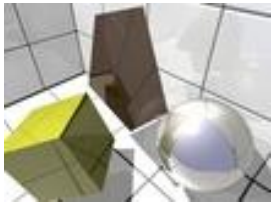
LP/MIP @ RENAULT SUPPLY CHAIN

Digital Transformation

Applied AI chapter
12 staff

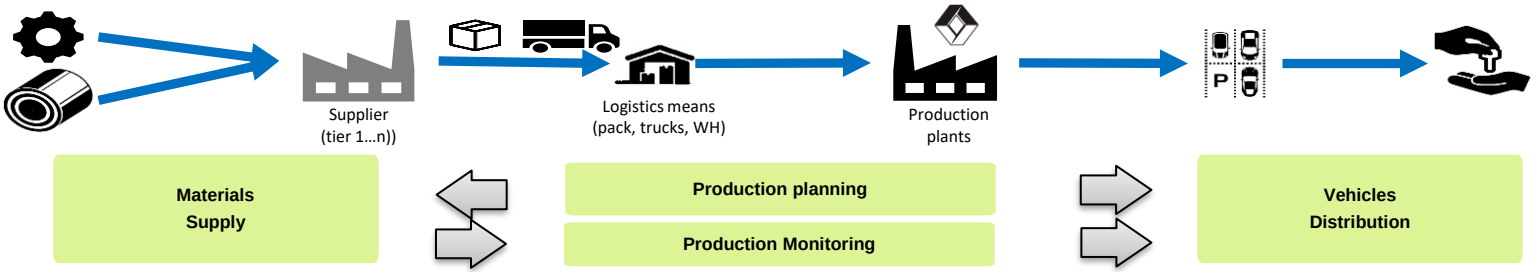


Product configuration
Knowledge compilation

Natural Language Processing

Operations Research
(5 staff + 2 interns)

