Description of MLCLSP Test Instances

Hartmut Stadtler, Christopher Sürie

Technische Universität Darmstadt
Institut für Betriebswirtschaftslehre
Fachgebiet Fertigungs- und Materialwirtschaft
Hochschulstraße 1
D-64289 Darmstadt
E-Mail: stadtler@bwl.tu-darmstadt.de, suerie@bwl.tu-darmstadt.de
Correspondence to: Christopher Sürie

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1. Overview

The test instances provided here serve as a basis for computational tests on lot-sizing problems of the MLCLSP type without backlogging (Multi-Level Capacitated Lot-sizing Problem, see Sect. 2 for a model formulation). They are structured according to the test instances of Tempelmeier and Derstroff (1996) (available at http://www.uni-koeln.de/wiso-fak/spw/publikationen/index.htm). The test instances described here are characterised by a longer planning horizon and seasonality in the demand data. However, some instances of test sets C, D and E with corresponding attributes match the ones of Tempelmeier and Derstroff (1996) exactly.
The solutions made available via this website are not proven to be optimal, because of the problem size and the solution approach used. However, they are the best solutions known to the authors. The research community is encouraged to submit better or optimal solutions, which then will be made public, too.
The test instances are grouped into sets of test instances by the number of periods in the planning horizon (T), the number of products (items, operations) (J), the number of resource groups (M) and whether or not setup times are included in the model. Resulting are the eight sets shown in Table 1.

Test set	T	J	M	Setup times
A+	24	10	3	No
B+	24	10	3	Yes
C	16	40	6	No
C+	48	40	6	No
D	16	40	6	Yes
D+	48	40	6	Yes
E	16	100	10	No
E+	48	100	10	No

Table 1: Test sets

The test instance data of each test set is characterised by the following criteria:

- The demand series is described by the number of periods in the planning horizon (T), the length and amplitude of the seasonal demand pattern and different coefficients of variation for the demand data reflecting stochastic variations.

- The products/operations are defined by their number (J), their structure (general or assembly), different TBO profiles and whether or not setup times are modelled.
- The resources are described by their number (M), their assignment (cyclic or non-cyclic) and by different utilization profiles.

Please note, that computational tests have not been performed for all possible combinations of the test instance defining criteria and hence solutions are - so far - only available for a subset of the test instances.

2. Model formulation

The dynamic multi-level capacitated lot-sizing problem aims at minimizing variable production costs over a finite planning interval. The variable production costs considered comprise inventory holding and setup costs. The planning interval is divided into several periods t and limited by the planning horizon T.

For each period in the planning interval the end item demand is assumed to be known and has to be fulfilled without backlogging. Inventory holding costs are calculated based on the end-of-period inventory. Setup costs and setup times accrue for an item in each period of production.

Resources have limited capacities per period and may be extended by overtime.
I&L model formulation (Stadtler, 1996):

$$\textit{Min.} \quad \sum_{j=1}^{J}\sum_{t=1}^{T} h_j \cdot I_{jt} + \sum_{j=1}^{J}\sum_{t=1}^{T} sc_j \cdot Y_{jt} + \sum_{m=1}^{M}\sum_{t=1}^{T} oc_{mt} \cdot O_{mt} \tag{1.1}$$

subject to

$$I_{jt-1} + X_{jt} = P_{jt} + \sum_{k \in S_j} r_{jk}^{d} \cdot X_{kt} + I_{jt} \qquad \forall\, j=1, ..., J,\ t=1, ..., T \tag{1.2}$$

$$\sum_{j=1}^{J} a_{mj} \cdot X_{jt} + \sum_{j=1}^{J} st_{jm} \cdot Y_{jt} \le C_{mt} + O_{mt} \qquad \forall\, m=1, ..., M,\ t=1,...,T \tag{1.3}$$

$$X_{jt} \le B_{jt} \cdot Y_{jt} \qquad \forall\, j=1,...,J,\ t=1, ..., T \tag{1.4}$$

$$\left.\begin{aligned} I_{jt} &\ge 0 && \forall\, j=1, ..., J,\ t=1, ..., T \\ O_{mt} &\ge 0 && \forall\, m=1, ..., M,\ t=1, ..., T \\ X_{jt} &\ge 0 && \forall\, j=1, ..., J,\ t=1, ..., T \\ Y_{jt} &\in \{0,1\} && \forall\, j=1, ..., J,\ t=1, ..., T \end{aligned}\right\} \tag{1.5}$$

Indices and index sets:

j Items or operations (e.g. end products, intermediate products, raw materials), $j=1, ..., J$

m Resources (e.g. personnel, machines, production lines), $m=1, ..., M$

t Periods, $t=1, ..., T$

S_j Set of immediate successors of item j in the bill of material

Data:

a_{mj} Capacity needed on a resource m for one unit of item j

B_{jt} Large number, not limiting feasible lot-sizes of item j in period t

C_{mt} Available capacity of resource m in period t

h_j Holding cost for one unit of item j in a period

oc_{mt} Overtime cost for one unit of resource m in period t

P_{jt} Primary, gross demand for item j in period t

r^d_{jk} Number of units of item j required to produce one unit of the immediate successor item k

sc_j Setup cost for a lot of item j

st_{jm} Setup time for item j on resource m

Variables:

I_{jt} Inventory of item j at the end of period t

O_{mt} Amount of overtime on resource m used in period t

X_{jt} Production quantity of item j in period t (lot-size)

Y_{jt} Binary setup variable (=1, if item j is produced in period t, 0 otherwise)

The objective function (1.1) aims at minimizing the sum of inventory holding, setup and overtime costs. All other production costs are assumed to be fixed and independent of time, consequently no direct production costs are attributed to a lot-size X_{jt}.

Multi-level inventory balance constraints (1.2) make sure that no backlogging will occur. For multi-level production a lot-size of item k will result in a dependent demand for its immediate predecessor items j. Required capacities for lot-size production must not exceed available normal capacities (possibly extended by overtime; 1.3). Capacity requirements result from both production time per item times the amounts produced as well as setup times incurred with each lot. Setup constraints (1.4) enforce binary variables Y_{jt} to unity, in case a lot of item j is produced in a period t. All variables are restricted to non-negative or binary values, respectively (1.5).

3. Nomenclature

Each test instance is identified by a string comprising seven elements/positions.

