# GTAAP Data Sets: From Spring 2001 to Spring 2003 (inclusive)

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**Abstract**

This report is about the initial data-sets of the GTA assignment problem available in the form of text files. The latter data-sets are available only from the MySQL database.

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# 1 GTA data-sets

The GTA assignment problem has provided us with 12 sets of real-world data. They are described below:

1. Spring2001b(B): Contains the boosted data of 2001 spring semester. This is different from the data Rob Glaubius used. The difference is due to some errors in Rob's data which are fixed in this data-set. The "b" in the name of the data-set refers to this difference. The "B" refers to the boosted nature of the data-set. The data-sets are boosted by the addition of dummy GTAs (Table 1). This was done by Hui Zou.
2. Spring2001b(O): This is the original data of 2001 spring semester. Differs from the data used by Rob because of the fixed errors. The "O" refers to the original nature of the data-set.
3. Fall2001b(B): This is the boosted data of 2001 fall semester. Differs from the data used by Rob because of the fixed errors.
4. Fall2001b(O): This is the original data of 2001 fall semester. Differs from the data used by Rob because of the fixed errors.
5. Fall2002(B): This is the boosted data of 2002 fall semester.
6. Fall2002(O): Original data of 2002 fall semester.
7. Spring2003(B): Boosted data of 2003 spring semester.
8. Spring2003(O): Original data of 2003 spring semester.
9. Fall2002(B)-NP: Boosted data of 2002 fall semester without pre-assignments. The "NP" stands for no pre-assignments.
10. Fall2002(O)-NP: Original data of 2002 fall semester without pre-assignments.
11. Spring2003(B)-NP: Boosted data of 2003 spring semester without pre-assignments.
12. Spring2003(O)-NP: Original data of 2003 spring semester without pre-assignments.

Only Fall2002 and Spring2003 data-sets had pre-assignments. Removing these pre-assignments gave us the 4 data-sets listed in 9, 10, 11 and 12.

All these data-sets are stored under the DATA directory. The following directory tree illustrates the directory structure:

```
/home/misc/gta/GTA-Data-Sets/DATA-+
                                  |-- Fall2001b(B)
                                  |-- Fall2001b(O)
                                  |-- Fall2002(B)
                                  |-- Fall2002(B)-NP
                                  |-- Fall2002(O)
                                  |-- Fall2002(O)-NP
                                  |-- Spring2001b(B)
                                  |-- Spring2001b(O)
                                  |-- Spring2003(B)
                                  |-- Spring2003(B)-NP
                                  |-- Spring2003(O)
                                  |-- Spring2003(O)-NP
```

The directory of each data-set (For example: Fall2001b(O)) contains the following files:

- **constraint-data**: contains data of courses that require same GTA. It also contains courses that require their assigned GTA to be confined within themselves.
- **exceptions.lisp**: contains courses that do not require GTAs and courses that have pre-assigned GTAs.
- **grading**: contains data about courses that require GTAs to be graders.
- **gtas**: contains data about all GTAs.
- **lab**: contains data about courses that are lab courses.
- **lecture**: contains data about courses that are lecture courses.
- **recitation**: contains data about courses that are recitation courses.
- **short-grading**: contains data about half-semester courses that require GTAs to be graders.
- **short-lab**: contains data about half-semester courses that are lab courses.
- **short-lecture**: contains data about half-semester courses that are lecture courses.
- **short-recitation**: contains data about half-semester courses that are recitation courses.

Some of the files may be empty, but they should be present. Table 1 describes the characteristics of the data-sets.

