DEPARTMENT OF INDUSTRIAL & SYSTEMS ENGINEERING | SYSTEMS DESIGN PROJECT 2015/16

FINISHED GOODS LOT SIZE OPTIMIZATION

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INTRODUCTION

AMS, the manufacturing arm of a nutrition company, produces milk formulas to meet demand worldwide.

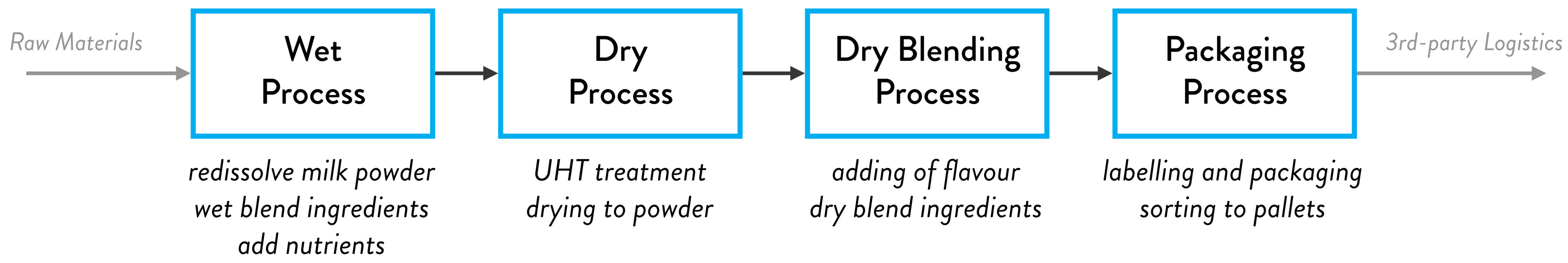
6 product families, targeting different markets

Babies, Toddlers, **Mothers**, Adults, **Children**

≈250 SKUs

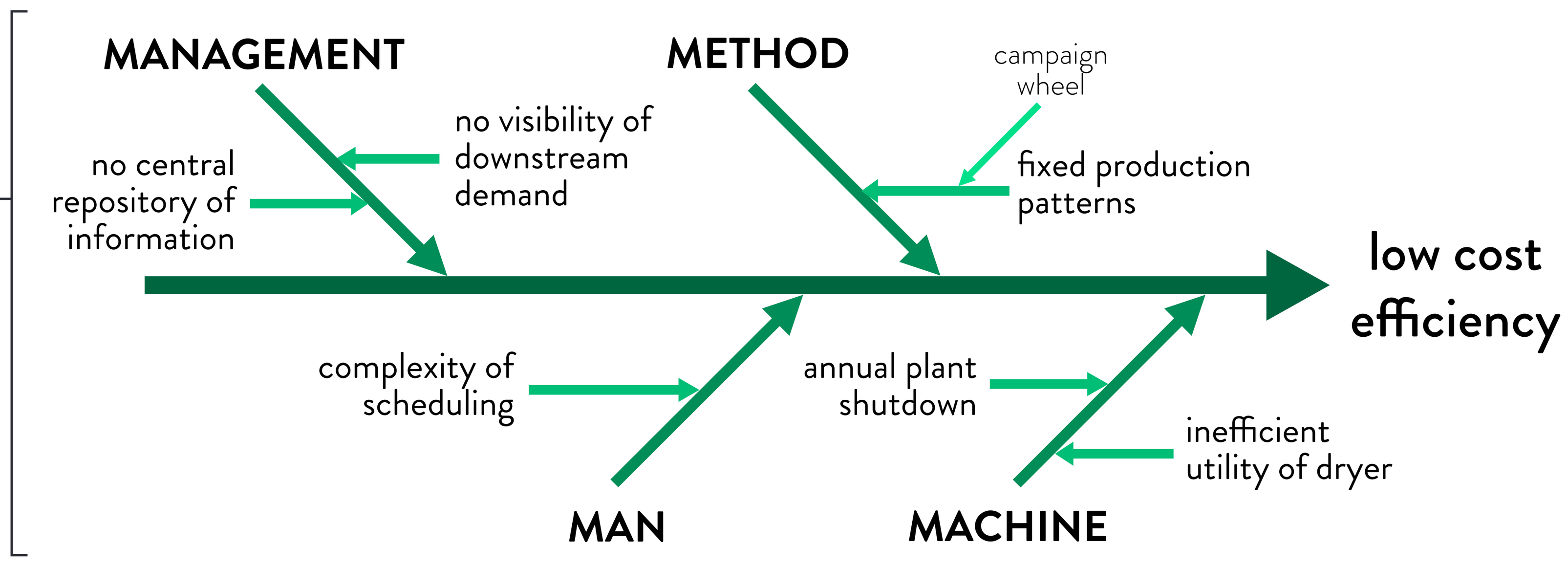
specific to: *country*, *milk formulation*, *packaging*