RENAULT END TO END SUPPY-CHAIN : KEY FIGURES

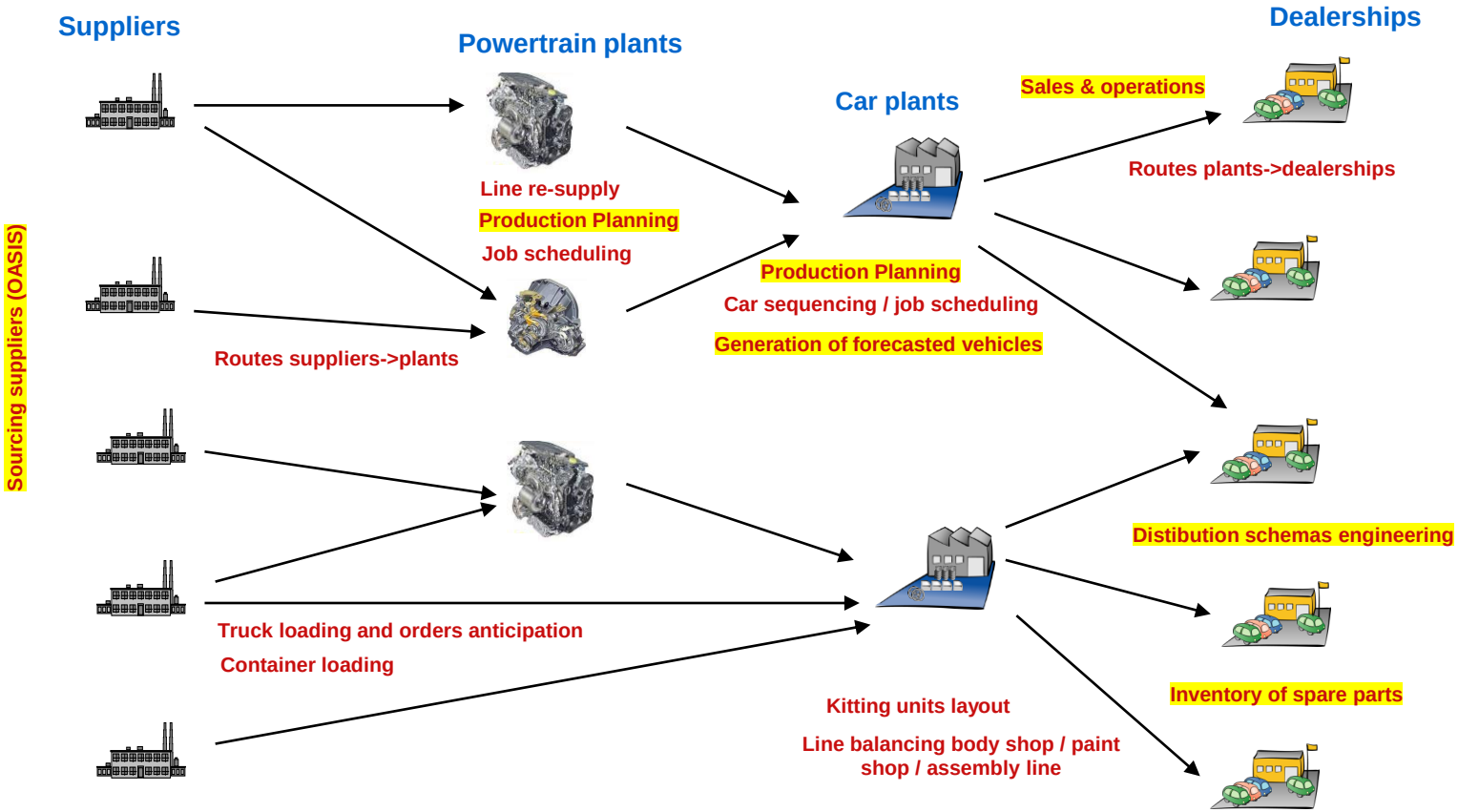


- 3,500 trucks or containers/day to supply our plants
- 200,000 m3 of transported parts/day
- 3,500 supplier sites
- 13 logistics platforms

- 40 Renault plants in 17 countries
- 7,500 model versions
- 300,000 parts references

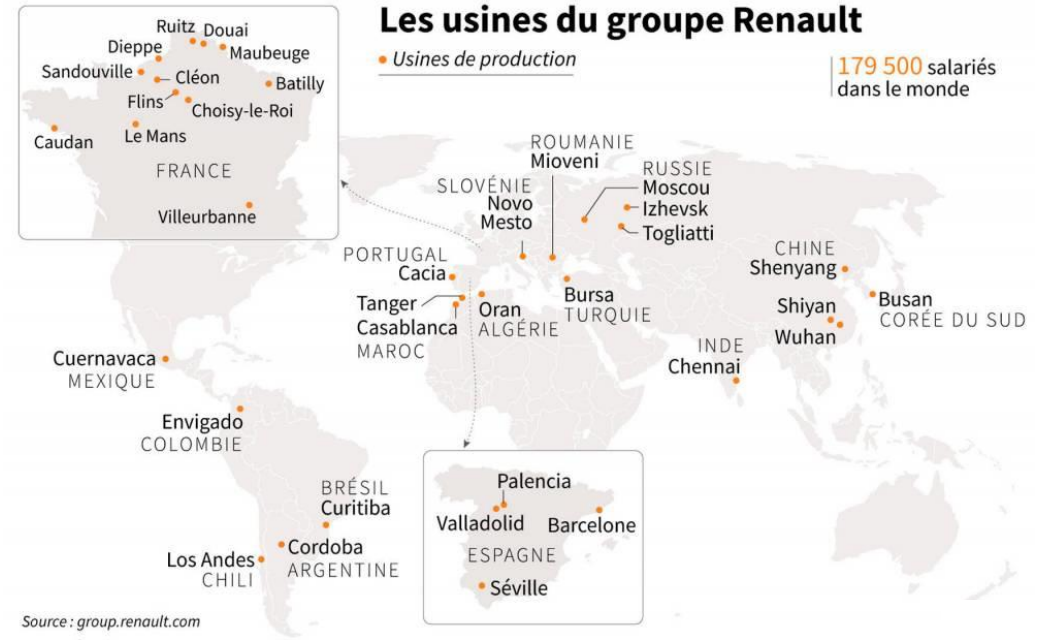
- Around 2,000 trucks or boats per day to deliver our cars
- To over 5,000 destinations
- Over 200 ports used worldwide