Table 1: *Characteristics of the GTA Data Sets.*

| **Data Sets** | **Data Sets reference** | **Original/Boosted** | **Solvable?** | **#GTAs/Domain size** | **#Courses/#variables** | **Total capacity** | **Total load** | **Ratio =** $\frac{\text{TotalCapacity}}{\text{TotalLoad}}$ | **#Unary constraints** | **#Binary constraints** | **#Non-Binary constraints** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring2001b(B) | 1 | B | $\surd$ | 35 | 69 | 35 | 29.6 | 1.18 | 277 | 1179 | 70 |
| Spring2001b(O) | 2 | O | $\times$ | 26 | 69 | 26 | 29.6 | 0.88 | 277 | 1179 | 52 |
| Fall2001b(B) | 3 | B | $\surd$ | 35 | 65 | 31 | 29.3 | 1.06 | 267 | 1676 | 70 |
| Fall2001b(O) | 4 | O | $\surd$ | 34 | 65 | 30 | 29.3 | 1.02 | 267 | 1676 | 68 |
| Fall2002(B) | 5 | B | $\surd$ | 33 | 31 | 16.5 | 13 | 1.27 | 233 | 1124 | 66 |
| Fall2002(O) | 6 | O | $\times$ | 28 | 31 | 11.5 | 13 | 0.88 | 233 | 1124 | 56 |
| Spring2003(B) | 7 | B | $\surd$ | 36 | 54 | 29.5 | 27.4 | 1.08 | 250 | 622 | 72 |
| Spring2003(O) | 8 | O | $\surd$ | 34 | 54 | 27.5 | 27.4 | 1.00 | 250 | 622 | 68 |
| Fall2002(B)-NP | 9 | B | $\times$ | 33 | 59 | 32 | 29.5 | 1.08 | 233 | 1124 | 66 |
| Fall2002(O)-NP | 10 | O | $\times$ | 28 | 59 | 27 | 29.5 | 0.91 | 233 | 1124 | 56 |
| Spring2003(B)-NP | 11 | B | $\surd$ | 36 | 64 | 33 | 30.2 | 1.09 | 250 | 622 | 72 |
| Spring2003(O)-NP | 12 | O | $\surd$ | 34 | 64 | 31 | 30.2 | 1.02 | 250 | 622 | 68 |

Table 2: *Characteristics of the Constraints.*

| **Data Sets** | **#Unary constraints** | **Binary constraints** | | **Non-Binary constraints** | | | | **Degree** | |
|---|---|---|---|---|---|---|---|---|---|
| | | #Mutex constraints | #Equality constraints | #Capacity constraints | Maximum arity | Mean arity | Minimum arity | Mean | Standard Deviation |
| 1 | 277 | 1146 | 33 | 70 | 63 | 63 | 63 | 102.10 | 26.85 |
| 2 | 277 | 1146 | 33 | 52 | 63 | 63 | 63 | 85.66 | 24.77 |
| 3 | 267 | 1631 | 45 | 70 | 59 | 58 | 57 | 118.13 | 14.63 |
| 4 | 267 | 1631 | 45 | 68 | 59 | 58 | 57 | 116.35 | 14.36 |
| 5 | 233 | 1098 | 26 | 66 | 55 | 54 | 53 | 105.12 | 15.46 |
| 6 | 233 | 1098 | 26 | 56 | 55 | 54 | 53 | 96.74 | 14.28 |
| 7 | 250 | 575 | 47 | 72 | 58 | 58 | 58 | 88.83 | 24.23 |
| 8 | 250 | 575 | 47 | 68 | 58 | 58 | 58 | 85.20 | 23.73 |
| 9 | 233 | 1098 | 26 | 66 | 55 | 54 | 53 | 102.45 | 13.86 |
| 10 | 233 | 1098 | 26 | 56 | 55 | 54 | 53 | 93.30 | 13.37 |
| 11 | 250 | 575 | 47 | 72 | 58 | 58 | 58 | 88.59 | 23.77 |
| 12 | 250 | 575 | 47 | 68 | 58 | 58 | 58 | 84.96 | 23.26 |

# 2 Summary of the results using BT, LS, ERA, RGR and RDGR

Tables 3, 4, and 5 summarize the results.