PROCESS FLOW



PROBLEM DESCRIPTION

AMS recognizes that the **current state** of its production processes could be further improved, which would lead to reduced cost.



OBJECTIVE

To improve AMS' production cost efficiency by:

1. Analyzing current production schedules and related data
2. Developing and solving a linear model to identify optimum lot size and production schedules that will minimize changeover and inventory costs
3. Identifying further recommendations for future use that would facilitate further improvements in cost efficiency

DATA FILTERING

In preparation for the use of actual data on the model, production and shipping data from AMS' SAP system is filtered to provide the **Master Production Schedule (MPS)** and the **Master Arrival Schedule (MAS)** respectively. The procedure below adheres to the assumptions used in the model.

SAP Material	SKU	Batch	Mat. Doc.	Material Description	Pstng Date	Quantity	Factor	Quantity (LBS)
10057972	100M713230140	1006776	4910074073	[illegible] VAN 400G CAN PHL	11/03/2015	-15,552.000	0.882	-13714.51641
10057972	100M713230140	1006776	4909866845	[illegible] VAN 400G CAN PHL	10/19/2015	-5,184.000	0.882	-4571.505469
10057972	100M713230140	1006776	4909262591	[illegible] VAN 400G CAN PHL	08/18/2015	-11,928.000	0.882	-10518.69545
10057972	100M713230140	1006076	4909262591	[illegible] VAN 400G CAN PHL	08/18/2015	-15,720.000	0.882	-13862.66705

Sample shipping data from SAP. Columns in green are manually-added calculations. Sample production data is in a similar format.

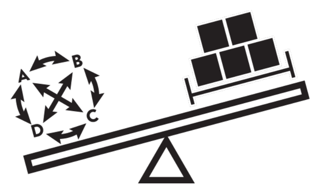
PROCEDURE

1. Remove unmatched batch numbers in shipping and production input to clean up incomplete information.
2. Map material number (identifier in SAP) to SKU.
3. Consolidate shipping and production data by month of posting date.
4. Calculate total quantity produced/shipped per SKU (in lbs.) using the quantity (in eaches) and conversion factor.
5. Summarize for every month to get MAS and MPS tables from SAP shipping and production data respectively.

	1	2	3	4	5	6	7	8	9	10	11	12
100M713230140					24381.36			24381.36		4571.51	13714.52	
100M713230160		73186.42	99557.23	100742.44	52149.03	104298.05	26074.51	104298.05	26074.51	26074.51	52149.03	88890.38
100M713230185					5419.40	32156.63	32156.63		32156.63		39464.95	
100M713233104				1825.43	608.48	608.48	588.19			3468.31		
100M713233140		19979.17			7619.18		21016.23	16762.19	4169.38	11090.13		49566.97
100M713233171			48237.85	93186.75	64682.57	46045.22	96475.70	123100.48	117579.76	58300.45	217912.13	35082.07

Sample MPS, generated from SAP data. Sample MAS is in a similar format.

MODEL



With sufficient understanding of the production process, a mathematical model is then designed to identify the optimal production schedule and lot sizes, with the objective of the model set to **minimize changeover and inventory costs**.

