INTEGRATED SYSTEMS DESIGN IN AN AUTOMOTIVE INDUSTRY - USING CAD AND SIMULATION IN LAYOUT AND PROCESS OPTIMIZATION

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ABSTRACT
This paper discusses production systems design issues, applied to an internal logistic system in the automotive industry.
In this paper, production systems design software tools – Simulation and Computer Aided Design are integrated, exploring ways of dealing with data diversity and assuring valid and efficient production systems, taking advantage of the mentioned data integration.
This integration is implemented on AutoCAD (layout design) and WITNESS (simulation), using MS Access as the system knowledge repository. The software package developed was called IDS (*Integrated Design of Systems*).
This approach supports global system optimization that considers all important system resources and system performance measures.
Solutions achieved are expected to be better than solutions obtained with non-integrated approaches.
IDS approach is open and accessible, thus enabling different companies to use this advanced production systems design tool, taking advantage of simulation and CAD systems and their integration.
This application intends to validate the concept and functionalities of the proposed tool, on a real industrial case study.

Keywords: Integrated Systems Design; Production Systems Planning and Design; CAD and Simulation; Layout Optimization.

1. INTRODUCTION

1.1. Description of the PSPD problem

Production **S**ystem **P**lanning and **D**esign (PSPD) is a complex set of tasks using knowledge from several fields: scientific, logical, economical, management, statistical, technical and information technology. It consists of planning and evaluating different alternatives of systems aiming the global optimal usage of inputs and all kinds of resources. Alternatives are designed regarding dynamic time changes and stochastic influences (Francis and White 1974)(Heragu 2006).

Nowadays, there is a great pressure on production systems design to be developed or reorganised rapidly and efficiently due to the worldwide competitive market and rapid progress in manufacturing processes. In this dynamic context, flexibility, modularity and robustness are desired production system properties.

This paper deals with production systems design and its improvement. It is focused on the design of systems and layouts based on material flows, on re-layout processes and also on the design of layouts influenced by different types of uncertainties. It discusses production systems design issues, applied to an internal logistic system in the automotive industry.

As far as Production Systems Design is concerned, three basic classes of software tools have been used: **Computer Aided Design**, Process **Simulation** and **Information** Systems. However, these software tools have been used with low levels of integration. The absence of data integration within these three classes of software tools, and also the absence of a systemic approach to Production Systems Design have been causing duplication of work, waste of time, incoherencies, difficulties in project team communication, and errors in the design phase.

The **integration** is implemented through ***I****ntegrated* ***D****esign of* ***S****ystems* (IDS) tool, which uses AutoCAD (layout design), WITNESS (simulation) and Microsoft Access (database) (see Figure 1), and makes use of the issues discussed in Vik et al. (2010b)(2010c), concerning the production system design software tool developed and presented in the above papers. Pandey et al. (2000) make an interesting contribution towards this type of tools integration, developing a model that is optimised by simulation and then adapted the results into a layout. Also, Altinkilinc (2004) improved the system with simulation and then used a CRAFT method for layout optimization.

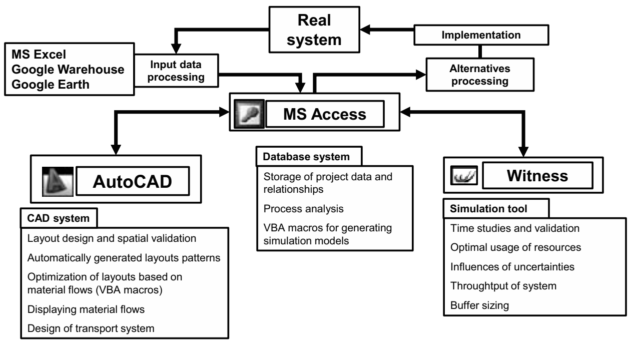


Figure 1 - IDS Overview

MS Access provides an open database structure, allowing integration and data exchange between WITNESS and AutoCAD. Simulation helps on dynamic systems analysis and CAD on static arrangement on a feasible implementation. Iteratively the results from the simulations are used to improve CAD layout design, and CAD layouts are used in new simulation experiments. This approach supports global system optimization that considers all important system resources and system performance measures.

According to Grajo (1995), *layout optimization* and *simulation* are two tasks that are fundamental to facility planning. Burgess et al. (1993) proclaimed that simulation is the only methodology robust enough to the systematic examination of key variables of factory performance. Simulation methodology enables the representation of many attributes of real life problems that are difficult to consider in analytical models for the layout optimization (Tam and Li 1991)(Tang and Abdel 1996)(Pandey et al. 2000)(Castillo and Peters 2002).

The main differences between the traditional (non-integrated) approach and IDS are shown in Figure 2. The traditional approach (upper image) often uses tools separately or with minimum relative integration and data can be stored in several places and in different formats. On the other hand, IDS makes use of a full integration (lower image). A similar idea of integration is described in other works (Chee 2009)(Benjaafar and Sheikhzadeh, 2000)(Sly and Moorthy, 2001).

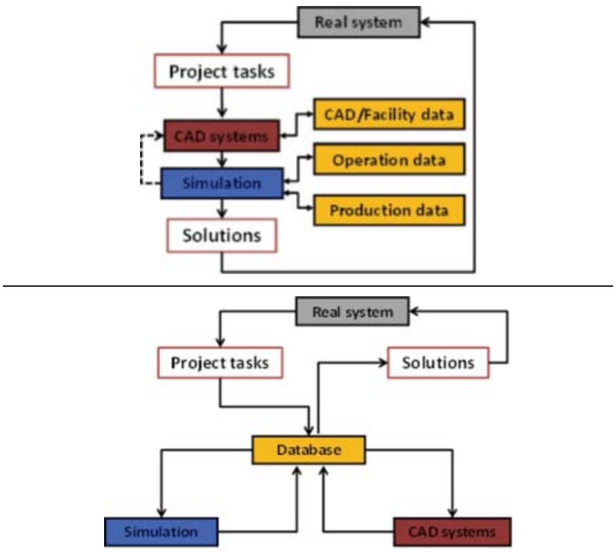


Figure 2 – Traditional and proposed (IDS) approaches

Integration is managed by one common database. It allows specifying and controlling simulation model from database and read/write the required/received data.

