHCR's Supply and Logistics Services (SMLS), Procurement and Contracting Services, suppliers, logistics providers, and global warehouses were closely involved in this research. The Quality Assurance and Product Development (QA&PD) unit within SMLS was the direct contact. Created in 2010, the QA&PD unit is responsible for quality and specifications for CRIs, maintains the UNHCR CRI Catalogue, and represents UNHCR in inter-agency (IFRC, ICRC, UNICEF, MSF and IOM) QMS dialogue. The key question driving this research is:

How should CRIs be packed, palletized and loaded into containers in order to effectively protect the goods, maximize unit load and transportation cube capacity, improve receipt and dispatch speed, and reduce international transport cost?

This thesis uses simulation to identify “most attractive” design concepts to pursue and evaluate the potential impact of design improvements. The types of simulation done are:

- Supplier simulation of alternative package and pallet design concepts that tests designs by physically assembling CRIs on the proposed pallet and loose package designs then loading both into a forty-foot container.
- Software simulation, which is used often by consumer goods companies, to identify pallet sizes and loading configurations that work well across a

range of the most common real world vessel, truck and plane unit load dimensions.

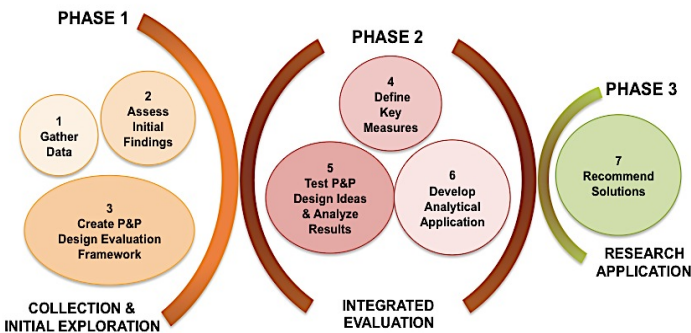
- A “what-if” analysis of transport cost by mode that compares the actual cost of transport in 2013 to transport cost that could potentially have been realized if package and pallet redesigns had been in place for the seven CRIs.

The thesis concludes with a set of recommendations regarding how UNHCR can take this work forward.

Methodology

Driven by the key research question, an academic but also pragmatic research application approach was established to guide implementation of this study. The methodology is segmented in three strategic phases: Collection and Initial Exploration, Integrated Evaluation, and Research Application, as seen in the diagram below.

Strategic Methodology Diagram



Findings

The culmination of data collection and interviews of t led to the findings listed in in the table below, which informed the research focus on quantity, speed, and quality.

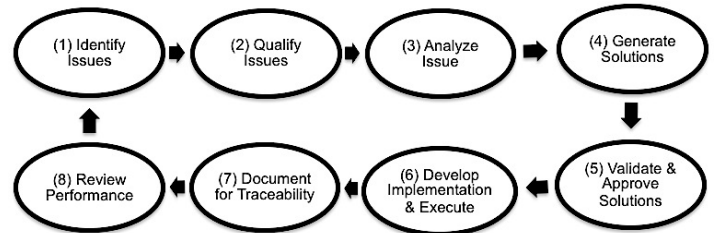
Initial Findings Table from Data Collection

Finding	Description	Supporting Evidence	Focus
#1 P&P Damages	Several accounts of CRI shipments with inadequate cargo security each and often causing product damage.	~5% of in-transit current EUR1 pallet movement inside container. Photo documentation.	Quality, Quantity
#2 Cube Efficiency	CRIs arriving in containers inbound at GSMs show significant amount of unused space	Initial QA&PD tested the cube utilization of current EUR1 pallet, using internal software and showed at least 17% of unused FEU space. Photo documentation.	Quantity
#3 Loading Rates & Safety	Some CRI packaging is not optimally designed for fast receipt and dispatch. At times, the packaging compromises safety of staff during stacking process	10% of loose bales of blankets in straight stacks collapse, requiring additional staff time	Speed
#4 SM and P&P Process	Underdeveloped operating P&P process and procedures limits optimal use of resources, strategic partnerships, and tools Applying heuristic approach of gathering input from select suppliers to possibly drive product requirements	Limited to no process documentation. P&P Evaluation Workshop noted observations. UNOIOS Audit Report 2013 Action Item 5 & 6 [26].	Quality
#5 IT Integration	Quantities actually received at GSM, i.e. DWH receipts are not always accurately reflected in MSRP; Can be misleading on quality delivery performance metrics	System report data provided inconsistent with Goods Received Note documents	Quality