OBJECTIVE FUNCTION

$$\min\left(\sum_k c\sum_{t=1}^{t_{\max}} x_{k,t} + \sum_f (d_f - c)\sum_{t=1}^{t_{\max}} z_{f,t}\right) + \sum_k h\left(\sum_{t=1}^{t_{\max}} I_{k,t} + \sum_{t=1}^{t_{\max}} q_{k,t}\right)$$

INTRA-FAMILY CHANGEOVERS; INTER-FAMILY CHANGEOVERS — CHANGEOVER COST

INVENTORY > 1ST MONTH; 1ST MONTH INVENTORY — INVENTORY COST

CONSTRAINTS

1. Shelf life

$$\sum_{i=0}^{t_s} q_{k,t-i} \ge D_{k,t}$$

2. Inventory balance

$$I_{k,t} = I_{k,t-1} + q_{k,t} - D_{k,t}$$

3. Production capacity

$$\sum_k \sum_l \left(q_{k,t}\cdot L_{k,l}\cdot N_{l,n}\right) \le Q_{n,t}$$

4. Dryer lower limit

$$M\left(1-y_{l,t}\right) + \sum_k \left(L_{k,l}\cdot q_{k,t}\right) \ge MOQ_l$$

5. Linking q with x

$$q_{k,t} \le M\cdot x_{k,t}$$

6. Linking x with F and z

$$z_{f,t} \le \sum_k \left(F_{k,f}\cdot x_{k,t}\right)$$

$$M\cdot z_{f,t} \ge \sum_k \left(F_{k,f}\cdot x_{k,t}\right)$$

7. Linking x with L and y

$$y_{l,t} \le \sum_k \left(L_{k,l}\cdot x_{k,t}\right)$$

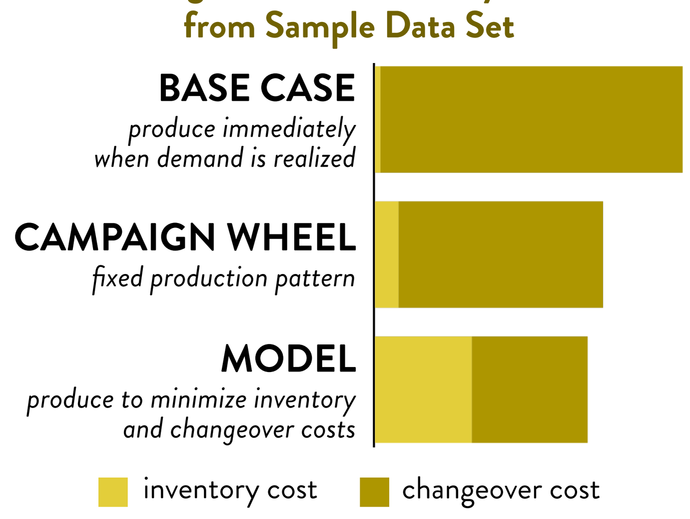
$$M\cdot y_{l,t} \ge \sum_k \left(L_{k,l}\cdot x_{k,t}\right)$$

VERIFICATION

Using a smaller set of data comprising 42 SKUs from 4 different product families, the result shows a trend of reasonable improvement.

Inventory cost is expected to be lowest for base case, and will rise in return for fewer changeovers (as seen below). The optimal balance between inventory and changeover costs is achieved by the model.

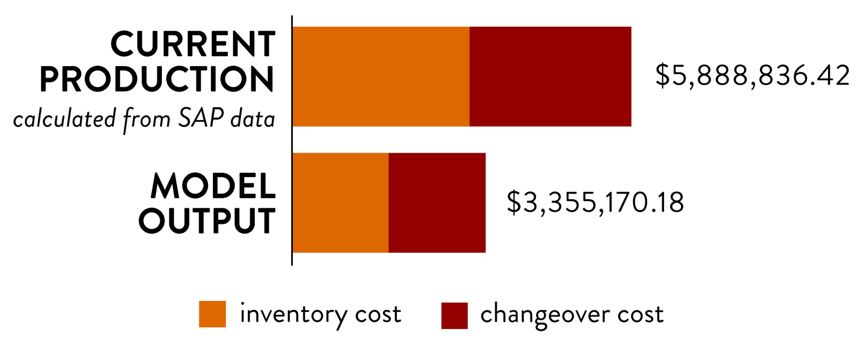
Changeover and Inventory Costs from Sample Data Set



RESULTS (2015 DATA)

With the **MAS and MPS tables** generated for 2015 from SAP, the **linear model** is then solved using **AIMMS**, and the calculated costs of the model output and SAP output compared.