The IDS tool **generates** automatically the **simulation model** and shows several alternatives and provides detailed information on production systems performance measures subject to different designs/configurations, enabling to choose the best solution.

Solutions achieved are expected to be better than solutions obtained with non-integrated approaches.

IDS approach is open and accessible, thus enabling different companies to use this advanced production systems design tool, taking advantage of simulation and CAD systems and their integration.

This application intends to validate the concept and functionalities of the proposed tool.

1.2. Case study description

This case study is focused on the internal logistic system in the automotive industry. The company "Magna Exteriors and Interiors" ("Cadence Innovation" until 2009) is a producer and designer of plastic parts.

It was set up in 1946 and started by producing plastic parts for kitchen and garden. Since 1982, it has been producing plastic parts for the automotive industry, such as: painted bumpers (33%, around 4300 per day), control desks (38%, 3000 per day), door fillers (22%, 6200 per day) and grid of cooler (7%) in 2008.

This paper is focused on the production of bumpers (see illustration in Figure 1) and internal logistics linked with it. A similar topic was discussed on a project in 2007 and 2008 (Jareš, 2008)(Vik and Jareš, 2008)(Vik et al. 2010d).

The factory in Liberec City produces parts for five Škoda car models, four part types for each of them (front and rear bumpers, central strips, front grids). This project involves only "big parts" (bumpers), while "small parts" (strips, grids) are omitted once its production is independent of the bumpers on which this project is focused.

There are 21 different colours available for regular bumpers. The combination of colour and car model (part type) is named by the term **"colour-type"** (**CT**). Every car model is limited to a specific set of colours, as shown in Figure 3. Occasionally, non-standard colours are used for special customers (police, taxis, companies, etc.), yet these colours are omitted here.

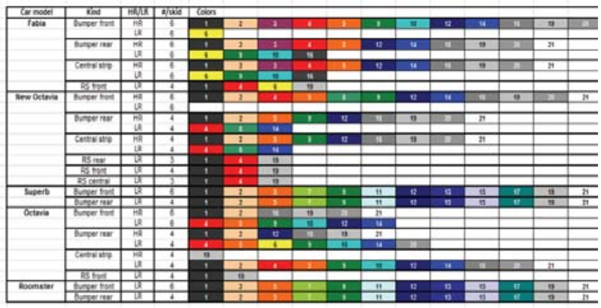


Figure 3 – Colour-Type (CT) table

The complete production processes are in Figure 4, and the factory layout in Figure 13.

Injection moulding machines produce non-coloured bumpers (**batch production**). According to the amounts of items in the "Warehouse of coloured parts", non-coloured bumpers are sent to the "Paint shop". This process is controlled by kanban pull system of orders that cares to hold the established level of products in the Warehouse (so called "safety level").

After the painting operations, painted bumpers (also called colour-type , CT) are transported by a conveyor to the check quality workstations ("*Check WS*"), where quality is checked and visual defects are brushed and polished. After that, CTs are hung on another conveyor, moved close to the "Warehouse" and stored there in special containers (crates) (see Figure 5).

Based on customer orders, CTs are removed from the Warehouse, assembled and dispatched to the customers. This part of logistics system is based on the JIT principle ("Just-In-Time").

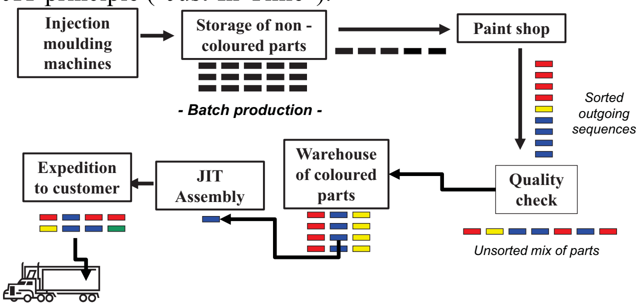


Figure 4 – Schema of production

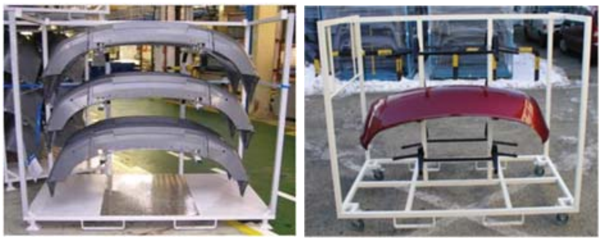


Figure 5 – Transportation units for coloured bumpers

The approach proposed, through IDS tool, should be helpful to acquire the following information:

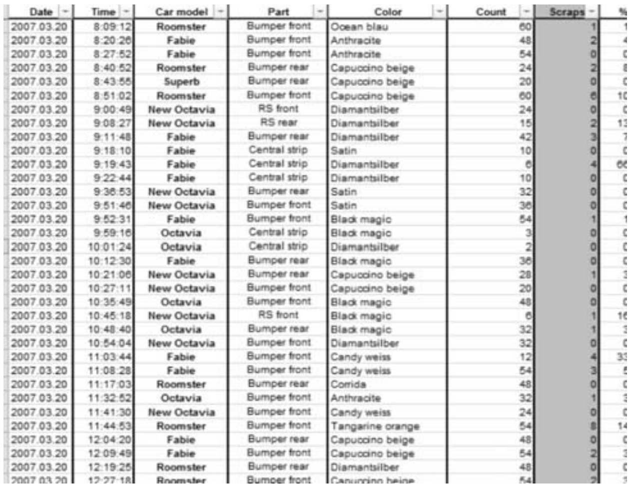
- Necessary number of brushing operators (Check Quality workstations), number of operators for the take-down operation and forklift drivers
- Utilization rates for system resources
- Size of the buffer and storages (mainly temporary floating buffer and Warehouse)
- Condition of holding a safety level in the storages
- Required number of containers in the system
- Paint shop scheduling approaches/solutions

For this purpose, a simulation model is built (automatic generation through IDS) and a set of experiments is run. Required input data are processed and analysed in the following section. This model can also be used for testing different paint shop schedules.