Position	Criteria	Value	Attribute
1	Operations structure	G K	General Assembly
2	Resource assignment	0 5	Non-cyclic Cyclic
3	Setup time profile	0 1 2 3 4	Non Dependant on test set Dependant on test set Dependant on test set Dependant on test set
4	Coefficient of variation	1 2	Slight variations (0.1) Strong variations (0.2)
5	Resource utilization profile	1 2 3 4 5	90/90/90 70/70/70 50/50/50 90/70/50 50/70/90
6	TBO profile	2 3 4	Dependant on test set Dependant on test set Dependant on test set
7	Amplitude of seasonal pattern	0 1 2	No seasonality Slight seasonalitiy (0.3) Strong seasonality (0.5)

Table 2: Nomenclature of test instances

Example: G 5 0 1 1 3 0 defines a test instance with

- General product/operation structure (G),
- Cyclic resource assignment (5),
- No setup times (0),
- Slight demand variations (1),
- 90 % resource utilization on all resources (1),
- Test set specific TBO profile (3),
- No seasonality in the demand series (0).

4. Common Features for all Test Instances

4.1. Index Sets

R_m Set of products which can be produced on resource m

S_j Set of immediate successors of item j in the bill of material

4.2. Data

Mean net demand ($\overline{D}_j^n$) is calculated according to the specific product/operation structure based on mean primary demand:

$$\overline{D}_j^n = \overline{D}_j^p + \sum_{k \in S_j} r_{jk}^d \cdot \overline{D}_k^n$$

$a_{mj} = 1$ for all $m = 1, ..., M$ and $j \in R_m$
= capacity needed on resource m for the production of one unit of product j (production coefficient)

C_m $$C_m = \frac{\sum_{j \in R_m} a_{mj} \cdot \overline{D}_j^n + \sum_{j \in R_m} st_j}{RU_m}$$ for all $m = 1, ..., M$
= available capacity of resource m

$e_j = 1$ for all $j = 1, ..., J$
= marginal holding cost for product j

h_j $$h_j = e_j + \sum_{k=j+1}^{J} r_{kj}^d \cdot h_k$$ for all $j = J, ..., 1$
= holding cost for product j
(provided items are sorted according to their low level code in descending order)

$I_{j,0} = 0$ for all $j = 1, ..., J$
= starting inventory for product j

$I_{j,T} = 0$ for all $j = 1, ..., J$
= ending inventory for product j

$oc_{mt} = 10{,}000$ for all $m = 1, ..., M$ and $t = 1, ..., T$
= overtime cost for one unit of capacity on resource m in period t

$r_{jk}^d = 1$ for all $j = 1, ..., J$ and $k \in S_j$
= the number of units of product j required to produce one unit of its immediate successor product k

RU_m Resource utilization of resource m

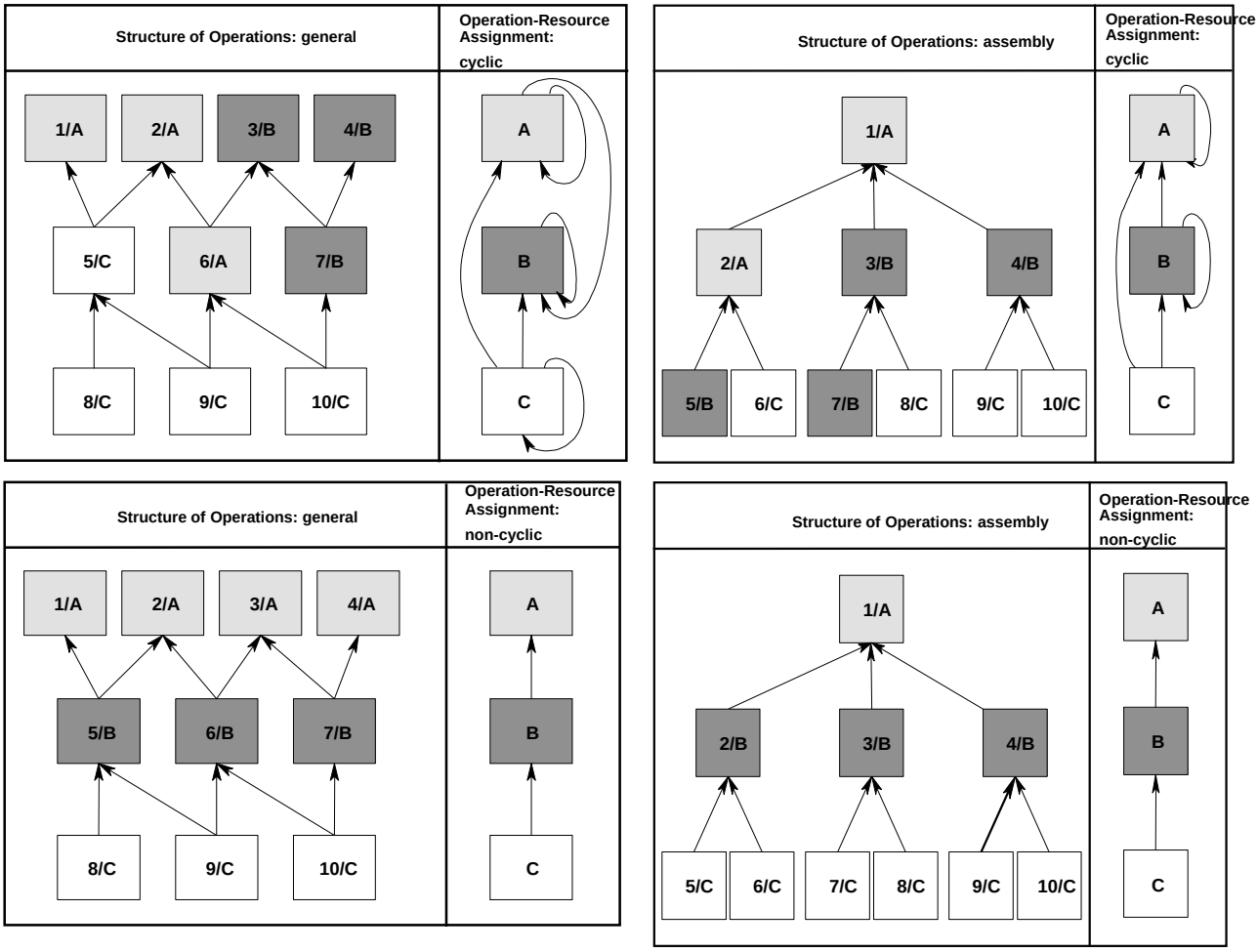
sc_j $sc_j = \frac{1}{2} \cdot e_j \cdot TBO_j^2 \cdot \overline{D}_j^n$ for all $j = 1, ..., J$
= setup cost for product j

5. Data of Test Sets

The following data is additionally provided in ASCII-files. See paragraph “6. Installation” for details.

