

INTEGRATED AUTOMOTIVE MANUFACTURING SUPPLY

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ABSTRACT

Supply planning and traffic flow planning are major activities in the automotive manufacturing environment worldwide. Traditionally, the impact of supply planning strategies on plant traffic is rarely considered. This paper describes the development of a Decision Support System (DSS) that will assist automotive manufacturers to analyse the effect of supply planning decisions on plant traffic during the supply planning phase of their logistics planning process. In essence, this DSS consists of a Supply Medium Decision Support Tool (SMDST) (an interactive MS-Excel model with Visual Basic interfacing) and a traffic flow simulation model tool (using eM-Plant simulation software).

OPSOMMING

Verskaffingsbeplanning en verkeersvloei-beplanning is belangrike aktiwiteite in die motorvervaardigingsbedryf wêreldwyd. Tradisioneel word die uitwerking van verskaffings-beplanningsstrategie op aanlegverkeer selde in ag geneem. Hierdie artikel beskryf die ontwikkeling van 'n Besluitnemings Ondersteuningstelsel (DSS) wat motorvervaardigers sal ondersteun in die analise van die effek van verskaffingsbeplanningbesluite op aanlegverkeer tydens die verskaffingsbeplanningsfase van hulle logistieke beplanningsproses. Hierdie DSS bestaan hoofsaaklik uit 'n Verskaffings-vervoermiddel Besluitnemingshulpmiddel (SMDST) ('n interaktiewe MS-Excel model met "Visual Basic" koppelling) asook 'n simulasiemodel van verkeersvloei (met eM-Plant simulatiesagteware).

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1. INTRODUCTION

Supply planning and traffic flow planning are major activities in the automotive manufacturing environment worldwide. Supply planning directly influences the traffic within a manufacturing plant. The impact of supply planning strategies like Just-in-Time, Just-in-Sequence and Direct Supply on plant traffic is rarely considered, as supply and traffic flow planning are traditionally seen as separate activities.

BMW is one of the leading international automotive manufacturers. BMW Plant 9 in Rosslyn, South Africa, is planning to switch production from the E46 (current 3-series) model to the E90 (new 3-series) model in 2005. Logistic supply planning for the new E90 model was recently started and is still at a stage where it is relatively open and flexible to justifiable suggested changes.

2. PROBLEM STATEMENT

BMW SA and other automotive manufacturers are facing various specific problems relating to supply and traffic flow planning. One of these problems is in selecting the best supplier transportation medium among various alternatives for the supply of each part family, taking into account the effects on plant traffic. Several variables have to be considered during this decision making process, and no decision support tool exists at present to assist during this process.

Another problem faced by automotive manufacturers lies in assessing the impact of physical relocation decisions on plant traffic. Several proposed plant layout changes and changes to the location of supplier delivery points are considered for BMW Plant 9 in Rosslyn. These proposed changes will imply large relocation expenses, and will inevitably have a major impact on the traffic flow within the plant. The consequent impact of these proposed layout changes has to be investigated, analysed and compared.

3. DEVELOPING A DECISION SUPPORT SYSTEM

In response to this problem, tools have been developed that will assist automotive manufacturers to analyse the effect of supply planning decisions on plant traffic during the supply planning phase of their logistics planning process. Even though these tools can function independently, their real value is only realised once they are used in conjunction with one another as a Decision Support System (DSS). *“Decision support systems couple the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions. It is a computer based support system for management decision makers who deal with semi-structured problems”*[12]. DSS are used in making decisions where sufficient structure exists for computer and analytical aids to be of value but where human judgements are essential. The aim when developing a DSS is to create a supportive tool for management use that does not attempt to automate the decision process, predefine objectives, or impose solutions. It should serve as an extension of the user’s problem solving capabilities. In essence, the DSS developed during this

project consists of a *Supply Medium Decision Support Tool (SMDST)* and a *Traffic Flow Simulation Model* tool.