OR tools in the supply chain

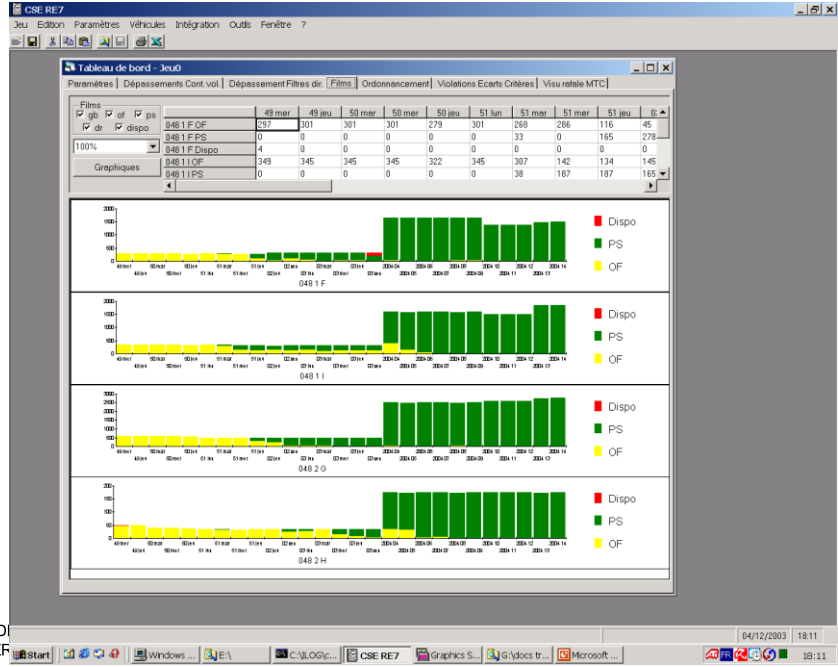


Whenever LP/MIP could be used, it was used !

Solvers : CPLEX since 1992, COIN/OR … but also CPO, LocalSolver



Car Production planning (daily)

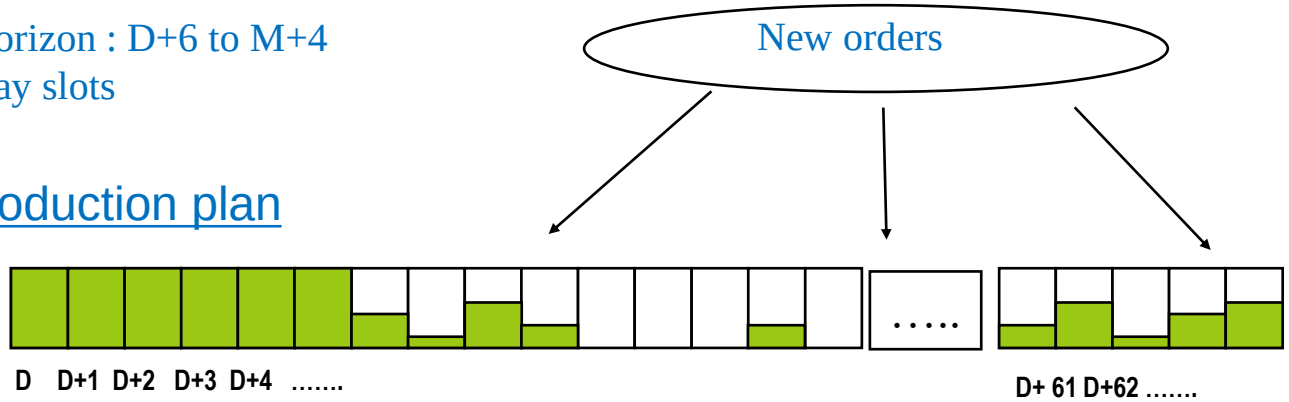


Planning tool in every RENAULT's car factory worldwide
Mission : to optimize the daily production plan
Scope : total production of 2M vehicles in 2022

Car production planning

Horizon : D+6 to M+4
Day slots

Production plan



Constraints :
- Line specialization
- Suppliers capacities
- Plant capacities

Objectives :
1. Maximize nb orders in the production plan
2. Satisfy the customer wished delivery date
3. Satisfy the plan stability
4. Smoothing of complex vehicles / ….

Multi-objective optimization (LP), customized for each plant

Car sequencing (daily)