2. SYSTEM DATA ANALISYS

2.1. Paint shop data processing

Data about product arrivals are taken from production data set, provided by company´s ERP system. That data is recorded in the check workstations where each worker must save information about products in the system (barcodes). These data can be used as schedules for paint shop. Production data consists of time (date), car model, CT name, colour, number of parts, and number of scraps (see Figure 6).



Date	Time	Car model	Part	Color	Count	Scraps	%
2007.03.20	8:09:12	Roomster	Bumper front	Ocean blau	60	1	[illegible]
2007.03.20	8:20:26	Fabie	Bumper front	Anthracite	48	2	[illegible]
2007.03.20	8:27:52	Fabie	Bumper front	Anthracite	54	0	[illegible]
2007.03.20	8:40:52	Roomster	Bumper rear	Capuccino beige	24	2	[illegible]
2007.03.20	8:43:55	Superb	Bumper rear	Capuccino beige	20	0	[illegible]
2007.03.20	8:51:02	Roomster	Bumper front	Capuccino beige	60	6	[illegible]
2007.03.20	9:00:49	New Octavia	RS front	Diamantsilber	24	0	[illegible]
2007.03.20	9:08:27	New Octavia	RS rear	Diamantsilber	15	2	[illegible]
2007.03.20	9:11:48	Fabie	Bumper rear	Diamantsilber	42	3	[illegible]
2007.03.20	9:18:10	Fabie	Central strip	Satin	10	0	[illegible]
2007.03.20	9:19:43	Fabie	Central strip	Diamantsilber	6	4	[illegible]
2007.03.20	9:22:44	Fabie	Central strip	Diamantsilber	10	0	[illegible]
2007.03.20	9:36:53	New Octavia	Bumper rear	Satin	32	0	[illegible]
2007.03.20	9:51:46	New Octavia	Bumper front	Satin	36	0	[illegible]
2007.03.20	9:52:31	Fabie	Bumper front	Black magic	54	1	[illegible]
2007.03.20	9:59:16	Octavia	Central strip	Black magic	3	0	[illegible]
2007.03.20	10:01:24	Octavia	Central strip	Diamantsilber	2	0	[illegible]
2007.03.20	10:12:30	Fabie	Bumper rear	Black magic	36	0	[illegible]
2007.03.20	10:21:06	New Octavia	Bumper rear	Capuccino beige	28	1	[illegible]
2007.03.20	10:27:11	New Octavia	Bumper front	Capuccino beige	20	0	[illegible]
2007.03.20	10:35:49	Octavia	Bumper front	Black magic	48	0	[illegible]
2007.03.20	10:45:18	New Octavia	RS front	Black magic	6	1	[illegible]
2007.03.20	10:48:40	Octavia	Bumper rear	Black magic	32	1	[illegible]
2007.03.20	10:54:04	New Octavia	Bumper front	Diamantsilber	32	0	[illegible]
2007.03.20	11:03:44	Fabie	Bumper front	Candy weiss	12	4	[illegible]
2007.03.20	11:08:28	Fabie	Bumper front	Candy weiss	54	3	[illegible]
2007.03.20	11:17:03	Roomster	Bumper rear	Corrida	48	0	[illegible]
2007.03.20	11:32:52	Octavia	Bumper front	Anthracite	32	1	[illegible]
2007.03.20	11:41:30	New Octavia	Bumper front	Candy weiss	24	0	[illegible]
2007.03.20	11:44:53	Roomster	Bumper front	Tangarine orange	54	8	[illegible]
2007.03.20	12:04:20	Fabie	Bumper rear	Capuccino beige	48	0	[illegible]
2007.03.20	12:09:49	Fabie	Bumper front	Capuccino beige	54	2	[illegible]
2007.03.20	12:19:25	Roomster	Bumper rear	Diamantsilber	48	0	[illegible]
2007.03.20	12:27:18	Roomster	Bumper front	Capuccino beige	54	2	[illegible]

Figure 6 - Paint shop data

2.2. P-Q analysis

Production data is summarised and the P-Q analysis is processed. Figure 7 shows production volumes for each CT during a chosen week.

Product portfolio varies – currently 103 CTs are considered. It is not necessary to simulate all of them once they show similar properties and behaviour. For the purpose of the simulation model, 10 CTs (2 HR, 8 LR) were chosen – see arrows in top image of Figure 7.

HR and LR stand, respectively, for "High-runners" (large-size production batch) and "Low-runners" (small-size production batch).

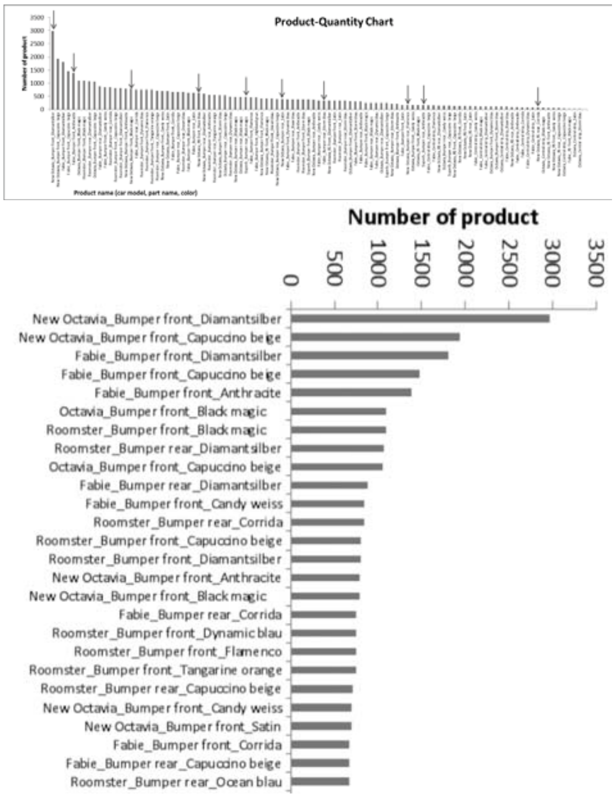


Figure 7 – P-Q analysis

2.3. Output quality

From the data set shown in Figure 6, it was synthesized the percentage of conformity and unconformities. The attribute "vol" was defined as the "quality level" (1..5) and results aggregated in Table 1.