P&P Design Evaluation Process

The findings and examination of QA&PD’s current P&P design evaluation process inspired the development of a P&P design evaluation framework, that will further progress UNHCR’s current SC Monitor and Control process. This research recommends that UNHCR adopt the more detailed process in order to achieve optimal quality assurance, clear coordination, effective planning, focused management, and exposure of opportunities for future improvements, as seen below.

Recommended UNHCR Packaging Evaluation Process



CRI Flows

This study quantified CRI flows and international transport costs between key supply chain nodes: supplier (S), country/field warehouses (F), and the seven Global Stock Management stockpiles (GSM) (G). Goods are shipped by three modes – air, sea and land, and may be loose, palletized or in cages.

UNHCR CRI Summary of Category Flows

Category	Modes of Transport (X)			CRI Shipment Type (Y)		Flows Per Category
	Air Pallet	Sea Container	Land Truck	Pallets ¹¹	Loose	
S – F		X _S	X _T		Y _L	3
S – G		X _S	X _T	Y _P	Y _L	4
G – FE	X _A		X _T	Y _P	Y _L	4
G – FS		X _S	X _T	Y _P	Y _L	4
15 Total Category Flows						

Shipped via X_A = Air, X_S = Sea Containers, and/or X_T = Trucks
Shipped on Y_P = Pallets and/or Y_L = Loose

The table above is a summary of four flows:

- S – F is the flow from supplier to country/field warehouse
- S – G is the flow from supplier to GSM
- G – FE is the flow from GSM to country/field warehouses, as an emergency shipment.
- G - FS is the flow from GSM to country/field warehouses

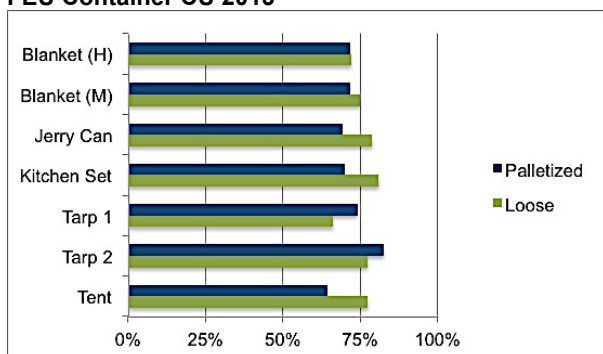
Key Measures

Four measures were developed to quantify the magnitude of opportunities for improvement and of actual realized improvement for each CRI and for the seven CRIs in total:

1) **Transport quantities** in number of containers, shown in the next column, directly shipped to the field, as well as quantities shipped through the seven GSM warehouses. Additionally, the number of units that can fit in each mode of transport.

2) **Transport Container CU**, in the figure below, details the FCL FEU CU for each CRI for loose and palletized configurations.

FEU Container CU 2013



3) **Per unit international transport cost** divided by landed cost at port of entry.