Table 3: *Best results obtained by BT using the various ordering heuristics.*

| **Data Sets** | Unassigned Courses | Solution Quality | Unused GTAs | Available Resource | Time [sec] | CC ($\times 10^8$) | Ordering Heuristic |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 2.67 | 3 | 10.5 | 48 | 1.73 | DDD-OCCURENCE |
| 2 | 12 | 2.31 | 0 | 4.5 | 94 | 1.39 | DDD-OCCURENCE |
| 3 | 2 | 2.72 | 0 | 4.7 | 25 | 1.00 | DLD-OCCURENCE |
| 4 | 2 | 2.65 | 0 | 2.7 | 22 | 0.92 | DLD-OCCURENCE |
| 5 | 0 | 3.97 | 1 | 5.5 | 11 | 0.16 | DDD-PREFERENCE |
| 6 | 3 | 3.73 | 0 | 1.5 | 2 | 0.04 | DLD-PREFERENCE |
| 7 | 0 | 3.20 | 0 | 5.5 | 235 | 3.62 | DLD-OCCURENCE |
| 8 | 0 | 3.22 | 0 | 1.5 | 25 | 0.75 | DLD-OCCURENCE |
| 9 | 1 | 2.77 | 2 | 6.5 | 253 | 3.40 | DDD-FIL |
| 10 | 7 | 2.86 | 0 | 3.5 | 162 | 2.27 | DDD-FIL |
| 11 | 1 | 4.40 | 2 | 5.9 | 30 | 1.27 | DLD-PREFERENCE |
| 12 | 2 | 4.15 | 0 | 2.3 | 25 | 1.07 | DLD-PREFERENCE |

Table 4: *Best results using LS and ERA (500 runs, 5 min each).*

| Data Set | LS | | | | | ERA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Unassigned Courses | Solution Quality | Unused GTAs | Available Resource | CC ($\times 10^8$) | Unassigned Courses | Solution Quality | Unused GTAs | Available Resource | CC ($\times 10^8$) |
| 1 | 4 | 3.67 | 0 | 11.8 | 2.71 | 0 | 3.12 | 0 | 10.5 | 0.01 |
| 2 | 14 | 3.22 | 0 | 3.7 | 2.07 | 23 | 2.84 | 7 | 14.4 | 0.22 |
| 3 | 5 | 3.06 | 1 | 7.5 | 2.15 | 0 | 3.01 | 0 | 3.6 | 0.02 |
| 4 | 4 | 2.98 | 1 | 5.5 | 2.17 | 0 | 2.99 | 0 | 1.6 | 0.07 |
| 5 | 2 | 3.40 | 0 | 5.0 | 0.85 | 0 | 3.62 | 2 | 3.0 | 0.02 |
| 6 | 4 | 3.61 | 0 | 2.0 | 0.16 | 8 | 3.22 | 1 | 2.0 | 0.51 |
| 7 | 1 | 4.09 | 4 | 12.5 | 4.09 | 0 | 3.31 | 4 | 11.8 | 0.02 |
| 8 | 3 | 3.64 | 2 | 11.5 | 3.72 | 0 | 2.82 | 2 | 7.8 | 0.11 |
| 9 | 5 | 3.68 | 0 | 11.7 | 2.25 | 2 | 3.56 | 1 | 7.5 | 0.20 |
| 10 | 7 | 3.74 | 0 | 4.3 | 2.05 | 9 | 3.01 | 2 | 4.5 | 0.20 |
| 11 | 7 | 3.57 | 0 | 10.5 | 3.48 | 0 | 2.78 | 0 | 5.5 | 0.06 |
| 12 | 9 | 3.64 | 0 | 7.2 | 3.15 | 0 | 3.28 | 0 | 1.5 | 0.03 |