3.1 Supply medium decision support tool

User requirements specification

The tool should:

- Be fast, efficient and user friendly to implement and use
- Incorporate all variables influencing the supply medium selection process
- Be easily integrated with existing software and applications in use by automotive manufacturers
- Be flexible enough to allow for easy updating or addition of data
- Calculate and compare the number of deliveries required per day for all supplier deliveries for use as input to a traffic flow simulation model
- Have a User Manual assisting the implementation and use of the tool
- Be available in English and German, as it will be distributed to and used by automotive manufacturers in South Africa and Germany

Tool development

The Supply Medium Decision Support Tool (SMDST) developed is an interactive MS-Excel model with Visual Basic interfacing. The tool was developed as far as possible to satisfy the abovementioned user requirements. The developed tool consists of three main components, namely input data sheets, main street and Visual Basic (VBA) module.

Input data sheets

These three sheets (namely the **Boundary Conditions-**, **Part Families-** and **Delivery Cycle Times** sheet) contain all the data required to perform the calculations, and can be viewed and updated conveniently while using the tool. This includes:

- *Truck information*
 - Truck types available
 - Dimensions of loading area for each truck type
 - Load restrictions for each truck type
 - Cost per day for each truck type
- *Supplier information*
 - All suppliers
 - Delivery cycle time for each supplier
- *Part family information*
 - All parts delivered
 - Part weight
 - Parts required per final product

- Stillage dimensions
- Stillage weight
- Parts per stillage

Main sheet

This sheet serves as the main user interface. Here the user can set the following criteria in the tool:

- *Part family to be analysed*: selected from a drop-down list on the main sheet.
- *Offloading device*: the user can specify whether a forklift or stacker will be used to offload the parts from the delivery vehicle. This has an influence on the maximum height that parts can be stacked on the delivery vehicle in later calculations.
- *Manner of offloading*: the user can specify whether the parts will be offloaded from the side or back of the delivery vehicle. This has an influence on the way the parts will be packed on the delivery vehicle.
- *Stackability*: the user can specify whether the stillages may be stacked on top of one another when packed on the delivery vehicle.

Visual Basic module

This module contains the code for all the calculations made by the tool. All necessary data are extracted from the *input data sheets* and *main sheet* into the VBA module, calculations are made and results are displayed for the user in the main sheet.

Following the user requirements, all calculations enabling the tool were translated from MS-Excel formulas into Visual Basic code in order for it to be easily integrated with existing software and applications in use by automotive manufacturers.² A user manual has been made available to guide the user during the set-up and use of the tool. The SMDST and user manual have been made available in English and German.

Variables have been declared in VBA to be used during calculations. All variables have been declared as one of the following four types:

- *Integer*: a whole number (not a fractional number) that can be positive, negative, or zero
- *Double*: also known as type “*Real*”, which can be any value (whole or fractional) in the infinitely divisible range of values between positive and negative infinity
- *String*: also known as type “*text*”, containing any combination of text
- *Boolean*: equal to one of two values: *true* or *false*

The following is a list of variables that have been declared in VBA and a description of the logic behind the VBA calculations. Values are read from the main- and input

² EM-Planner is a good example of such an application. It's “API” function allows for easy integration of VBA programs into its models. Refer to www.tecnomatix.com for more on this application.

data sheets and the appropriate variables (in VBA) set equal to these values each time any variable is changed in the input data sheets or main sheet by the user.