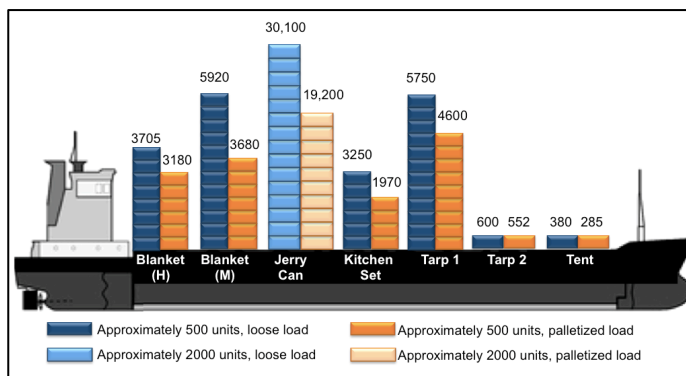
4) **Transport cost by mode** of items shipped directly to the field, as well as transport costs of items shipped through the seven GSM warehouses. Costs of freight shipped from GSM warehouses outbound to the field are broken down by mode (sea, air, road). Air cargo shipments make up the largest portion of total transport cost.

The measures are focused on transport because transportation is one of three logistical drivers that determine the performance of any supply chain [1] as it is the platform for moving products around the world. In the humanitarian setting, most locations are remote and difficult to access, which pose logistical challenges and contribute to high cost of transport.

Results of Experiments

Exp	Results	Key Consideration Points
A-1	Custom pallets yield higher quantities for each CRI, an average increase of 25% in total qty units, in FCL FEU	<ul style="list-style-type: none"> This experiment was physically tested at the suppliers' sites for containers Cost for main suppliers indicate there will be no cost change to custom style Supplier impact assessment needed to understand if there are sourcing limitations
A-2	Standard EUR2 pallet shows greater increase than CUS3 pallet for Blanket (M) for all modes of transport air, land, sea.	<ul style="list-style-type: none"> Software tested experiment for all modes of transport most commonly used for UNHCR, for only one the medium thermal blanket Default container dimensions slightly vary from cube dimensions in A-1 CUS3 dimensions used for A-2 differs from CUS1 and CUS2 used in A-1
B-1	Plastic Sheet Tarps packaged in a box increases 21% in total qty in a FEU HC than bale package	<ul style="list-style-type: none"> Parameters for carton box came from UNHCR Plastic Sheet Tarp supplier. Software tested experiment for all modes of transport Environmental impact analysis of carton boxes versus bale not performed
B-2	Blanket (M) packaged in a box increases 27% in total qty in a FEU HC container than bale pkg	<ul style="list-style-type: none"> Box measurements from similar blanket supplier outside of humanitarian aid Software tested experiment for all modes of transport Blanket (M) is the highest shipped CRI in 2013, over 4 million units inbound

Total CRI Unit Quantity Per FEU FCL



Experiments

To find the P&P design that will yield the highest CRI load quantity and transport cube efficiency as well as improve speed of dispatch for loose CRIs, and improve safety of staff handling the P&P; two design experiments were developed and conducted concurrently as part of this research, as follows:

Experiment A – Focused on pallet design by testing the current ISO standard (EUR1: 1.2 x .8 x .144 m) pallet design against customized (CUS1: 1.1 x .75 x .115 m, CUS2: 1.2 x .8 x .115 m, CUS3: 1.12 x .79 x .107 m) and alternative ISO standard (EUR2: 1.2 x 1 x 1.45 m) pallets.

Experiment B – Challenged package design by selecting two specific CRIs, the medium thermal blanket and plastic sheets 4 x 5 m, and understanding the financial, environmental, quality, and efficiency implications of changing the current bale to carton packaging of those two identified CRIs.

The table below provides a quick summary of the key results and points of considerations of all the performed experiments.

Reducing Transport Costs

By improving P&P design, UNHCR has the potential to realize dramatic savings in transport costs, while improving product quality and enhancing the speed of dispatch. Two potential improvement models were developed an applied to reach the estimated savings in transport costs for 2013. First, a Utilization Potential Improvements table shows the current PD

and FEU CU for the CRIs, and contrasts these with estimated potential results if P&P were redesigned. PD is measured by the total number of units in the package divided by the volume (cbm) of that package. CU figures were calculated by dividing the approximate volume filled with product to be transported by the total available volume of the FEU. Current utilization was calculated based on current loads provided by UNHCR and UNHCR suppliers. Two tables were created to compare the improvements under two Improvement Potential What-If Scenarios:

- Scenario A: Updated packaging dimensions reflected in the upcoming publication of the 2014 CRI Catalog.
- Scenario B: Carton boxes tested in Experiment B with packaging dimensions from the 2014 CRI Catalog upcoming release.