5.1. Test Set A+

Structure of operations and resource assignment:



Demand Series:

Criteria			Product j	Primary demand P_{jt} t=1, 2, ..., T
Operations structure	Coefficient of variation	Amplitude of seasonal pattern		
G	1	0	1	64,80,73,75,55,62,73,69,66,72,78,73,79,66,66,77,57,78,67,59,86,68,62,84
			2	28,29,31,32,31,30,34,28,29,30,27,26,36,26,30,31,26,37,33,31,27,29,29,32
			3	48,53,52,52,48,47,51,52,50,53,48,51,54,47,49,53,47,45,50,47,40,48,50,47
			4	94,119,104,104,95,115,106,100,114,106,105,133,89,99,79,90,124,98,117,89,84,103,105,91
G	1	1	1	53,49,62,57,50,62,72,70,84,87,100,95,94,90,95,86,89,64,73,63,60,50,55,55
			2	21,24,23,22,25,29,27,33,36,34,38,43,43,34,38,32,30,30,28,28,27,28,22,23
			3	35,37,39,40,41,46,50,53,61,62,65,64,61,65,69,74,60,46,53,45,39,41,37,36
			4	59,71,85,94,96,90,81,90,119,103,123,98,127,98,128,133,131,99,98,104,84,74,59,74
G	1	2	1	38,32,41,50,47,67,65,71,81,89,115,88,112,98,109,91,76,81,72,56,53,42,39,38
			2	18,15,17,19,23,24,29,35,34,41,40,45,44,38,40,41,39,33,27,28,26,24,17,14
			3	25,27,30,33,43,45,52,68,64,70,57,63,68,61,88,80,58,62,49,38,32,36,30,25
			4	48,55,53,74,80,83,102,108,125,152,140,152,169,131,168,118,110,126,82,71,81,57,59,49
G	2	0	1	59,87,100,85,76,86,69,71,76,73,82,74,71,81,92,84,55,43,54,66,74,75,67,71
			2	27,32,36,40,34,15,42,23,33,30,22,31,29,38,24,29,29,22,27,38,31,18,32,24
			3	35,32,53,57,60,44,51,38,37,56,62,58,47,51,44,61,60,50,62,42,48,43,63,50
			4	74,104,123,136,99,107,112,86,110,108,118,113,126,115,88,78,73,108,77,86,102,102,92,126
G	2	1	1	53,39,60,61,85,65,68,59,54,132,111,92,70,86,101,65,86,66,58,79,56,53,47,58
			2	19,21,28,18,31,24,29,28,42,39,33,43,49,28,37,40,37,29,22,31,27,22,22,26
			3	36,42,41,33,36,43,38,45,48,68,78,44,80,64,81,66,35,54,56,70,53,34,45,42
			4	54,69,75,70,103,109,108,120,116,77,117,118,184,143,123,70,101,105,99,94,66,97,69,75
G	2	2	1	33,33,34,40,48,51,72,84,119,133,94,101,119,93,95,72,105,85,84,101,62,54,51,27
			2	12,14,16,26,23,25,32,38,40,26,43,49,59,37,44,37,49,27,20,24,22,20,18,15
			3	27,23,20,38,47,34,53,58,69,73,74,80,86,90,60,63,59,51,42,55,43,44,35,31
			4	53,43,75,41,57,51,103,165,170,88,119,170,150,173,119,116,162,111,67,93,73,78,60,58
K	1	0	1	97,123,114,101,103,97,92,98,104,87,102,113,92,101,91,90,88,97,89,88,82,94,91,110
K	1	1	1	69,77,72,75,94,92,111,96,117,123,123,126,141,124,128,100,118,121,119,101,81,76,74,64
K	1	2	1	53,48,52,67,49,86,85,108,110,157,149,140,152,143,138,134,112,107,112,85,60,73,64,47
K	2	0	1	73,123,94,100,94,88,134,114,109,111,91,100,97,96,134,107,126,94,61,91,88,87,113,103
K	2	1	1	56,40,69,109,76,75,65,80,112,138,98,126,126,152,171,52,123,93,139,88,86,96,72,89
K	2	2	1	60,37,45,53,53,59,102,93,155,167,112,145,135,128,117,109,165,99,87,77,83,71,57,47

TBO profiles:

Operations structure	TBO profile	Product j		
		TBO = 2	TBO = 4	TBO = 6
G	3		1..10	
G	4	1..4	5..7	8..10
K	3		1..10	
K	4	1	2..4	5..10

Utilization profile:

Utilization profile	Resource utilization RU_m		
	Resource 1	Resource 2	Resource 3
1	90 %	90 %	90 %
2	70 %	70 %	70 %
3	50 %	50 %	50 %
4	90 %	70 %	50 %
5	50 %	70 %	90 %

Mean primary demand:

Mean primary demand ($\overline{D}_j^p$, as used for calculation of capacities and setup costs).

(**Please note:** For some demand series the mean primary demand used for the calculation of the capacities varies slightly from the mean demand of the respective demand series. This is due to the fact that the demand series fulfil specific stochastic criteria (coefficient of variation, amplitude of seasonal pattern.))

Product *j*		**1**	**2**	**3**	**4**	**5..10**
Operations structure	**General**	70	30	50	100	0
	Assembly	100	0	0	0	0