Table 1 – Part quality analysis

Quality level	%	vol
Perfect products	60%	1
Brushing	25%	2
Local repainting	5%	3
Complete repainting	5%	4
Waster	5%	5

2.4. Operation times of Check Workplace

These values were measured and an analysis was performed. All of them have *normal distributions*, as shown in Table 2.

Table 2 – Operation times

Operation	Mean [seconds]	Standard deviation [seconds]
Checking(1)	40	10
Polishing and brushing(2)	160	40
Checking (repaint, waster)(3,4,5)	20	3
Hang on /Take down of bumpers	10	5
Transportation and storing in the Warehouse	120	60
Assembly operation	300	50
Assembly (packing for resellers)	45	7
Painting	10800 (3 hours)	500

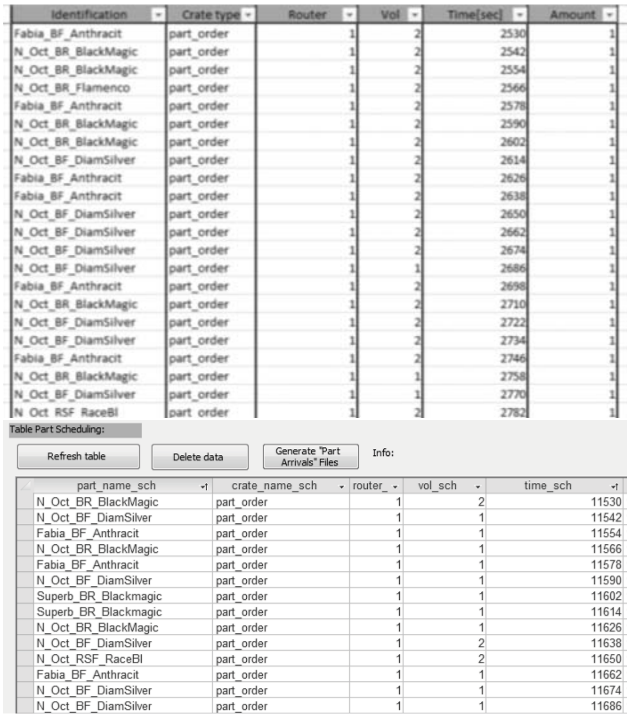
2.5. JIT orders, analysis and data preparation

JIT customers' orders come in a very random order. For feeding IDS system, VBA macro in MS Excel generates randomly JIT demands by the following rules (see Figure 8):

- The total percentage of CTs is based on volumes outgoing from the Paint shop,
- 25% of the demands are JIT assembly for direct factory customers, 75% of the demands are for resellers (determinated by *vol* attribute)
- JIT orders are generated at a rate that corresponds to 5500 parts per day

2.6. Safety level of resources in the Warehouse

Customers also demand holding safety storage level of bumpers, usually for two days. The consumption for two days, for the chosen CT, is in Figure 9, as well as the number of full loaded containers.



Identification	Crate type	Router	Vol	Time[sec]	Amount
Fabia_BF_Anthracit	part_order	1	2	2530	1
N_Oct_BR_BlackMagic	part_order	1	2	2542	1
N_Oct_BR_BlackMagic	part_order	1	2	2554	1
N_Oct_BR_Flamenco	part_order	1	2	2566	1
Fabia_BF_Anthracit	part_order	1	2	2578	1
N_Oct_BR_BlackMagic	part_order	1	2	2590	1
N_Oct_BR_BlackMagic	part_order	1	2	2602	1
N_Oct_BF_DiamSilver	part_order	1	2	2614	1
Fabia_BF_Anthracit	part_order	1	2	2626	1
Fabia_BF_Anthracit	part_order	1	2	2638	1
N_Oct_BF_DiamSilver	part_order	1	2	2650	1
N_Oct_BF_DiamSilver	part_order	1	2	2662	1
N_Oct_BF_DiamSilver	part_order	1	2	2674	1
N_Oct_BF_DiamSilver	part_order	1	1	2686	1
Fabia_BF_Anthracit	part_order	1	2	2698	1
N_Oct_BR_BlackMagic	part_order	1	2	2710	1
N_Oct_BF_DiamSilver	part_order	1	2	2722	1
N_Oct_BF_DiamSilver	part_order	1	2	2734	1
Fabia_BF_Anthracit	part_order	1	2	2746	1
N_Oct_BR_BlackMagic	part_order	1	1	2758	1
N_Oct_BF_DiamSilver	part_order	1	1	2770	1
N_Oct_RSF_RaceBl	part_order	1	2	2782	1

Table Part Scheduling:

Refresh table | Delete data | Generate "Part Arrivals" Files | Info:

part_name_sch	crate_name_sch	router_	vol_sch	time_sch
N_Oct_BR_BlackMagic	part_order	1	2	11530
N_Oct_BF_DiamSilver	part_order	1	1	11542
Fabia_BF_Anthracit	part_order	1	1	11554
N_Oct_BR_BlackMagic	part_order	1	1	11566
Fabia_BF_Anthracit	part_order	1	1	11578
N_Oct_BF_DiamSilver	part_order	1	1	11590
Superb_BR_Blackmagic	part_order	1	1	11602
Superb_BR_Blackmagic	part_order	1	1	11614
N_Oct_BR_BlackMagic	part_order	1	1	11626
N_Oct_BF_DiamSilver	part_order	1	2	11638
N_Oct_RSF_RaceBl	part_order	1	2	11650
Fabia_BF_Anthracit	part_order	1	1	11662
N_Oct_BF_DiamSilver	part_order	1	1	11674
N_Oct_BF_DiamSilver	part_order	1	1	11686

Figure 8 - JIT orders analysis

type	colour	2 days consumption	# bumpers in the skid	#containers
New Octavia, bumper rear	blackmagic	400	8	50
	cappucino	260	8	33
	corrida	40	8	5
	flamengo	50	8	7
	sprint	50	8	7
	island	40	8	5
	highland	20	8	3
	stormblau	100	8	13
	dynamic	60	8	8
	anthracit	250	8	32
	satin	120	8	15
	brilliant	410	8	52
	candy	200	8	25
		2000		***255***

Figure 9 – JIT order analysis

After the complete data are collected, the simulation model can be developed, experiments run and final reports would be available. This type of approach is described in the work of Mecklenburg (2001) and is also based on the author´s experience.