Production sequence

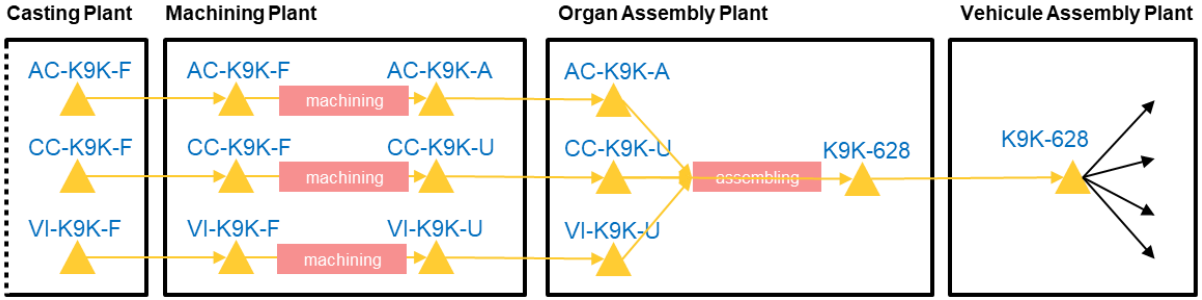
Paint batches

Spacing soft constraints

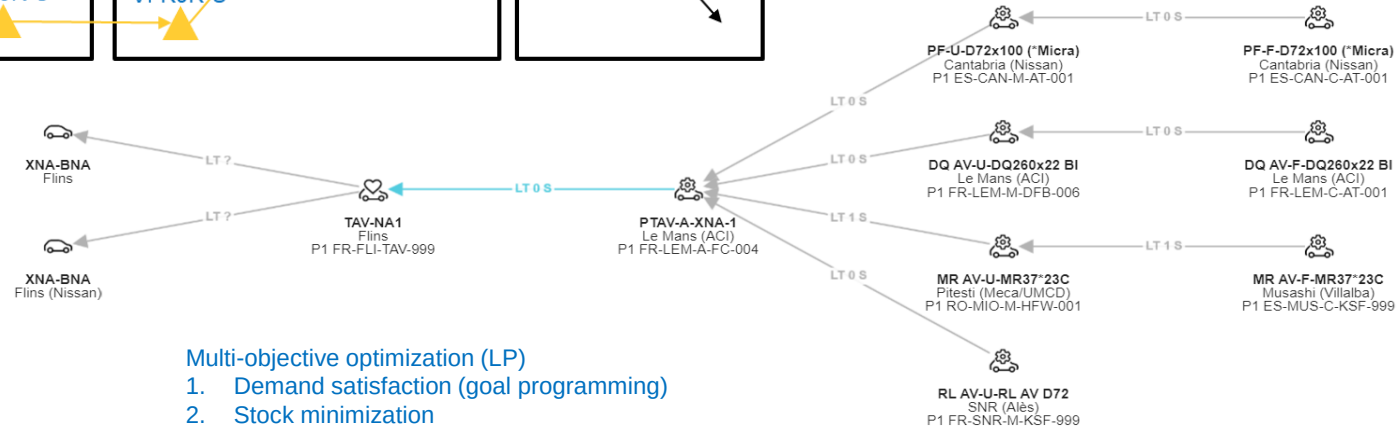
- Paint batches
  - ✓Minimize solvent consumption due to paint color changes
- Spacing for the assembly shop : spacing ratios (ex: DD DD ¼)
  - ✓To smooth complex vehicles
  - ✓Not to overburden workstations

Engine/gearbox production planning (monthly)

Planning tool for engines, gearboxes, and all their components
Mission : to optimize the production plan for the next 18 months & solve capacity bottlenecks
Scope : 985 production lines worldwide