Table 5: *Best results using restart strategies (500 runs, 5 min each).*

| Data Set | RGR | | | | | RDGR | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Unassigned Courses | Solution Quality | Unused GTAs | Available Resource | CC ($\times 10^8$) | Unassigned Courses | Solution Quality | Unused GTAs | Available Resource | CC ($\times 10^8$) |
| 1 | 0 | 2.60 | 1 | 10.6 | 21.5 | 0 | 2.53 | 0 | 10.6 | 31.3 |
| 2 | 7 | 2.68 | 0 | 0 | 9.68 | 8 | 2.10 | 0 | 0.6 | 20.05 |
| 3 | 0 | 3.13 | 0 | 3.6 | 12.9 | 1 | 2.92 | 2 | 4.5 | 24.7 |
| 4 | 1 | 2.81 | 0 | 2.6 | 8.81 | 2 | 2.96 | 1 | 3.6 | 10.31 |
| 5 | 0 | 3.77 | 0 | 5.5 | 14.22 | 0 | 3.71 | 0 | 5.5 | 8.59 |
| 6 | 2 | 3.62 | 0 | 0 | 0.15 | 2 | 3.40 | 0 | 0 | 2.42 |
| 7 | 0 | 3.11 | 2 | 5.5 | 17.50 | 0 | 3.03 | 1 | 5.5 | 21.68 |
| 8 | 0 | 3.30 | 1 | 1.5 | 14.23 | 0 | 2.72 | 0 | 1.5 | 14.89 |
| 9 | 1 | 2.81 | 1 | 6.5 | 14.11 | 1 | 2.68 | 1 | 6.5 | 26.35 |
| 10 | 5 | 2.85 | 0 | 1.0 | 0.8 | 4 | 3.05 | 0 | 1.0 | 19.93 |
| 11 | 1 | 3.05 | 1 | 5.8 | 15.88 | 0 | 2.72 | 2 | 5.5 | 5.45 |
| 12 | 1 | 2.70 | 1 | 3.5 | 10.47 | 1 | 2.52 | 0 | 3.5 | 27.14 |

# 3 Results obtained from BT using the various ordering heuristics

Table 6: *Best results obtained by BT using the various ordering heuristics.*

| Data Sets | Unassigned Courses | Solution Quality | Unused GTAs | Available Resource | Time [sec] | CC ($\times 10^8$) | Ordering Heuristic |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 2.67 | 3 | 10.5 | 48 | 1.73 | DDD-OCCURENCE |
| 2 | 12 | 2.31 | 0 | 4.5 | 94 | 1.39 | DDD-OCCURENCE |
| 3 | 2 | 2.72 | 0 | 4.7 | 25 | 1.00 | DLD-OCCURENCE |
| 4 | 2 | 2.65 | 0 | 2.7 | 22 | 0.92 | DLD-OCCURENCE |
| 5 | 0 | 3.97 | 1 | 5.5 | 11 | 0.16 | DDD-PREFERENCE |
| 6 | 3 | 3.73 | 0 | 1.5 | 2 | 0.04 | DLD-PREFERENCE |
| 7 | 0 | 3.20 | 0 | 5.5 | 235 | 3.62 | DLD-OCCURENCE |
| 8 | 0 | 3.22 | 0 | 1.5 | 25 | 0.75 | DLD-OCCURENCE |
| 9 | 1 | 2.77 | 2 | 6.5 | 253 | 3.40 | DDD-FIL |
| 10 | 7 | 2.86 | 0 | 3.5 | 162 | 2.27 | DDD-FIL |
| 11 | 1 | 4.40 | 2 | 5.9 | 30 | 1.27 | DLD-PREFERENCE |
| 12 | 2 | 4.15 | 0 | 2.3 | 25 | 1.07 | DLD-PREFERENCE |

Table 7: *Results for Data-set 1* .