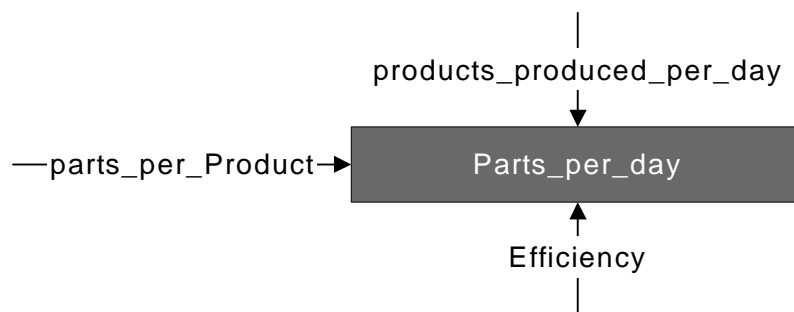
- **products_produced_per_day** (as type Integer): the number of cars produced in the plant per day, value read from *Main* sheet
- **parts_per_Product** (as type Integer): the number of the part of the specific part family required per car produced, value read from *Part Families* sheet
- **efficiency** (as type Double): measure of the usage efficiency of the specific part family, calculated as: 100% - percentage (%) scrapped, value read from *Part Families* sheet
- **parts_per_Stillage** (as type Integer): the number of parts that are packed in a single stillage, value read from *Part Families* sheet
- **partWeight** (as type Double): the weight of a single part of the specific part family, value read from *Part Families* sheet
- **lengthStillage** (as type Double): the length of the stillage used for the specific part family, value read from *Part Families* sheet
- **widthStillage** (as type Double): the width of the stillage used for the specific part family, value read from *Part Families* sheet
- **heightStillage** (as type Double): the height of the stillage used for the specific part family, value read from *Part Families* sheet
- **offloadingDevice** (as type String): an indication of whether a *forklift* or *stacker* will be used to offload the stillages from the delivery vehicle, read from *Main* sheet
- **offloadingManner** (as type String): an indication of whether the stillages will be offloaded from the *side* or *back* of the delivery vehicle, read from *Main* sheet
- **stackability** (as type Boolean): an indication of whether the stillages may be stacked on top of one another or not when packed on the delivery vehicle, read from *Main* sheet
- **maxWeightVehicle** (as type Double): the load weight restriction of the vehicle under consideration, value read from *Boundary Conditions* sheet
- **maxWeightTrailer** (as type Double): the load weight restriction of the vehicle's trailer under consideration, value read from *Boundary Conditions* sheet
- **stillageWeight** (as type Double): the weight of the stillage used for the specific part family, value read from *Part Families* sheet
- **lengthVehicle** (as type Double): the length of the vehicle's *carrying space*³ under consideration, value read from *Boundary Conditions* sheet
- **widthVehicle** (as type Double): the width of the vehicle's carrying space under consideration, value read from *Boundary Conditions* sheet
- **heightVehicle** (as type Double): the height of the vehicle's carrying space under consideration, value read from *Boundary Conditions* sheet
- **lengthTrailer** (as type Double): the length of the trailer's carrying space under consideration, value read from *Boundary Conditions* sheet
- **widthTrailer** (as type Double): the width of the trailer's carrying space under consideration, value read from *Boundary Conditions* sheet

³ Defined as the space that can be utilised for packing stillages in / on the vehicle, and *not* the dimensions of the entire vehicle

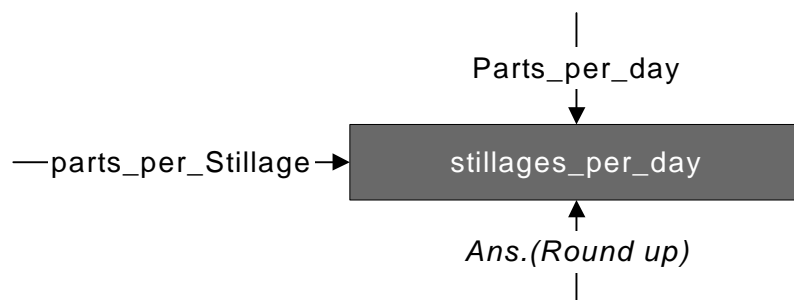
- **heightTrailer** (as type Double): the height of the trailer's carrying space under consideration, value read from *Boundary Conditions* sheet
- **boundaryDistanceRight** (as type Double): the *boundary distance*⁴ on the vehicle's right side, value read from *Boundary Conditions* sheet
- **boundaryDistanceLeft** (as type Double): the boundary distance on the vehicle's left side, value read from *Boundary Conditions* sheet
- **boundaryDistanceFront** (as type Double): the boundary distance on the vehicle's front, value read from *Boundary Conditions* sheet
- **boundaryDistanceBack** (as type Double): the boundary distance on the vehicle's back, value read from *Boundary Conditions* sheet
- **boundaryDistanceTop** (as type Double): the boundary distance on the vehicle's top, value read from *Boundary Conditions* sheet