5.2. Test Set B+

Structure of operations and resource assignment: see test set A+

Demand Series: see test set A+

TBO profiles: see test set A+

Utilization profile: see test set A+

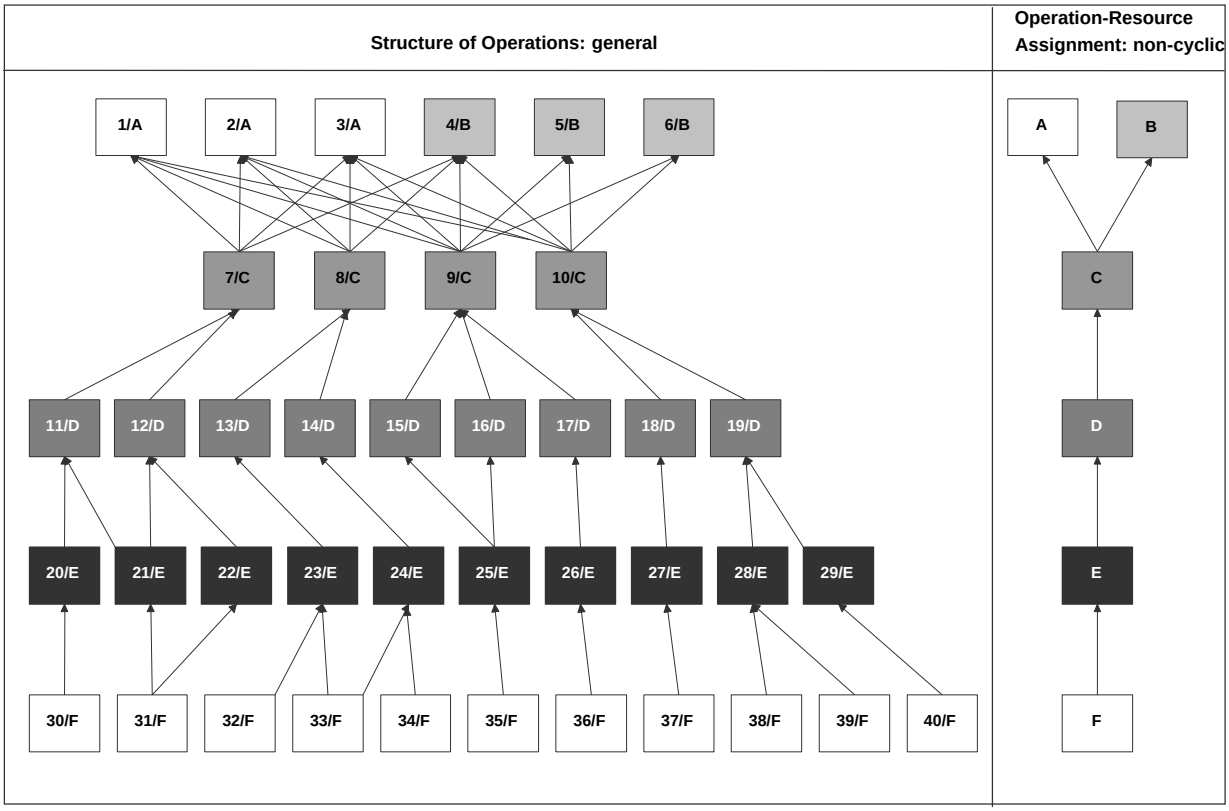
Mean primary demand ($\overline{D}_j^p$): see test set A+

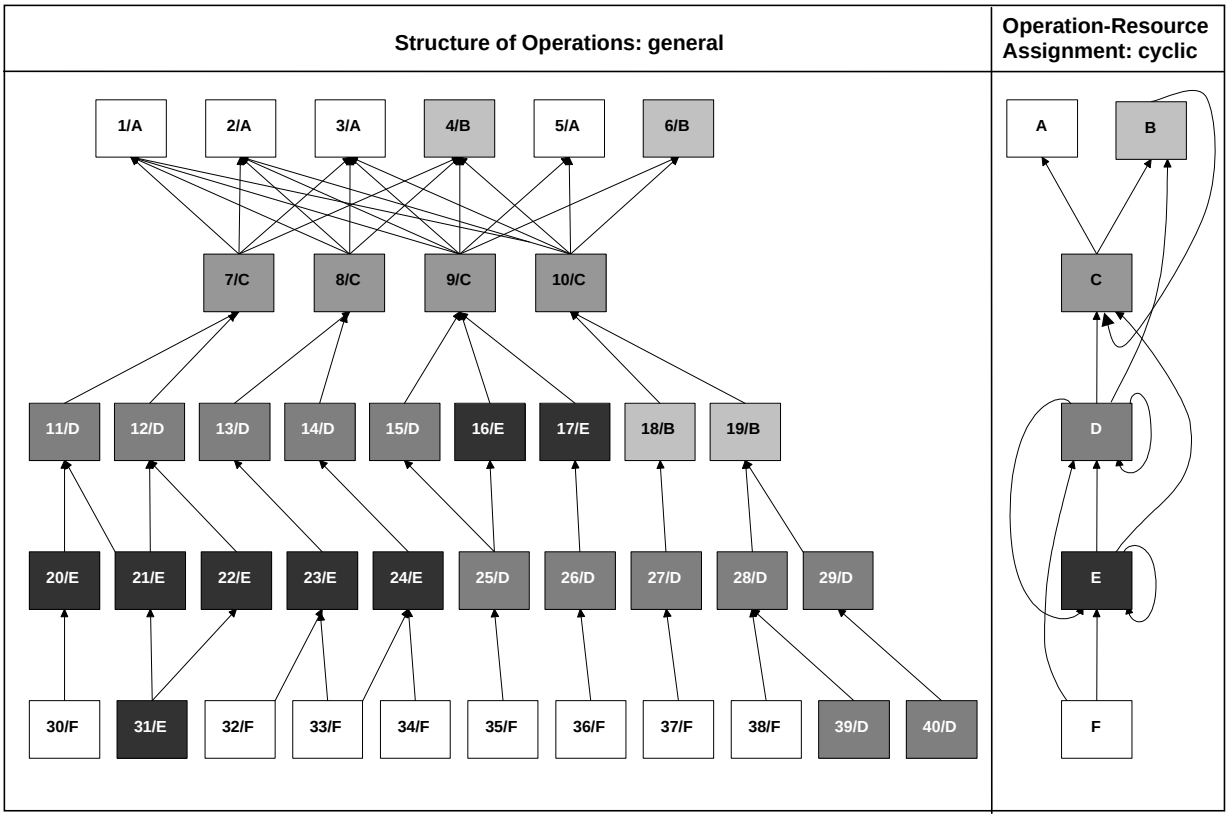
Setup time profiles:

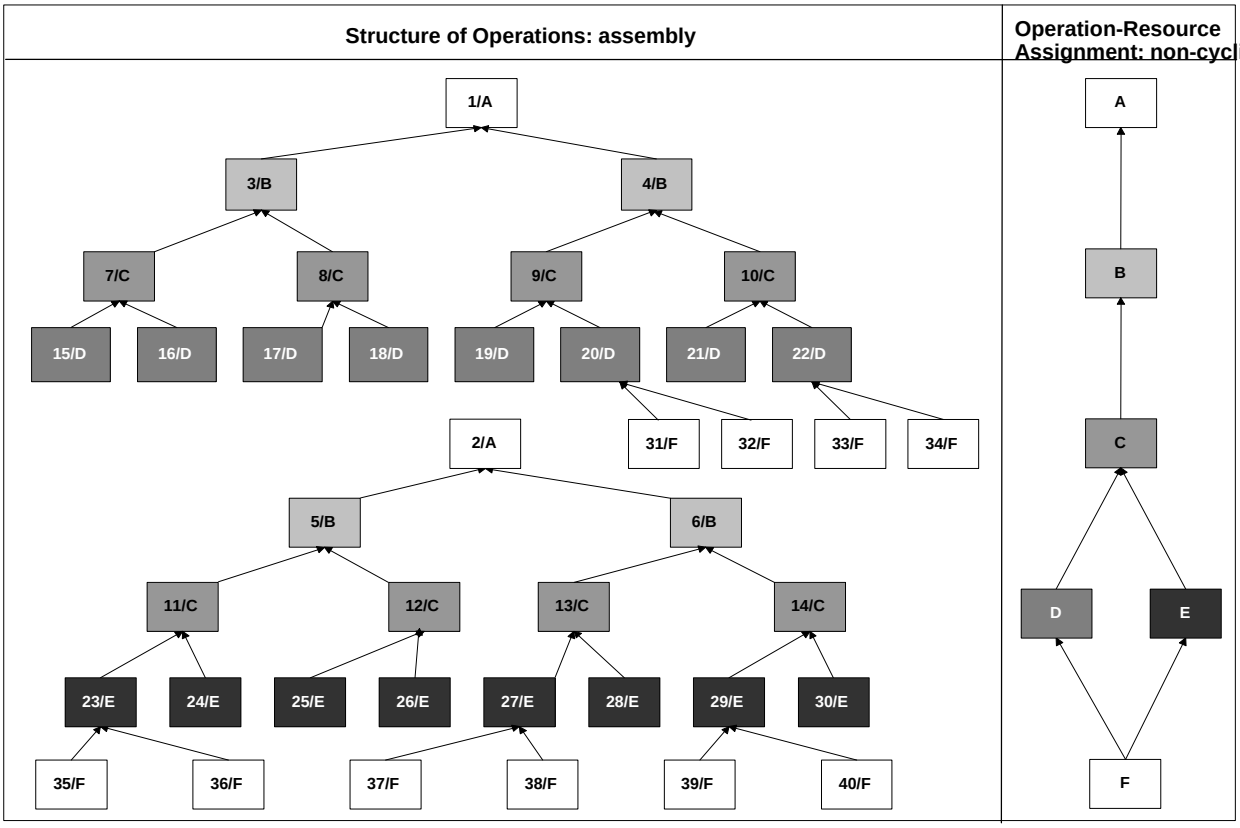
Setup time profile	**Product *j***		
	1, 2, 5, 6	3, 4	7..10
1	$st_j = 10$	$st_j = 15$	$st_j = 5$
2	$st_j = 10$	$st_j = 5$	$st_j = 15$
3	$st_j = 30$	$st_j = 45$	$st_j = 15$
4	$st_j = 30$	$st_j = 15$	$st_j = 45$

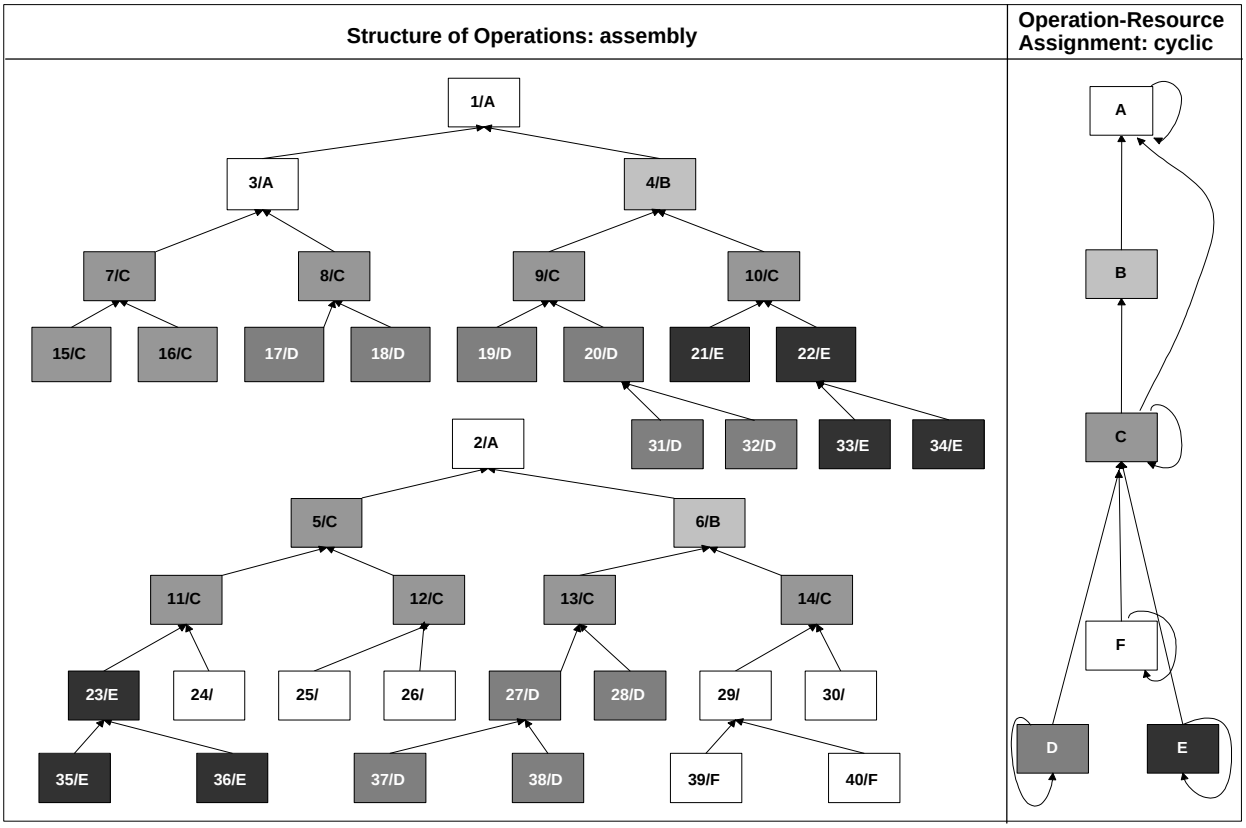
5.3. Test Set C

Structure of operations and resource assignment:






Structure of Operations: assembly
Operation-Resource Assignment: non-cyclic
1/A
3/B
4/B
7/C
8/C
9/C
10/C
15/D
16/D
17/D
18/D
19/D
20/D
21/D
22/D
2/A
31/F
32/F
33/F
34/F
5/B
6/B
11/C
12/C
13/C
14/C
23/E
24/E
25/E
26/E
27/E
28/E
29/E
30/E
35/F
36/F
37/F
38/F
39/F
40/F
A
B
C
D
E
F


Structure of Operations: assembly
Operation-Resource Assignment: cyclic
1/A
3/A
4/B
7/C
8/C
9/C
10/C
15/C
16/C
17/D
18/D
19/D
20/D
21/E
22/E
2/A
31/D
32/D
33/E
34/E
5/C
6/B
11/C
12/C
13/C
14/C
23/E
24/
25/
26/
27/D
28/D
29/
30/
35/E
36/E
37/D
38/D
39/F
40/F
A
B
C
F
D
E

Demand Series:

Criteria			Product j	Primary demand P_{jt} t=1, 2, ..., T
Operations structure	Coefficient of variation	Amplitude of seasonal pattern		
G	1	0	1	40,33,43,41,43,32,42,42,41,39,38,45,38,35,46,42
			2	20,18,21,21,19,19,17,23,19,18,22,17,24,21,18,23
			3	27,27,34,30,27,31,34,30,27,30,26,37,28,31,28,33
			4	60,54,64,62,60,48,70,60,62,46,63,66,65,60,56,64
			5	20,19,21,14,21,21,22,21,21,20,19,19,21,19,19,23
			6	28,30,25,30,30,26,31,36,31,28,32,25,31,34,33,30
G	1	1	1	28;25;38;40;47;38;53;54;52;47;42;45;33;27;33;29
			2	14;14;18;20;21;23;21;29;24;21;24;17;21;16;13;16
			3	19;21;30;29;30;37;43;38;34;36;29;37;24;24;20;23
			4	43;42;56;61;66;58;89;77;79;55;70;66;57;47;40;44
			5	14;14;18;13;23;25;28;27;26;24;21;19;18;14;13;16
			6	20;23;22;29;33;31;39;46;39;33;35;25;27;26;23;21
G	1	2	1	21;21;34;40;51;43;61;62;59;52;45;45;30;22;24;21
			2	10;11;16;20;22;25;24;34;27;24;26;17;19;13;9;11
			3	14;17;27;29;32;41;49;44;39;40;31;37;22;20;15;16
			4	32;34;51;61;71;64;102;89;90;62;75;66;52;38;30;32
			5	10;12;16;13;25;28;32;31;30;27;22;19;17;12;10;11
			6	15;19;20;29;35;35;45;53;45;37;38;25;25;22;17;15
G	2	0	1	40;47;46;42;41;48;51;35;47;25;44;37;24;33;43;37
			2	23;19;22;27;22;23;19;26;16;11;16;16;21;20;21;18
			3	31;32;41;28;35;26;28;36;21;31;19;27;32;23;40;30
			4	47;60;84;61;59;65;75;74;55;59;48;48;43;77;66;71
			5	16;27;19;15;12;19;22;19;20;24;19;25;25;19;17;22
			6	24;31;32;33;28;22;36;34;34;33;40;25;35;24;33;16
G	2	1	1	28;37;40;41;45;58;65;45;60;30;49;37;21;26;31;25
			2	16;14;19;26;24;27;24;33;20;13;17;16;18;15;15;12
			3	22;25;36;27;39;31;35;46;26;37;21;27;28;18;28;21
			4	33;47;74;60;65;78;95;96;70;71;53;48;38;60;47;49
			5	11;21;16;14;13;23;28;24;25;29;21;25;22;14;12;15
			6	17;24;28;32;31;26;45;44;43;40;44;25;31;18;23;11
G	2	2	1	21;30;37;41;48;64;74;52;68;33;52;37;19;21;23;18
			2	12;12;17;26;26;31;27;38;23;14;19;16;17;12;11;9
			3	16;20;33;27;41;35;40;53;30;41;22;27;25;14;21;15
			4	25;38;67;60;70;87;109;110;80;79;57;48;34;49;35;35
			5	8;17;15;14;14;25;32;28;29;32;22;25;20;12;9;11
			6	12;20;25;32;33;29;52;50;49;44;47;25;28;15;17;8
K	1	0	1	20;18;21;21;19;19;17;23;19;18;22;17;24;21;18;23
			2	27;27;34;30;27;31;34;30;27;30;26;37;28;31;28;33
K	1	1	1	14;14;18;20;21;23;21;29;24;21;24;17;21;16;13;16
			2	19;21;30;29;30;37;43;38;34;36;29;37;24;24;20;23
K	1	2	1	10;11;16;20;22;25;24;34;27;24;26;17;19;13;9;11
			2	14;17;27;29;32;41;49;44;39;40;31;37;22;20;15;16
K	2	0	1	23;19;22;27;22;23;19;26;16;11;16;16;21;20;21;18
			2	31;32;41;28;35;26;28;36;21;31;19;27;32;23;40;30
K	2	1	1	16;14;19;26;24;27;24;33;20;13;17;16;18;15;15;12

			2	22;25;36;27;39;31;35;46;26;37;21;27;28;18;28;21
K	2	2	1	12;12;17;26;26;31;27;38;23;14;19;16;17;12;11;9
			2	16;20;33;27;41;35;40;53;30;41;22;27;25;14;21;15

TBO profiles:

Operations structure	TBO profile	**Product *j***		
		TBO = 2	TBO = 4	TBO = 6
G	2			1..40
G	3		1..40	
G	4	1..6	5..29	30..40
K	2			1..40
K	3		1..40	
K	4	1..2	3..30	31..40

Utilization profile:

Utilization profile	**Resource utilization RU_m**		
	Resource 1, 2	Resource 3, 4	Resource 5, 6
1	90 %	90 %	90 %
2	70 %	70 %	70 %
3	50 %	50 %	50 %
4	90 %	70 %	50 %
5	50 %	70 %	90 %

Mean primary demand:
Mean primary demand ($\overline{D}_j^p$, as used for calculation of capacities and setup costs):

(**Please note:** For some demand series the mean primary demand used for the calculation of the capacities varies slightly from the mean demand of the respective demand series. This is due to the fact that the demand series fulfil specific stochastic criteria (coefficient of variation, amplitude of seasonal pattern.))

Product *j*		**1**	**2**	**3**	**4**	**5**	**6**	**7..40**
Operations structure	**General**	40	20	30	60	20	30	0
	Assembly	20	30	0	0	0	0	0

5.4. Test Set C+

Structure of operations and resource assignment: see test set C

Demand Series: Demand Series of test set C have been trebled.