3. PROCESS SPECIFICATION AND SIMULATION MODEL

All the process is specified in the IDS database, then IDS generates de Simulation Model and submits it to WITNESS, to run in batch mode (by default).

A schema of the simulation model is presented in Figure 10. Text boxes with blue background are buffers or conveyors, text boxes with yellow background represent real facilities and grey text boxes are logic control (virtual) processes (that are not in the real system). Flows represent transportation (conveyors, containers or final products), information flows are customers' orders or signals for paint shop.

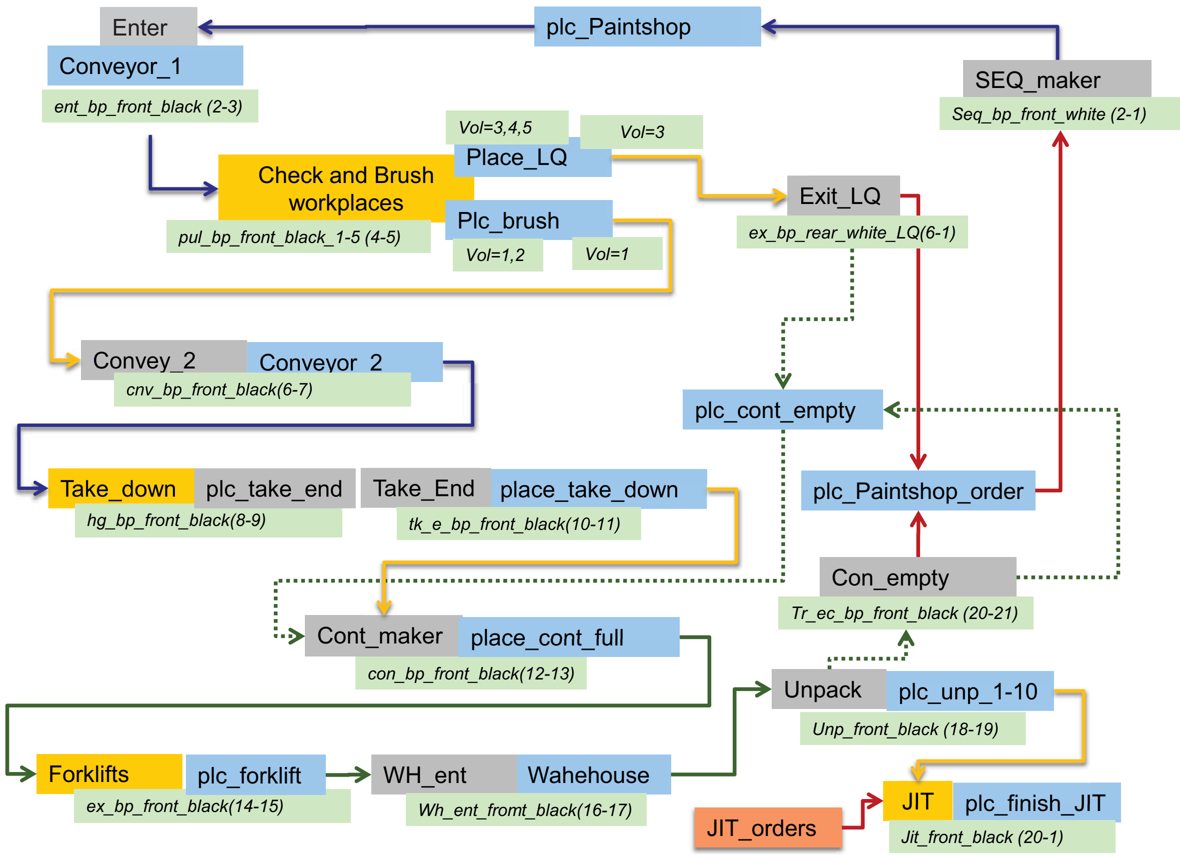
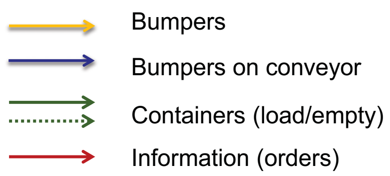


Figure 10 – Schema of the Process (to simulation model)



The *quantity* of resources can be easily changed as parameters in the experiments (e.g. *Checks Quality*, *Forklifts* and *Take down*).

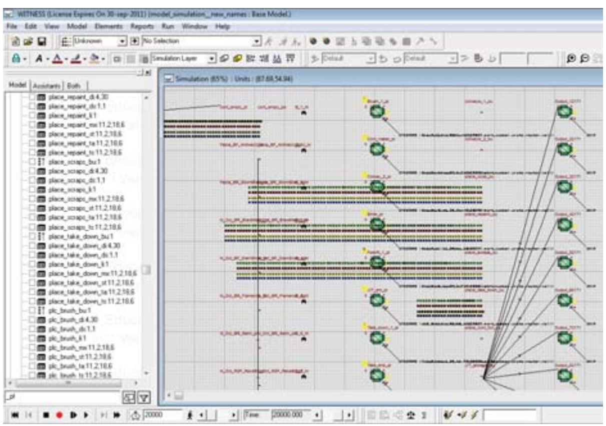


Figure 11 – IDS Generated simulation model

3.1. Brief description of the simulation model

JIT orders are the main inputting entities; all processes are controlled based on them. In a JIT assembly (*"JIT"*), the JIT orders are joined with the corresponding CT. CTs are taken from containers that are unpacked.