With these variables set, VBA continues by making the following calculations for the remaining variables:

- **Parts_per_day** (as type Double): the number of parts of the specific part family required per day, calculated from:

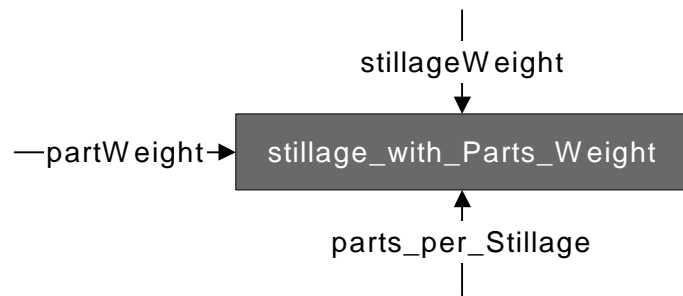


- **Stillages_per_day** (as type Integer): the number of stillages of the specific part family required per day, calculated from:

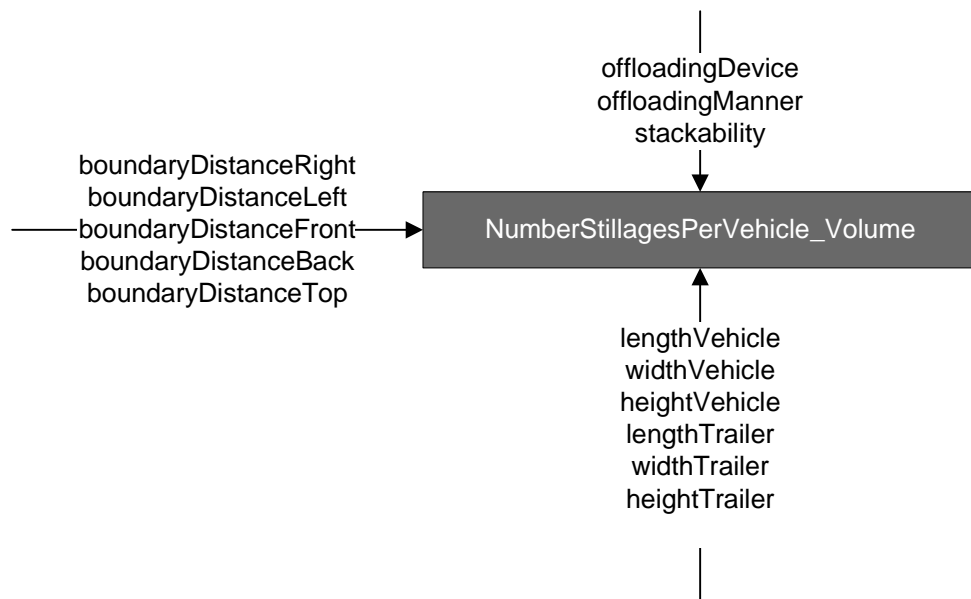


- **stillage_with_Parts_Weight** (as type Double): the weight of a full stillage (stillage carrying parts), calculated from:

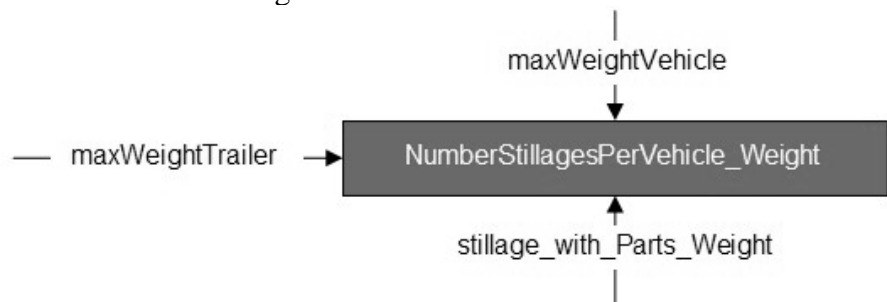
⁴ Defined as the distance on a specific side of a vehicle than cannot be utilised as carrying space, due to restrictions of the offloading device used