Improvement Potential for Scenarios A and B

CRIS	Scenario A: 2014 CRI Catalog Updates			Scenario B: Bale to Box Exp + 2014 CRI Catalogue Updates		
	% PD	CU (includes %PD)		% PD	CU (includes %PD)	
		% Loose	% Pallet		% Loose	% Pallet
Blanket (H)	23	29	12	14	19	12
Blanket (M)	23	29	37	28	34	43
Jerry Can	18	24	25	18	24	30
Kitchen Set	41	48	57	41	48	57
Plastic Sheet	7	12	20	10	15	23
Plastic Roll	88	97	92	60	68	63
Tent	0	5	10	0	5	15
Total		26.6	31.3		25.1	33.9

Based on the packaging changes, the percentage improvement potential for scenarios A and B are as shown in the table above. Both scenarios show improvement of greater than 25% for loose loads and greater than 30% for palletized loads.

Second, with all the data gathered and improvement potential percentages calculated, the estimated savings assessing two “what-if” outcomes were calculated. The improvement percentages are applied to each mode of transport, as an estimated assumption.

The final analysis and calculations show that the total project transportation savings are quite similar at \$4.83M and \$4.95M between the Improvement Potential What-If Scenarios A and B, respectively. It can be observed that the improvements to pallets drive a significant portion of savings for both scenarios.

These estimated calculations for transportation cost savings potential is the minimum amount as the analysis presented limitations such as obtaining air cargo details. An advantage worth addressing is that any change in CRI P&P design, will also be considered at other humanitarian aid organizations.

Therefore, the savings will yield more money to dedicate to aid relief for beneficiaries.

Near-Term Managerial Recommendations

The recommendations in the near term are:

- 1) *Pallet Design*. Allow custom (size) pallets for selected suppliers that have large quantity CRI orders. The rest of the suppliers should send by EUR2 pallets and use better lashing or other tools to secure cargo inside the container.
- 2) *P&P Design Evaluation Process*. Implement developed process. Utilize P&P Evaluation Framework and P&P Design Change Evaluation Index tool for future P&P improvement efforts.
- 3) *KPIs*. Build upon the key measures by capturing more relevant performance metrics such as environmental impact.
- 4) *UNHCR P&P Guidelines*. Further develop guidelines manual (provided to UNHCR), and reinforce shipping policies to manage quality of inbound products and support operational efficiencies throughout the supply chain network.

Long-Term Managerial Recommendations

The recommendations in the long-term are:

- 1) *Pallet Design*. With the Humanitarian Quality Assurance Working Group, UNHCR has the opportunity to spearhead the effort of defining the standard pallet for CRIs that all suppliers must follow. This group should work together to develop a collective standard to contribute to logistics efficiencies improvements and generate cost reductions, especially within transportation, that will ultimately help beneficiaries.
- 2) *Package Design*. Investigate the business case and environmental impact of switching from bale to box packaging for the blankets and plastic sheets.
- 3) *Investment in P&P Design Process Infrastructure*. The current process of setting CRI P&P requirements through collaborating with select suppliers builds positive relationships and trust among these suppliers. However, with investment in improving SCML efficiency, quality assurance processes, and IT P&P software application such as TOPS Pro provides UNHCR the opportunity to understand what is needed from suppliers and ultimately drive their own requirements.

Primary References

[1] Chopra, S., & Meindl, P. (2010). *Supply Chain Management* (4th ed.). Prentice Hall.
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 [3] Ulrich, K. T., & Eppinger, S. (2008). *Mechanical Engineering: Product Design and Development* (Fourth ed.). USA: McGraw-Hill Primis.