Then, empty containers are transported to the storage ("*Con_empty"*) that makes signal for the paint shop (*"plc_Paintshop_order"*) to produce new parts ("*SEQ_maker"*) in sequences of a rate 4:1 (HR:LR). The paint shop (*"plc_Paintshop"*) is represented by a buffer where a part must stay for a defined period, equal to the operation time. Parts going from the paint shop are taken from the conveyor ("*Conveyor_1"*) and checked (*"CheckWP"*). Parts with low quality are sent out (*"place_LQ"*), while the good parts are hung to the conveyor (*"Conveyor_2"*). From there, they are taken down ("*Take_down"*) and stored in the container (*"Cont_maker"*). Full containers are transported by forklifts to Warehouse (*"WH_ent"*). From Warehouse, containers are taken and unpacked (*"Unpack"*).

The simulation model is automatically generated based on data from DB (see Figure 11).

3.2. Results for the current production capacity

The number of containers in the system is estimated by basic calculations. These values must be validated with the simulation results to establish realistic safety levels.

Figure 12 shows a schema of the safety level analysis. Initial simulation model shows the number of full-loaded containers for a given CT (New Octavia Black Magic, HR) in the Warehouse. The simulation model shows between 10-20 full loaded containers in the Warehouse, with a calculated safety level of 41. This value is established by a 2-day production and the recalculated value into full-loaded containers is based on their capacity. Therefore, it must be increased the number of containers to accomplish holding safety level condition. In current state, there are the following number of facilities: *"Check WS"* (10), *"Forklifts"* (2), *"Take down"* (2) and *"JIT WS"* (10).

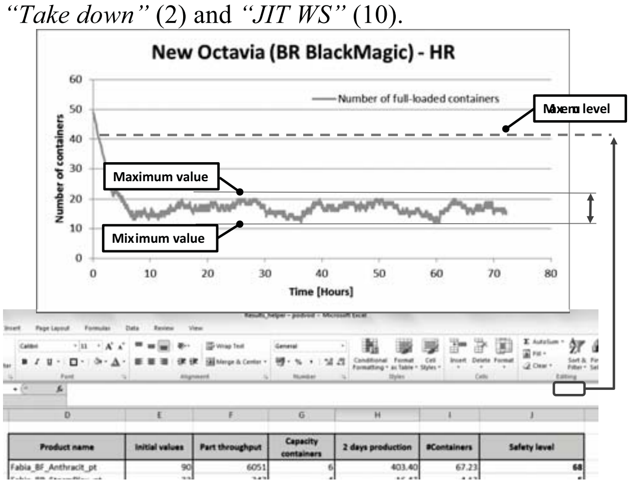


Figure 12 – Safety level determination

3.3. Experiment - increased production

In this experiment, the influences of changes of increased production in the system are studied. There are schedules tested for 10 000 daily production on the current system (paint shop outgoing sequences, operation times, quality).

The simulation model used in the increased production analysis is the same as used in the current system. Several different facilities quantities have been tested in order to guarantee the desired safety level. The main results of this experiment are in Table 3 and define the following number of facilities: *"Check WS"* (10), *"Forklifts"* (**3**), *"Take down"* (2) and *"JIT WS"* (**14**).

The total throughput during three days is 29985 that corresponds to a 10 000 daily production. The utilization of "*CheckWS*" is around 90% and forklifts are busy on 64%. The assembly workstations, work on an average of 90%. The total stable number of full-loaded containers in the Warehouse is around 150, without considering safety storages of each CTs.

Results of the experiment enable the selection of an adequate configuration for the production increase.

Table 3 – Results of increased production experiment

Number of facilities – optimal configuration:

Name	Quantity
Check WS	10
Forklifts	3
Take down	2
JIT WS	14

Throughput:

part_throughput	crate_throughput	value_throughput
N_Oct_BR_BlackMagic	part_order	6758
Superb_BR_Anthracit	part_order	522
N_Oct_BR_Flamenco	part_order	495
N_Oct_RSF_RaceBl	part_order	1305
Fabia_BF_Anthracit	part_order	8172
Fabia_BR_StormBlau	part_order	342
N_Oct_RSR_Corrida	part_order	107
Superb_BR_Blackmagic	part_order	684
N_Oct_BF_DiamSilver	part_order	11177
N_Oct_BR_Satin	part_order	423

Facility usage:

Total time | Percentage

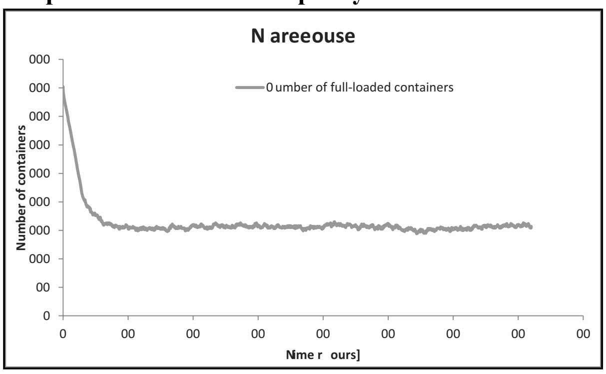
machine_name	kind_of_process	busy_time	blocking_time	waiting_time_part
Brush_1	quantity_function	82.1372809960282	0	17.8627190039718
Take_down_1	quantity_function	27.4269847742791	0	72.5730152257209
Forklift_1	quantity_function	64.7818167627711	0	35.2181832372289

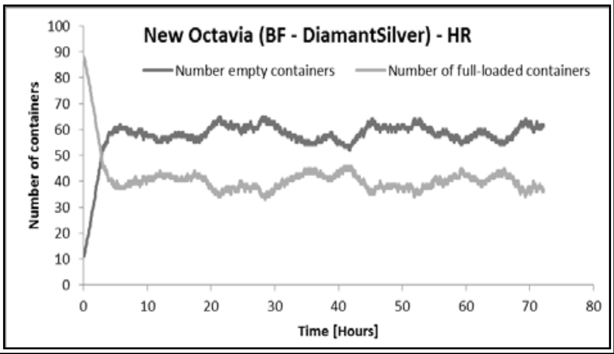
JIT workstations:

Total time | Percentage

machine_name	kind_of_process	busy_time	blocking_time	waiting_time_part
JIT_12	machine	93.7801549047754	0	6.21984509522463
JIT_13	machine	94.6475897333336	0	5.35241026666645
JIT_14	machine	95.7220320434979	0	4.27796795650209
JIT_2	machine	66.9980269493993	0	33.0019730506007
JIT_3	machine	74.8159746992503	0	25.1840253007497
JIT_4	machine	91.5009076732587	0	8.49909232674135
JIT_5	machine	92.2983415484723	0	7.70165845152769
JIT_6	machine	86.2158556645025	0	13.7841443354975

Graphs of containers occupancy in the Warehouse:





4. CAD LAYOUT INTERACTIVE DESIGN WITH IDS

The Design and Improvement (Optimization) of the factory CAD Layout is supported by the IDS system in a very convenient way.