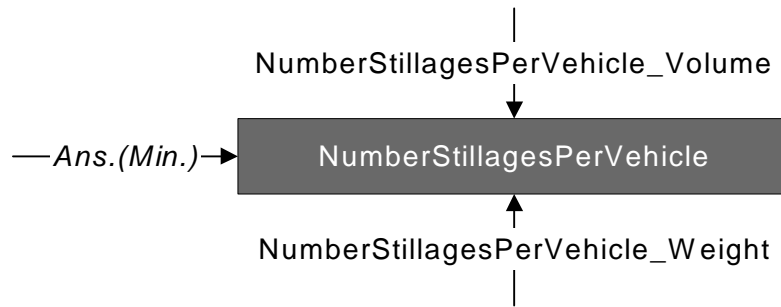
- **NumberStillagesPerVehicle_Volume** (as type Integer): the maximum number of stillages of a specific part family that fits into the vehicle's carrying space, calculated from:



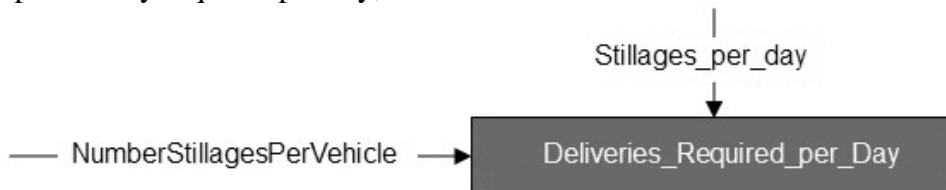
- **NumberStillagesPerVehicle_Weight** (as type Integer): the maximum number of stillages of a specific part family that can (theoretically) be packed on a vehicle before the vehicle reaches its weight restriction calculated from:



- **NumberStillagesPerVehicle** (as type Integer): the maximum number of stillages of a specific part family that can be packed on a vehicle calculated from:



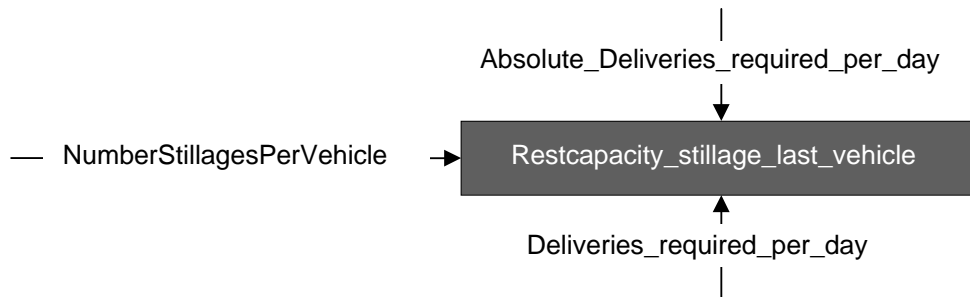
- **Deliveries_required_per_day** (as type Double): the number of deliveries of the specific part family required per day, calculated from:



- **Absolute_Deliveries_required_per_day** (as type Integer): the absolute number of deliveries of the specific part family required per day, calculated from:



- **Restcapacity_stillage_last_vehicle** (as type Integer) calculated from:



The calculation outputs are displayed on the main sheet of the tool's user interface (see Figure 1). Both the vehicle yielding the lowest number of deliveries required per day and the vehicle resulting in the *lowest cost per day* are automatically highlighted in the *main sheet* for easy identification (ref. 1 in Figure 1).