TBO profiles: see test set C

Utilization profile: see test set C

Mean primary demand ($\overline{D}_j^p$): see test set C

5.5. Test Set D

Structure of operations and resource assignment: see test set C

Demand Series: see test set C

TBO profiles: see test set C

Utilization profile: see test set C

Mean primary demand ($\overline{D}_j^p$): see test set C

Setup time profiles:

Setup time profile	**Product *j***			
	1..10	11..20	21..30	31..40
1	$st_j=50$	$st_j=40$	$st_j=30$	$st_j=20$
4	$st_j=60$	$st_j=90$	$st_j=120$	$st_j=150$

5.6. Test Set D+

Structure of operations and resource assignment: see test set C

Demand Series: see test set C+

TBO profiles: see test set C

Utilization profile: see test set C

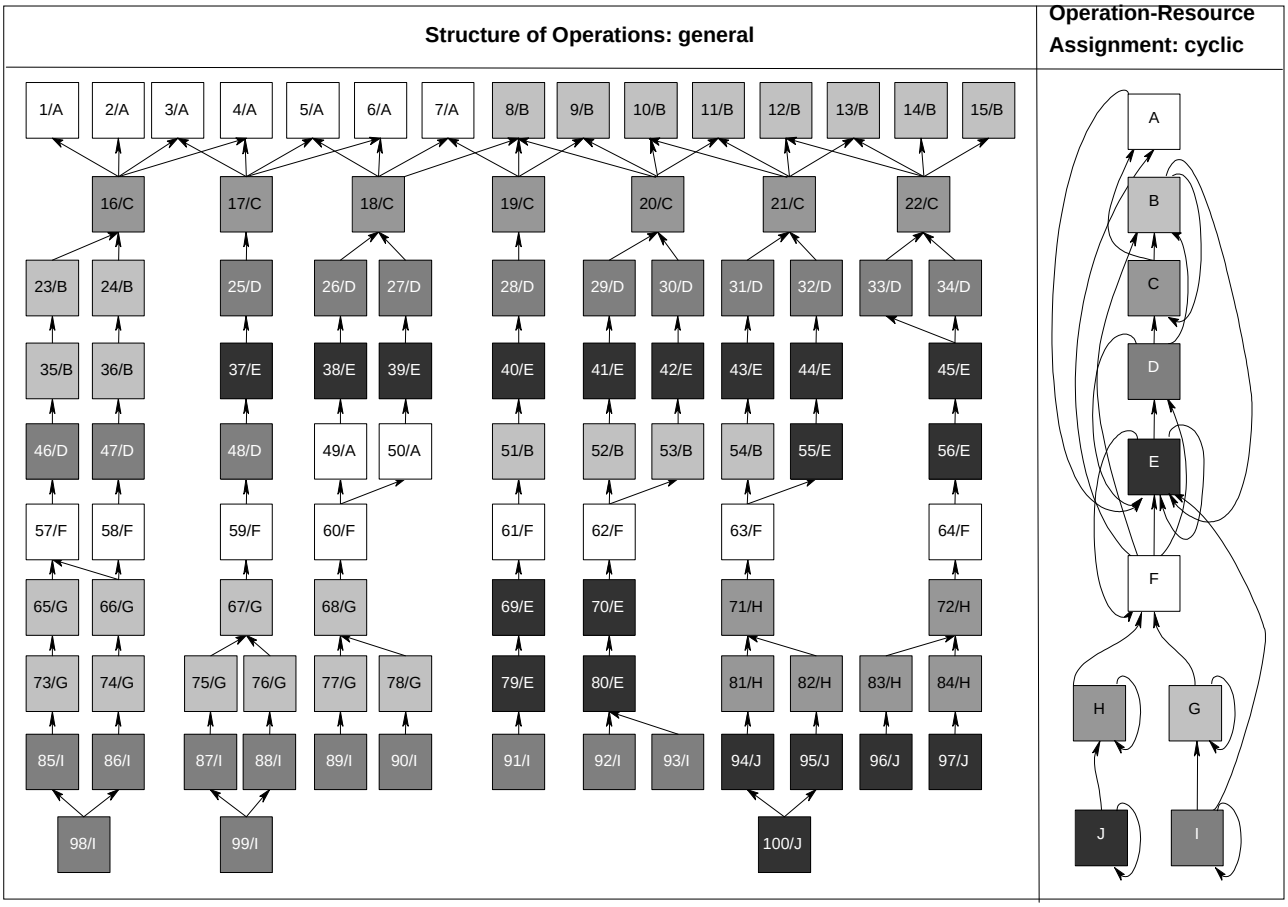
Mean primary demand ($\overline{D}_j^p$): see test set C

Setup time profiles: see test set D

Setup time profile	**Product *j***			
	1..10	11..20	21..30	31..40
1	$st_j=50$	$st_j=40$	$st_j=30$	$st_j=20$
4	$st_j=60$	$st_j=90$	$st_j=120$	$st_j=150$

5.7. Test Set E

Structure of operations and resource assignment:



Demand Series:

Criteria			Product j	Primary demand P_{jt} t=1, 2, ..., T
Operations structure	Coefficient of variation	Amplitude of seasonal pattern		
G	1	0	1	95, 98, 103, 88, 108, 89, 115, 79, 117, 98, 99, 105, 100, 96, 96, 114
			2	36, 38, 44, 40, 36, 43, 39, 38, 36, 47, 39, 36, 41, 36, 50, 41
			3	109, 120, 115, 136, 101, 116, 112, 146, 117, 115, 131, 114, 123, 123, 104, 138
			4	97, 85, 104, 98, 111, 99, 104, 94, 107, 77, 117, 97, 109, 101, 91, 109
			5	119, 138, 129, 115, 148, 126, 135, 127, 128, 134, 102, 148, 123, 128, 124, 156
			6	49, 51, 48, 51, 41, 58, 43, 55, 46, 54, 41, 58, 52, 51, 51, 51
			7	55, 60, 54, 68, 57, 66, 58, 57, 65, 52, 56, 70, 59, 49, 66, 68
			8	117, 123, 98, 141, 121, 99, 114, 112, 113, 120, 134, 133, 132, 109,129,125
			9	66, 69, 54, 78, 76, 69, 73, 68, 70, 66, 81, 66, 57, 76, 76, 75
			10	119, 96, 124, 124, 124, 106, 119, 107, 112, 135, 137, 115, 130, 106, 139, 127
			11	96, 101, 103, 91, 105, 81, 105, 109, 93, 85, 118, 94, 110, 103, 92, 114
			12	39, 38, 38, 41, 40, 41, 33, 48, 36, 45, 33, 46, 39, 42, 41, 40
			13	18, 21, 19, 17, 24, 19, 17, 20, 22, 21, 21, 21, 18, 18, 23, 21
			14	32, 41, 44, 41, 40, 34, 43, 44, 41, 34, 44, 38, 43, 39, 37, 45
			15	51, 50, 58, 60, 60, 54, 66, 62, 65, 50, 59, 72, 62, 64, 62, 65
G	2	0	1	65, 93, 110, 127, 134, 92, 123, 103, 76, 108, 74, 99, 119, 80, 97, 100
			2	39, 42, 34, 39, 40, 47, 43, 23, 39, 49, 41, 46, 45, 54, 32, 27
			3	121, 86, 155, 106, 102, 147, 71, 122, 144, 134, 132, 127, 136, 132, 80, 125
			4	112, 114, 97, 76, 120, 108, 79, 77, 69, 123, 88, 99, 78, 103, 119, 138
			5	128, 164, 119, 159, 151, 120, 131, 87, 102, 87, 132, 167, 164, 124, 118, 127
			6	47, 69, 43, 41, 46, 53, 39, 51, 46, 51, 45, 50, 36, 70, 66, 47
			7	77, 45, 51, 59, 75, 51, 81, 63, 50, 59, 53, 76, 52, 50, 72, 46
			8	130, 84, 115, 119, 89, 135, 129, 88, 157, 104, 145, 161, 142, 112, 105, 105
			9	74, 76, 43, 87, 58, 58, 67, 91, 78, 51, 70, 94, 65, 76, 69, 63
			10	110, 114, 92, 141, 121, 132, 147, 106, 108, 125, 111, 66, 162, 155, 112, 118
			11	136, 115, 66, 104, 89, 82, 97, 98, 113, 99, 66, 118, 118, 103, 118, 78
			12	34, 43, 39, 29, 27, 41, 41, 26, 45, 46, 39, 46, 39, 45, 43, 57
			13	18, 17, 23, 14, 21, 14, 19, 23, 13, 18, 24, 25, 24, 22, 20, 25
			14	53, 31, 41, 26, 31, 48, 40, 51, 36, 47, 34, 41, 40, 36, 50, 35
			15	51, 47, 74, 42, 65, 68, 58, 71, 45, 55, 52, 59, 72, 73, 80, 48

TBO profiles:

Operations structure	TBO profile	Product j		
		TBO = 1	TBO = 3	TBO = 5
G	2		1..100	
G	3			1..100
G	4	1..33	34..66	67..100

Utilization profile:

Utilization profile	Resource utilization RU_m		
	Resource 1..3	Resource 4..7	Resource 8..10
1	90 %	90 %	90 %
2	70 %	70 %	70 %
3	50 %	50 %	50 %
4	90 %	70 %	50 %
5	50 %	70 %	90 %

Mean primary demand:
Mean primary demand ($\overline{D}_j^p$, as used for calculation of capacities and setup costs):
(**Please note:** For some demand series the mean primary demand used for the calculation of the capacities varies slightly from the mean demand of the respective demand series. This is due to the fact that the demand series fulfil specific stochastic criteria (coefficient of variation, amplitude of seasonal pattern.))

Product *j*		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Operations structure	**General**	100	40	120	100	130	50	60	120
Product *j*		**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16 .. 100**
Operations structure	**General**	70	120	100	40	20	40	60	0

5.8. Test Set E+

Structure of operations and resource assignment: see test set E

Demand Series: Demand Series of test set E have been trebled.

TBO profiles: see test set E

Utilization profile: see test set E

Mean primary demand ($\overline{D}_j^p$): see test set E

6. Installation

Each test set comprises several master files containing the data described in Sect. 5 and a batch file that creates specific test instances using the master files. This procedure allows to create all possible test instances with systematic variation of attributes without saving each test instance separately.
The batch file (start_ini.bat) sets two environment variables, one (ORIGINALDIR) is the directory path, where the master files are stored and the other one (DATENDIR) is the path of the directory, where the test instance files will be stored. The user will have to specify these environment variables according to his specific directory structure. Then the batch file will create a test instance by copying several master files from ORIGINALDIR to DATENDIR and then renaming them. To execute start_ini properly the user will have to specify seven parameters according to the nomenclature given in Sect. 3.

Example: Original data of test set A+ is stored in C:\DATA\SET_A
Test instance G 5 0 1 1 3 0 shall be created in C:\TEMP

(1) Adjust the following lines in start_ini.bat according to the given directories:
set ORIGINALDIR=C:\DATA\SET_A

set DATENDIR=C:\TEMP

(2) Enter "start_ini G 5 0 1 1 3 0" at the DOS prompt.

Finally DATENDIR will consist of the following files with these contents:

Filename	Content	Structure
AUSLAST.PRN	Resource utilization profile	1 Row, M Columns (per machine)
DIREKT-B.PRN	Demand coefficients	Each Row: j, k, r_{jk}^{d}
INDEX.PRN	Index data	1 Row: J, T, M
L0.PRN	Beginning inventories	1 Row, J Columns (per product)
LT.PRN	Ending inventories	1 Row, J Columns (per product)
MITT_BED.PRN	Mean primary Demand	1 Row, J Columns (per product)
P-BEDARF.PRN	Demand series	J Rows (products), T Columns (periods)
PRODKOEF.PRN	Production coefficients	Each Row: m, j, a_{mj}
RUESTZ.PRN	Setup time profiles	Each Row: m, j, st_{jm}
TBO.PRN	TBO profiles	J Rows (per product), 1 Column
UEBER-KS.PRN	Overtime cost coefficients	M Rows (per machine), 1 Column
ZFKOEF.PRN	Marginal holding cost coefficients	1 Row, J Columns (per product)

7. Solutions

The best solutions known to us are available as spreadsheets (MS-EXCEL) organized as follows:

Test instance							Solution
G	5	0	1	1	3	0	151781,07
G	5	0	1	1	3	1	146733,222

8. References

Stadtler, H. (1996): Mixed integer programming model formulations for dynamic multi-item multi-level capacitated lotsizing, in: European Journal of Operational Research, Vol. 94, p. 561-581

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Tempelmeier, H. / Derstroff, M. (1996): A Lagrangean-based Heuristic for Dynamic Multilevel Multiitem Constrained Lotsizing with Setup Times, in: Management Science, Vol. 52, No. 5, p. 738-757