Production process of an engine

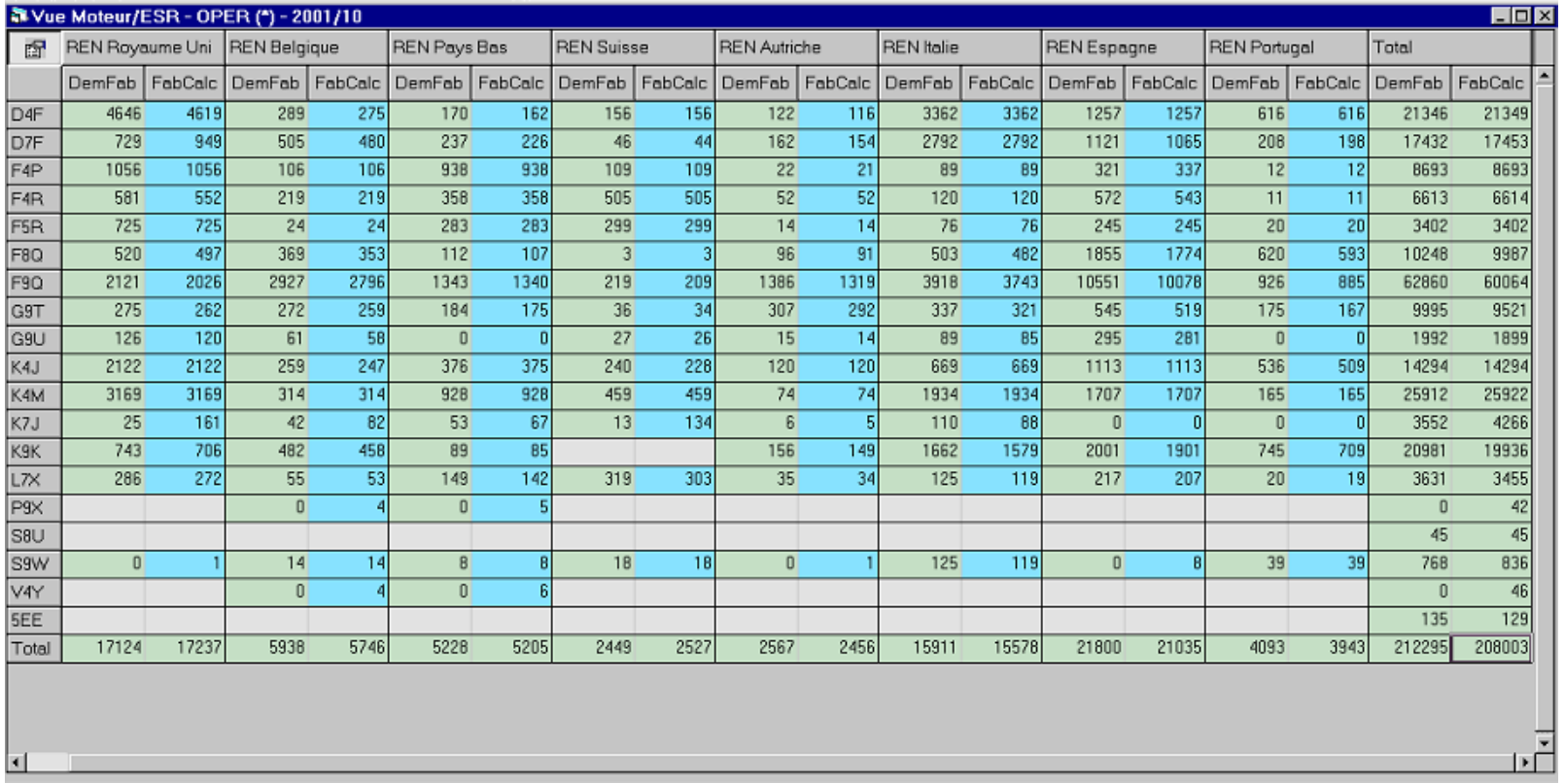


Production lines in Spain, France and Romania needed to produce car chassis

Multi-objective optimization (LP)

1. Demand satisfaction (goal programming)
2. Stock minimization
3. Transportation leadtime minimization

Goal programming (LP)



Vue Moteur/ESR - OPER (*) - 2001/10

	REN Royaume Uni		REN Belgique		REN Pays Bas		REN Suisse		REN Autriche		REN Italie		REN Espagne		REN Portugal		Total	
	DemFab	FabCalc	DemFab	FabCalc	DemFab	FabCalc	DemFab	FabCalc	DemFab	FabCalc	DemFab	FabCalc	DemFab	FabCalc	DemFab	FabCalc	DemFab	FabCalc
D4F	4646	4619	289	275	170	162	156	156	122	116	3362	3362	1257	1257	616	616	21346	21349
D7F	729	949	505	480	237	226	46	44	162	154	2792	2792	1121	1065	208	198	17432	17453
F4P	1056	1056	106	106	938	938	109	109	22	21	89	89	321	337	12	12	8693	8693
F4R	581	552	219	219	358	358	505	505	52	52	120	120	572	543	11	11	6613	6614
F5R	725	725	24	24	283	283	299	299	14	14	76	76	245	245	20	20	3402	3402
F8Q	520	497	369	353	112	107	3	3	96	91	503	482	1855	1774	620	593	10248	9987
F9Q	2121	2026	2927	2796	1343	1340	219	209	1386	1319	3918	3743	10551	10078	926	885	62860	60064
G9T	275	262	272	259	184	175	36	34	307	292	337	321	545	519	175	167	9995	9521
G9U	126	120	61	58	0	0	27	26	15	14	89	85	295	281	0	0	1992	1899
K4J	2122	2122	259	247	376	375	240	228	120	120	669	669	1113	1113	536	509	14294	14294
K4M	3169	3169	314	314	928	928	459	459	74	74	1934	1934	1707	1707	165	165	25912	25922
K7J	25	161	42	82	53	67	13	134	6	5	110	88	0	0	0	0	3552	4266
K9K	743	706	482	458	89	85			156	149	1662	1579	2001	1901	745	709	20981	19936
L7X	286	272	55	53	149	142	319	303	35	34	125	119	217	207	20	19	3631	3455
P9X			0	4	0	5											0	42
S8U																	45	45
S9W	0	1	14	14	8	8	18	18	0	1	125	119	0	8	39	39	768	836
V4Y			0	4	0	6											0	46
5EE																	135	129
Total	17124	17237	5938	5746	5228	5205	2449	2527	2567	2456	15911	15578	21800	21035	4093	3943	212295	208003