To illustrate both the sensitivity of the calculation output to parameter changes and the capability of the tool in terms of calculation speed and usage efficiency, a simple example follows:

The output shown in *Figure 1: Main Sheet* clearly indicates that (for the selected part family and settings):

- both the “OP Plastic” and “KAR” vehicles are the most favourable in terms of the number of deliveries required per day (4.5 deliveries required per day, on average)
- the “Laeapple” (a delivery vehicle from one of the suppliers) vehicle is the most favourable in terms of the daily cost implication (R1450 per day, on average)

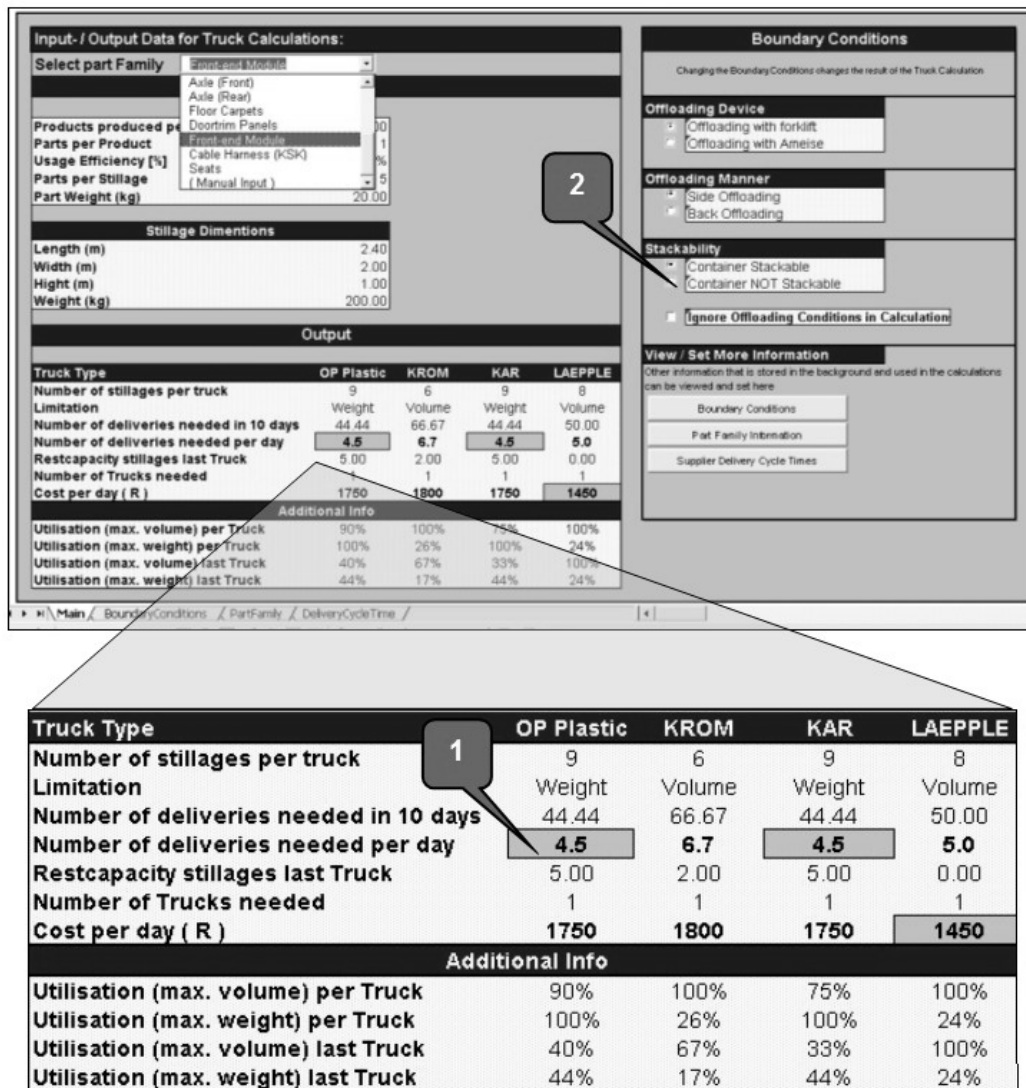


Figure 1: Main Sheet

By changing only one variable in the calculation, namely the *stackability*⁵ of the container (ref. 2 in Figure 1), the calculation output changes considerably (see *Figure 2: Capability example*).

⁵ An indication of whether the stillages may be stacked on top of one another or not when packed on the delivery vehicle