The specification of the material flows and processing's is previously made on the Database by fulfilling proper dialogs and tables, centralizing all the knowledge in the database.

IDS generated automatically a simulation model that runs on WITNESS. Embedded code in the simulation model, interpret simulation results of the system simulation runs and feeds them back into de database, enriching the system knowledge with facts as the intensity of material flows through each path and the needs for real buffer sizes (punctual accumulation of parts, during factory labour).

IDS supports the interactive process of improving successively the CAD layout, evaluating its performance or feasibility through simulation experiments.

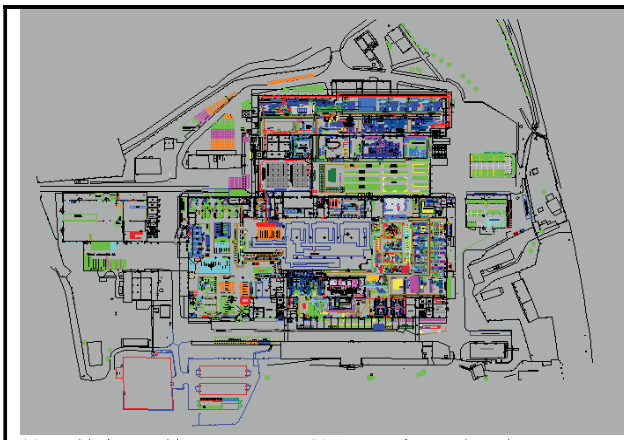
4.1. Material flows

Figure 13 identifies the production areas. In Figure 15, there are several layouts with generated material flows. The actual factory layout is on the background (grey colour). The top left image displays schematic layout with direct unconstrained material flows of all CTs and the top right image shows the chosen CT flows. For the design of a transportation aisle, it can be helpful to display flows based on a transportation unit –the bottom left image shows container flows. These flows are generated based on the transportation network of aisles. The bottom right image shows flows based on realistic shapes of aisles, conveyors and transportation roads.

4.2. Buffer size establishment

In order to find the optimal buffer (storages, warehouse) size, it is possible to integrate simulation and CAD results. This approach integrates results from the simulation *("maximum_value_simulation")* and CAD layout *("limitation_CAD")* as shown in Figure 14. Simulation results provide the maximum number of units (e.g. containers) in the given buffer during the simulated period, and in the CAD layout, there is a specific available space for these containers. In Figure 14, data for the Warehouse with available space provided by the layout for each CT is presented. In this case, there is enough space for all CT containers, as also shown in Figure 16.

The appropriate number of blocks representing containers is generated to the layout (see Figure 16, upper image - orange coloured blocks). Those Blocks representing 3D containers are automatically inserted into the layout. These blocks are arranged and placed in the correct position into shelves or stacked (see Figure 16, lower image). This is helpful to the realistic design of a warehouse structure, stocking containers in layers, 3D layout, the required manipulation for space (based on material flows and aisles) and the validation of the required space (the maximal number of parts that can be in the given buffer). IDS doesn't generate 3D animated models, although considers the specification of vertical accumulation. Previous authors experience could be relevant to include 3D animation for illustrative purpose on IDS (Vik et al. 2008a, 2008b, 2010a, 2010b).



(1)Mouldering machines (2)Storage of non-coloured parts
(3)Preparation of black parts (4)Paint shop
(5)Check Quality Workplaces (6)Take Down area
(7)Storage of full-loaded containers (8)JIT assembly workstations
(9)Expedition

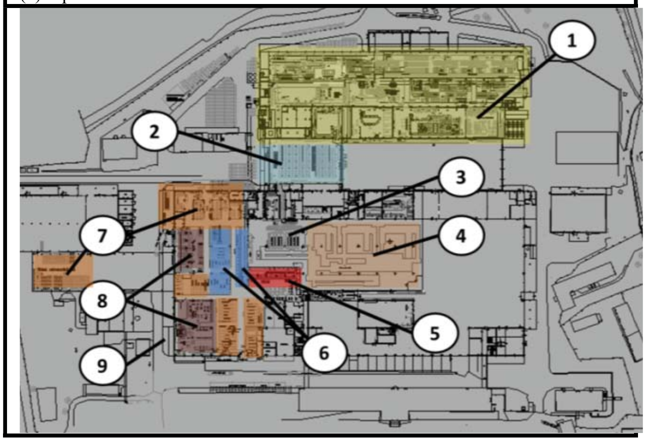
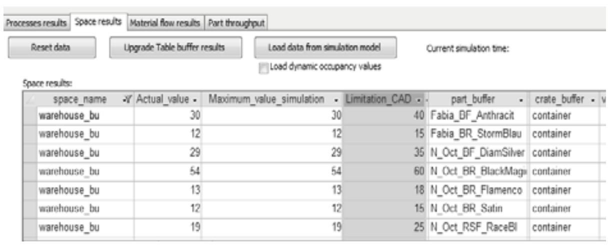


Figure 13 – Current layouts



space_name	Actual_value	Maximum_value_simulation	Limitation_CAD	part_buffer	crate_buffer
warehouse_bu	30	30	40	Fabia_BF_Anthracit	container
warehouse_bu	12	12	15	Fabia_BR_StormBlau	container
warehouse_bu	29	29	35	N_Oct_BF_DiamSilver	container
warehouse_bu	54	54	60	N_Oct_BR_BlackMagi	container
warehouse_bu	13	13	18	N_Oct_BR_Flamenco	container
warehouse_bu	12	12	15	N_Oct_BR_Satin	container
warehouse_bu	19	19	25	N_Oct_RSF_RaceBl	container