Sales & operations tools with LP/MIP

Detailed forecasts generation (monthly)
- Samples of fictive partial vehicles
- Product Mix objectives (versions, options)

✓ Quadratic MIP with barrier

Distribution of production capacities between countries (monthly)
- Invoice deadlines (June and Dec)
- Sales targets
- Transportation capacities

✓ Multi-objective optimization (LP and goal programming)

Production planning of show-room vehicles (on request)
- Production ramp-up
- Transportation capacities
- Countries demand (volume and timing)

✓ Multi-objective optimization (MIP)

Workforce scheduling in paint shop (on request)

Operators' movements

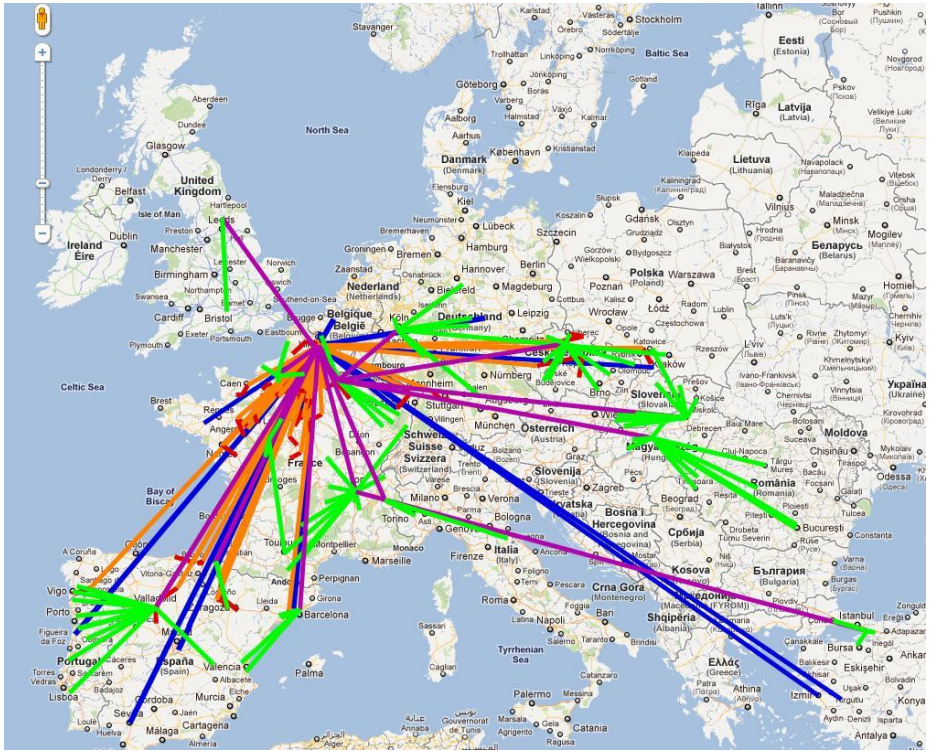
Holes assignement to operators

	Operateur0	Operateur1	Operateur2	Operateur3	Operateur4	Operateur5
Temps total (cmin)	143,12	181,19	154,97	161,39	162,49	111,83
TEP FOS A (cmin)	35,00	29,50	36,50	40,50	36,00	29,50
MIO (cmin)	24,00	24,00	28,00	28,00	28,00	20,00
OA int blocs (cmin)	11,16	34,75	10,23	10,54	15,05	6,12
OA ext blocs (cmin)	65,63	82,15	70,89	73,19	73,55	51,21
nb blocs	1	1	1	1	1	1
nb buses	7	7	8	8	8	6
nb trous	8	7	8	9	8	7
table buses	(0.0,0.0)	(0.0,0.0)	(0.0,15.0)	(0.0,15.0)	(0.0,0.0)	(0.0,0.0)
Taux engagement	76,53	96,89	82,87	86,30	86,89	59,80