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ($\times 10^3$ ) best solution | BT ($\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 6 | 2.95 | 2 | 13.0 | 247 | 4.56 | 5.33 | 3.89 | 4.65 | 69 | 56 | 1.33 | 1.57 |
| SLD-PREFERENCE | 8 | 4.13 | 3 | 13.6 | 30 | 1.41 | 4.52 | 0.06 | 20.89 | 69 | 61 | 0 | 5.05 |
| SLD-OCCURRENCE | 11 | 2.56 | 4 | 14.5 | 147 | 2.94 | 5.00 | 6.36 | 12.25 | 69 | 63 | 1.48 | 2.82 |
| SDD-FIL | 6 | 2.95 | 2 | 13.0 | 247 | 4.56 | 5.34 | 3.89 | 4.66 | 69 | 56 | 1.33 | 1.58 |
| SDD-PREFERENCE | 8 | 4.13 | 3 | 13.6 | 30 | 1.41 | 4.32 | 0.06 | 19.72 | 69 | 61 | 0 | 4.73 |
| SDD-OCCURRENCE | 11 | 2.56 | 4 | 14.5 | 149 | 2.94 | 4.94 | 6.36 | 12.15 | 69 | 63 | 1.48 | 2.80 |
| DLD-FIL | 10 | 3.08 | 3 | 14.2 | 275 | 4.86 | 5.25 | 7.53 | 7.79 | 69 | 60 | 1.52 | 1.57 |
| DLD-PREFERENCE | 4 | 4.07 | 3 | 11.8 | 38 | 1.64 | 3.28 | 0.06 | 35.63 | 69 | 64 | 0 | 5619 |
| DLD-OCCURRENCE | 9 | 2.70 | 3 | 13.6 | 145 | 3.11 | 5.26 | 3.54 | 6.79 | 69 | 63 | 0.60 | 1.17 |
| DDD-FIL | 2 | 2.92 | 3 | 11.8 | 264 | 4.51 | 4.96 | 16.65 | 19.52 | 69 | 55 | 9.39 | 11.03 |
| DDD-PREFERENCE | 6 | 4.06 | 3 | 13.0 | 45 | 1.65 | 4.22 | 1.31 | 19.84 | 69 | 63 | 0.22 | 4.17 |
| DDD-OCCURRENCE | 0 | 2.67 | 3 | 10.5 | 48 | 1.73 | 4.83 | 0.06 | 19.53 | 69 | 55 | 0 | 11.11 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 8: *Results for Data-set 2.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ($\times 10^3$ ) best solution | BT ($\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 17 | 2.84 | 0 | 2.5 | 291 | 3.98 | 4.08 | 67.36 | 69.37 | 69 | 52 | 44.95 | 46.28 |
| SLD-PREFERENCE | 16 | 4.28 | 0 | 3.6 | 136 | 2.02 | 3.93 | 33.19 | 74.71 | 69 | 51 | 21.35 | 47.78 |
| SLD-OCCURRENCE | 17 | 2.46 | 0 | 2.5 | 40 | 0.92 | 3.82 | 8.16 | 73.27 | 69 | 53 | 4.74 | 44.44 |
| SDD-FIL | 17 | 2.84 | 0 | 2.5 | 293 | 3.98 | 4.05 | 67.36 | 68.88 | 69 | 52 | 44.95 | 45.94 |
| SDD-PREFERENCE | 16 | 4.28 | 0 | 3.6 | 137 | 2.02 | 3.93 | 33.19 | 74.78 | 69 | 51 | 21.35 | 47.82 |
| SDD-OCCURRENCE | 17 | 2.46 | 0 | 2.5 | 41 | 0.90 | 3.58 | 8.16 | 71.14 | 69 | 53 | 4.74 | 43.10 |
| DLD-FIL | 15 | 2.46 | 0 | 4.3 | 230 | 2.59 | 3.19 | 65.57 | 87.14 | 69 | 55 | 34.79 | 46.34 |