Figure 14 – Warehouse/Buffers size analysis results

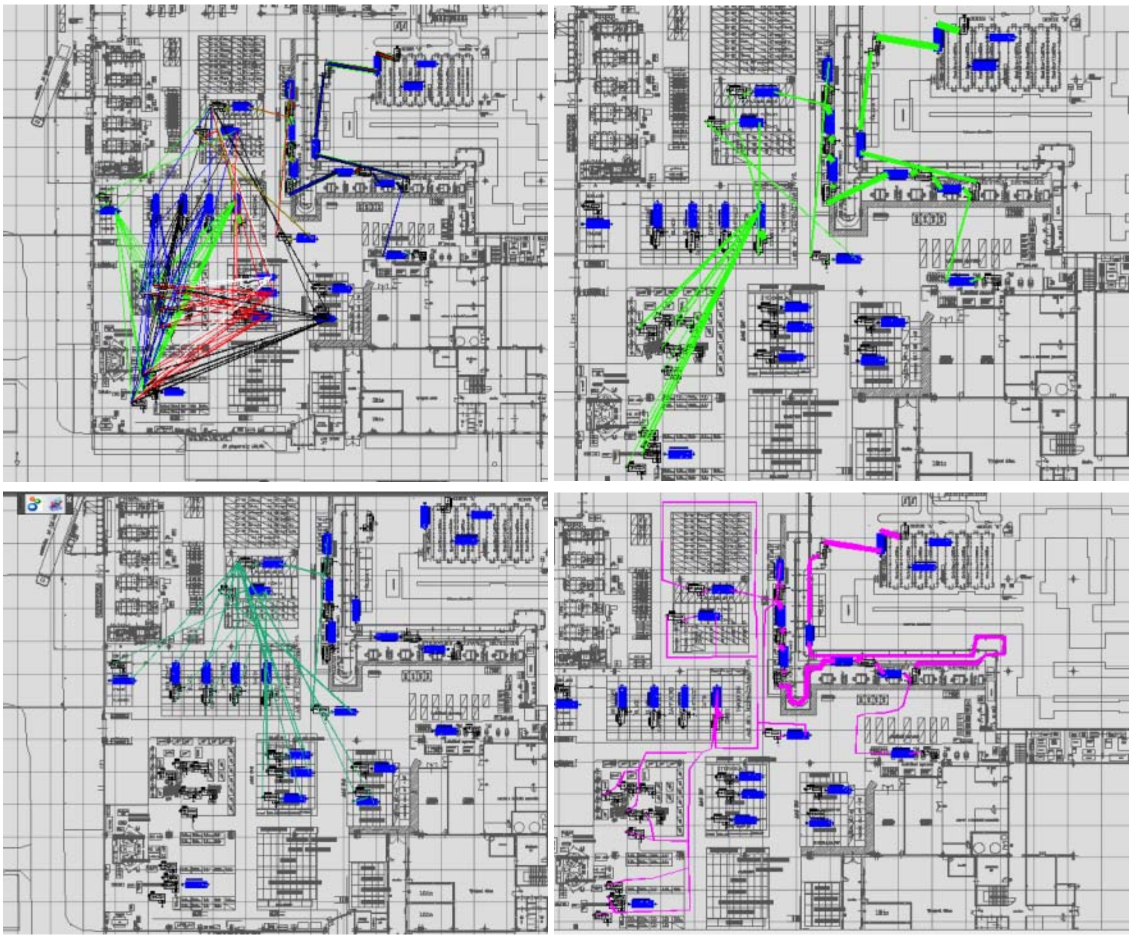


Figure 15 – Layouts with material flows

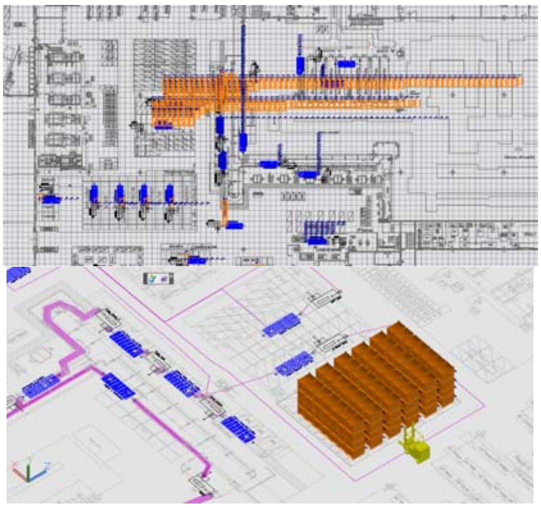


Figure 16 – Buffers space usage and 3D layout

	Traditional approach	IDS
Project aims establishing	2 days	2 days
Data analysis and input to DB (IDS)	3 days	3 days
Simulation model building	2 weeks	5 minutes
Experiments /alternatives design	3 hours	8 hours
CAD layout 2D	2 days	3 hours
CAD layout 3D	-	1 hour
Results analysis	8 hours	1h
Total time	4 weeks	1.5 weeks

Figure 17 - Time requirement summary

5. CONCLUSIONS

This project solves internal logistics in a factory of an automotive supplier, more precisely the logistics between the paint shop (batch production) and the JIT assembly controlled by customers' orders. To test the planned increased production (doubled), a simulation model was developed (generated) in IDS.

With this model, the optimal configuration was established as well as the safety level of containers in the Warehouse was estimated.

The required time for the complete work using IDS was 1.5 week – traditional approach needed 4 weeks to complete the job (see **Figure 17**).

The use of IDS tool has proved some important advantages of this integrated approach as opposed to the traditional non-integrated approach:

- Bidirectional information flows, i.e. inclusive feedbacks
- One common database
- Easy data transfer and unified data format
- Fast reaction to changes during the project elaboration
- Full use of software tools and their extension by new functions

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