Changeover and Inventory Costs for Demand Fulfillment in 2015



The model achieves significant savings in both inventory and changeover costs.

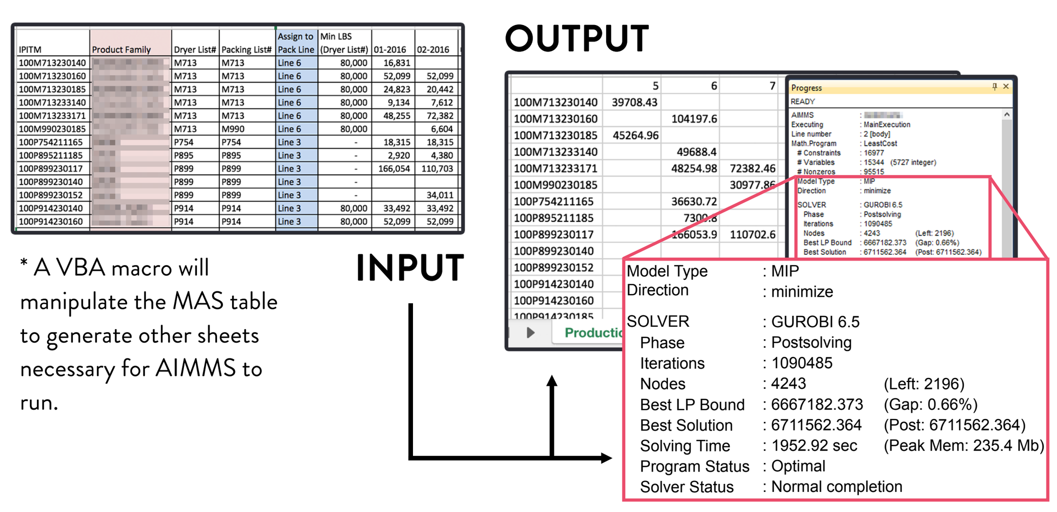
The table shows the breakdown of savings of the components.

Summary of Cost Savings for Demand Fulfillment in 2015

	SAVINGS
Inventory Cost	45.2%
Changeover Cost	40.7%
Total	43.0%

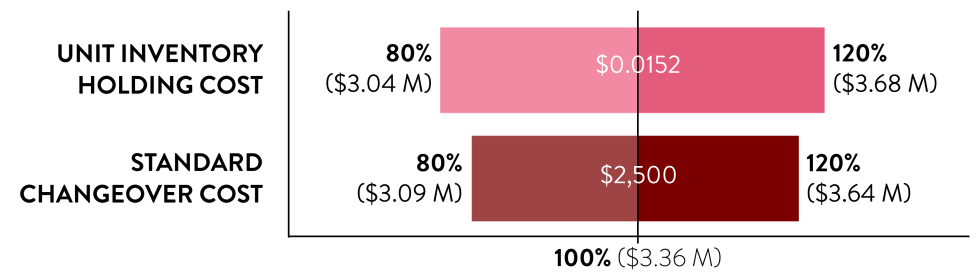
APPLICATION AND ANALYSIS

The 2016 forecasted demand (MAS) is obtained from the parent company's logistics management centre, parsed with VBA, and fed into the model.



SENSITIVITY ANALYSIS

The sensitivity of the model to changes in the unit holding cost and the standard changeover costs by ±20% is summarized below.



RECOMMENDATIONS

1. Where the model MPS disagrees with the current MPS, AMS production planners can **override and adjust the production pattern** with reference to the model MPS.
2. AMS can recommend customers to **shift orders earlier or later**, based on the production pressure for a given period.
3. If the annual plant shutdown schedule is more flexible, the model can be adjusted to find the optimal shutdown period.

FUTURE WORK

1. Develop a new model to find optimal production sequence
2. Improve the current model to include time constraints of production
3. Develop a centralized repository of information