| DLD-PREFERENCE | 16 | 3.90 | 0 | 5.0 | 205 | 2.44 | 3.34 | 55.14 | 81.92 | 69 | 55 | 29.36 | 43.62 |
| DLD-OCCURRENCE | 18 | 2.44 | 0 | 4.6 | 16 | 0.73 | 3.25 | 0.40 | 88.61 | 69 | 56 | 0.17 | 47.22 |
| DDD-FIL | 16 | 2.31 | 0 | 5.3 | 39 | 0.90 | 3.76 | 7.67 | 81.64 | 69 | 51 | 3.89 | 51.00 |
| DDD-PREFERENCE | 13 | 3.64 | 0 | 4.7 | 24 | 0.76 | 3.31 | 2.95 | 79.50 | 69 | 54 | 1.52 | 42.39 |
| DDD-OCCURRENCE | 12 | 2.31 | 0 | 4.5 | 94 | 1.39 | 3.22 | 21.19 | 79.85 | 69 | 53 | 11.12 | 42.32 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 9: *Results for Data-set 3.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ( $\times 10^3$ ) best solution | BT ( $\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 7 | 2.91 | 1 | 6.2 | 140 | 2.23 | 4.16 | 19.26 | 42.37 | 65 | 48 | 11.40 | 24.99 |
| SLD-PREFERENCE | 10 | 3.55 | 4 | 11.1 | 14 | 0.70 | 3.45 | 0.06 | 79.26 | 65 | 53 | 0 | 44.16 |
| SLD-OCCURRENCE | 9 | 2.76 | 0 | 8.5 | 16 | 0.79 | 3.85 | 0.06 | 50.10 | 65 | 54 | 0 | 25.98 |
| SDD-FIL | 7 | 2.91 | 1 | 6.2 | 140 | 2.23 | 4.15 | 19.26 | 42.40 | 65 | 48 | 11.40 | 25.01 |
| SDD-PREFERENCE | 10 | 3.55 | 4 | 11.1 | 14 | 0.70 | 3.47 | 0.06 | 79.77 | 65 | 53 | 0 | 44.44 |
| SDD-OCCURRENCE | 9 | 2.76 | 0 | 8.5 | 16 | 0.79 | 3.85 | 0.06 | 50.17 | 65 | 54 | 0 | 26.02 |
| DLD-FIL | 7 | 2.88 | 3 | 6.1 | 22 | 0.92 | 3.25 | 0.06 | 45.30 | 65 | 59 | 0 | 9.10 |
| DLD-PREFERENCE | 3 | 3.11 | 0 | 5.7 | 23 | 0.97 | 3.65 | 0.06 | 43.23 | 65 | 57 | 0 | 19.43 |
| DLD-OCCURRENCE | 2 | 2.72 | 0 | 4.7 | 25 | 1.00 | 3.71 | 0.21 | 32.61 | 65 | 58 | 0.04 | 10.34 |
| DDD-FIL | 6 | 3.05 | 1 | 5.9 | 139 | 2.07 | 3.91 | 17.14 | 31.78 | 65 | 58 | 4.91 | 9.68 |
| DDD-PREFERENCE | 6 | 3.40 | 0 | 5.9 | 39 | 0.94 | 3.57 | 0.06 | 35.37 | 65 | 58 | 0 | 12.82 |
| DDD-OCCURRENCE | 4 | 2.99 | 0 | 6.7 | 22 | 0.95 | 3.60 | 0.07 | 46.19 | 65 | 57 | 0 | 21.61 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 10: *Results for Data-set 4.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ( $\times 10^3$ ) best solution | BT ( $\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 8 | 2.91 | 1 | 6.2 | 35 | 0.95 | 4.26 | 3.83 | 40.93 | 65 | 48 | 2.31 | 24.29 |
| SLD-PREFERENCE | 10 | 3.55 | 3 | 9.1 | 13 | 0.65 | 3.46 | 0.06 | 84.81 | 65 | 51 | 0 | 48.92 |