	Trou734 [Buse59 Bloc1]	Trou736 [Buse60 Bloc2]	Trou735 [Buse62 Bloc2]	Trou701 [Buse189 Bloc2]	Trou700 [Buse188 Bloc1]	Trou789 [Buse225 Bloc1]
	Trou710 [Buse136 Bloc1]	Trou748 [Buse101 Bloc2]	Trou707 [Buse30 Bloc2]	Trou711 [Buse83 Bloc2]	Trou747 [Buse102 Bloc1]	Trou318 [Buse178 Bloc1]
	Trou757 [Buse136 Bloc1]	Trou110 [Buse110 Bloc2]	Trou758 [Buse135 Bloc2]	Trou725 [Buse40 Bloc2]	Trou706 [Buse81 Bloc1]	Trou305 [Buse165 Bloc1]
	Trou724 [Buse35 Bloc1]	Trou122 [Buse85 Bloc2]	Trou729 [Buse41 Bloc2]	Trou319 [Buse179 Bloc2]	Trou728 [Buse36 Bloc1]	Trou121 [Buse84 Bloc1]
	Trou109 [Buse109 Bloc1]	Trou21 [Buse21 Bloc2]	Trou738 [Buse42 Bloc2]	Trou306 [Buse166 Bloc2]	Trou737 [Buse37 Bloc1]	Trou320 [Buse180 Bloc1]
	Trou323 [Buse183 Bloc1]	Trou79 [Buse79 Bloc2]	Trou324 [Buse184 Bloc2]	Trou58 [Buse58 Bloc2]	Trou739 [Buse39 Bloc1]	Trou732 [Buse100 Bloc1]
	Trou20 [Buse20 Bloc1]	Trou744 [Buse200 Bloc2]	Trou321 [Buse181 Bloc2]	Trou740 [Buse43 Bloc2]	Trou78 [Buse78 Bloc1]	Trou755 [Buse100 Bloc1]
	Trou22 [Buse22 Bloc1]		Trou24 [Buse24 Bloc2]	Trou733 [Buse170 Bloc2]	Trou743 [Buse201 Bloc1]	
				Trou756 [Buse170 Bloc2]		

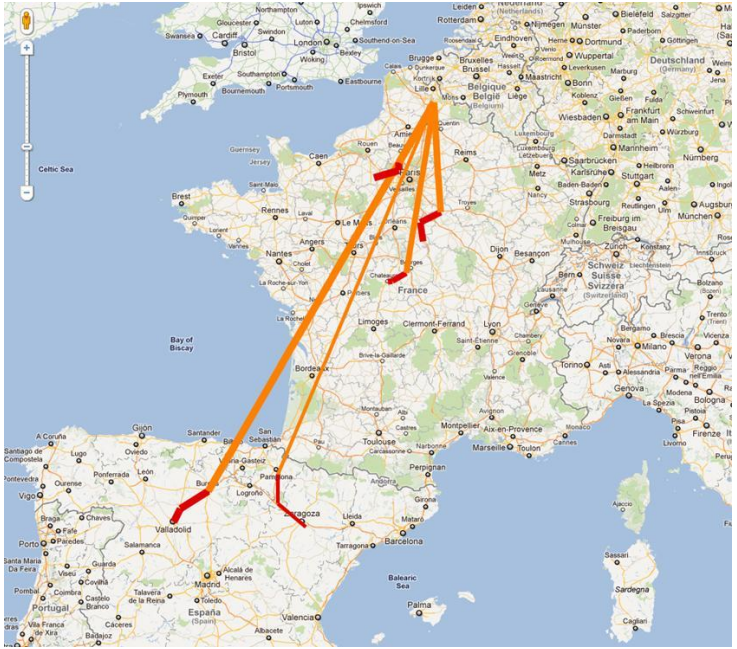
Column generation method

Network design for inbound flows (on request)

Routes towards Douai's plant (direct, milk-runs, x-dock)