| SLD-OCCURRENCE | 10 | 2.76 | 0 | 7.5 | 15 | 0.74 | 3.70 | 0.06 | 56.98 | 65 | 54 | 0 | 29.69 |
| SDD-FIL | 8 | 2.91 | 1 | 6.2 | 36 | 0.95 | 4.22 | 3.83 | 40.98 | 65 | 48 | 2.31 | 24.32 |
| SDD-PREFERENCE | 10 | 3.55 | 3 | 9.1 | 13 | 0.65 | 3.45 | 0.06 | 84.65 | 65 | 51 | 0 | 48.83 |
| SDD-OCCURRENCE | 10 | 2.76 | 0 | 7.5 | 15 | 0.74 | 3.69 | 0.06 | 56.87 | 65 | 54 | 0 | 29.63 |
| DLD-FIL | 7 | 2.96 | 1 | 4.1 | 20 | 0.86 | 3.52 | 0.06 | 42.49 | 65 | 58 | 0 | 12.16 |
| DLD-PREFERENCE | 5 | 3.11 | 0 | 5.7 | 21 | 0.90 | 3.41 | 0.06 | 53.85 | 65 | 56 | 0 | 26.05 |
| DLD-OCCURRENCE | 2 | 2.65 | 0 | 2.7 | 22 | 0.92 | 3.63 | 0.12 | 43.25 | 65 | 56 | 0.02 | 18.90 |
| DDD-FIL | 6 | 3.08 | 0 | 3.9 | 52 | 1.18 | 3.87 | 6.59 | 41.08 | 65 | 56 | 2.84 | 18.54 |
| DDD-PREFERENCE | 7 | 3.41 | 0 | 4.9 | 20 | 0.87 | 3.66 | 0.06 | 46.16 | 65 | 57 | 0 | 20.78 |
| DDD-OCCURRENCE | 6 | 2.99 | 0 | 6.7 | 273 | 3.13 | 3.37 | 47.22 | 52.58 | 65 | 55 | 22.23 | 24.93 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 11: *Results for Data-set 5.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ( $\times 10^3$ ) best solution | BT ( $\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 3 | 3.70 | 1 | 7.7 | 284 | 4.04 | 4.26 | 17.36 | 18.36 | 31 | 15 | 9.12 | 9.64 |
| SLD-PREFERENCE | 4 | 4.09 | 2 | 8.0 | 3 | 0.07 | 4.21 | 0.03 | 21.09 | 31 | 16 | 0 | 11.58 |
| SLD-OCCURRENCE | 4 | 3.68 | 1 | 8.0 | 145 | 1.74 | 3.96 | 7.59 | 16.69 | 31 | 16 | 4.11 | 9.07 |
| SDD-FIL | 3 | 3.70 | 1 | 7.7 | 281 | 4.01 | 4.27 | 17.36 | 18.51 | 31 | 15 | 9.12 | 9.71 |
| SDD-PREFERENCE | 4 | 4.09 | 2 | 8.0 | 3 | 0.07 | 4.22 | 0.03 | 21.13 | 31 | 16 | 0 | 11.60 |
| SDD-OCCURRENCE | 4 | 3.68 | 1 | 8.0 | 121 | 1.74 | 4.29 | 7.59 | 18.81 | 31 | 16 | 4.11 | 10.35 |
| DLD-FIL | 1 | 3.48 | 1 | 6.5 | 22 | 0.33 | 4.26 | 0.9 | 12.83 | 31 | 20 | 0.34 | 5.77 |
| DLD-PREFERENCE | 0 | 3.79 | 2 | 5.5 | 204 | 2.78 | 4.15 | 11.33 | 13.88 | 31 | 19 | 5.68 | 6.62 |
| DLD-OCCURRENCE | 3 | 3.78 | 1 | 6.3 | 85 | 1.22 | 4.35 | 3.24 | 9.42 | 31 | 20 | 1.27 | 3.67 |
| DDD-FIL | 1 | 3.51 | 1 | 5.7 | 266 | 3.92 | 4.41 | 11.56 | 12.94 | 31 | 17 | 5.94 | 6.65 |
| DDD-PREFERENCE | 0 | 3.97 | 1 | 5.5 | 11 | 0.16 | 3.66 | 1.26 | 37.07 | 31 | 18 | 0.74 | 21.73 |