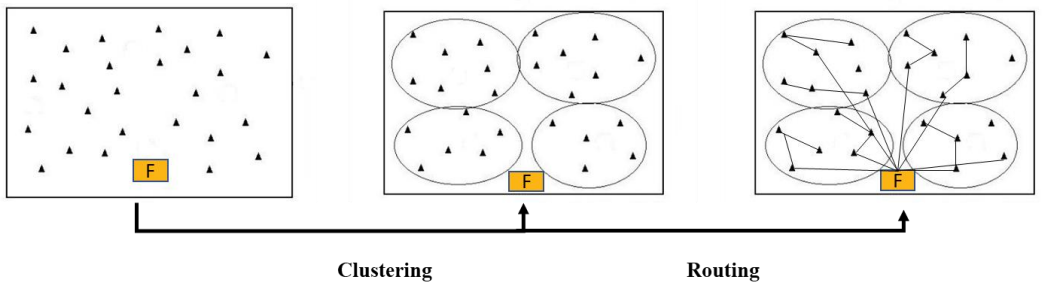


Milk-runs



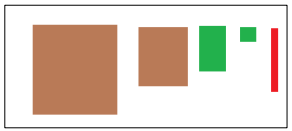
Optimization methods

1. Clustering: Partition of suppliers into clusters,
2. Routing: Identification of Direct and Indirect flows (MIP per cluster, MIP master problem)
3. Scheduling: Routes Assignment to weekdays (MIP).

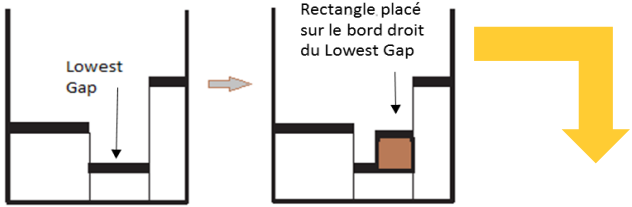


Trucks loading and orders anticipation (daily)

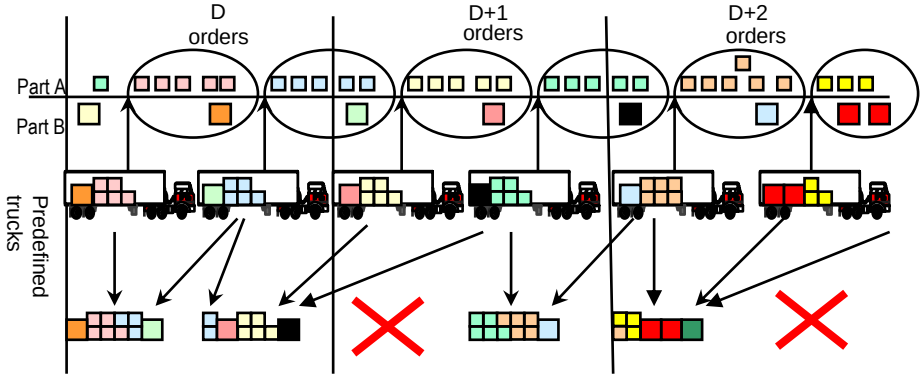
2D placement of items in the trucks with best fit heuristics



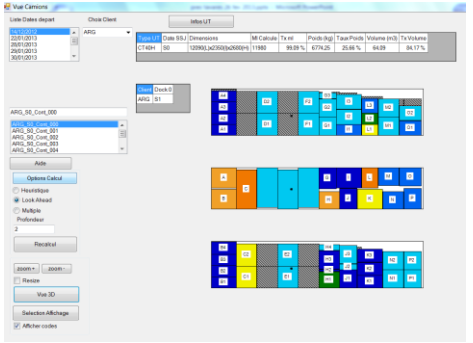
Items to place



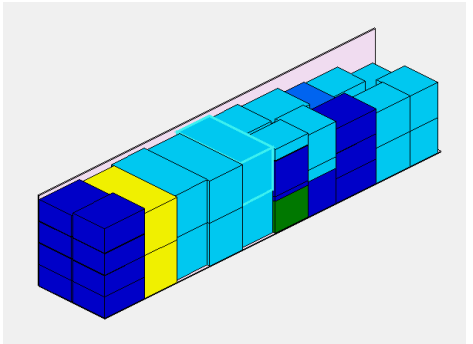
Build stacks and anticipate orders so as to maximize trucks filling rate
Construction heuristics + local search



3000 trucks / week – 7 weeks horizon / GCP



Visualization of trucks



Production volumes distribution
What-if scenario

Engine in shortage

Distribution of engine volumes between models ?

MIP optimization
- Min constraints
- Min/max satisfaction

Stock coverage

Vehicle plants capacities

Optimization web service

Sales forecasts and mix déformations authorized

Engine/gearbox plants capacities

Marginal profit per model

Volumes distribution which maximizes total profit

Q & A