| DDD-OCCURRENCE | 0 | 3.90 | 1 | 5.5 | 76 | 1.02 | 4.14 | 5.51 | 18.64 | 31 | 12 | 2.78 | 9.86 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 12: *Results for Data-set 6.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ( $\times 10^3$ ) best solution | BT ( $\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 7 | 3.32 | 0 | 4.5 | 244 | 3.34 | 4.10 | 36.37 | 43.77 | 31 | 9 | 22.37 | 26.76 |
| SLD-PREFERENCE | 6 | 4.10 | 0 | 2.3 | 45 | 0.64 | 4.47 | 4.70 | 26.47 | 31 | 8 | 2.74 | 14.98 |
| SLD-OCCURRENCE | 6 | 3.56 | 0 | 4.0 | 94 | 1.38 | 4.47 | 8.73 | 26.32 | 31 | 9 | 4.89 | 14.56 |
| SDD-FIL | 7 | 3.32 | 0 | 4.5 | 235 | 3.18 | 4.07 | 36.37 | 44.92 | 31 | 9 | 22.37 | 27.41 |
| SDD-PREFERENCE | 6 | 4.10 | 0 | 2.3 | 45 | 0.64 | 4.47 | 4.70 | 26.45 | 31 | 8 | 2.74 | 14.97 |
| SDD-OCCURRENCE | 6 | 3.56 | 0 | 4.0 | 93 | 1.38 | 4.50 | 8.73 | 26.45 | 31 | 9 | 4.89 | 14.63 |
| DLD-FIL | 5 | 3.37 | 0 | 2.5 | 11 | 0.14 | 3.99 | 1.82 | 38.66 | 31 | 13 | 0.99 | 21.70 |
| DLD-PREFERENCE | 3 | 3.73 | 0 | 1.5 | 2 | 0.04 | 4.04 | 0.12 | 35.77 | 31 | 11 | 0.05 | 20.85 |
| DLD-OCCURRENCE | 6 | 3.68 | 0 | 4.0 | 88 | 1.20 | 4.24 | 10.33 | 33.61 | 31 | 11 | 5.83 | 19.21 |
| DDD-FIL | 5 | 3.37 | 0 | 2.5 | 136 | 1.73 | 3.92 | 22.38 | 44.55 | 31 | 13 | 12.70 | 25.41 |
| DDD-PREFERENCE | 3 | 3.73 | 0 | 1.5 | 45 | 0.57 | 4.01 | 7.55 | 36.05 | 31 | 12 | 4.24 | 20.63 |
| DDD-OCCURRENCE | 6 | 3.75 | 0 | 4 | 90 | 0.79 | 2.63 | 8.38 | 28.45 | 31 | 13 | 4.68 | 16.15 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 13: *Results for Data-set 7.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ( $\times 10^3$ ) best solution | BT ( $\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| `SLD-FIL` | 13 | 3.28 | 5 | 13.2 | 82 | 1.59 | 5.12 | 2.47 | 9.36 | 54 | 39 | 0.81 | 3.42 |
| `SLD-PREFERENCE` | 14 | 4.13 | 5 | 12.5 | 53 | 1.04 | 5.00 | 3.96 | 13.04 | 54 | 39 | 1.28 | 5.57 |
| `SLD-OCCURRENCE` | 10 | 3.43 | 3 | 12.2 | 239 | 3.84 | 4.77 | 10.87 | 12.87 | 54 | 41 | 3.62 | 4.32 |
| `SDD-FIL` | 13 | 3.28 | 5 | 13.2 | 84 | 1.63 | 5.11 | 2.47 | 9.10 | 54 | 39 | 0.81 | 3.32 |
| `SDD-PREFERENCE` | 14 | 4.13 | 5 | 12.5 | 53 | 1.04 | 4.95 | 3.96 | 5.52 | 54 | 39 | 1.28 | 5.52 |
| `SDD-OCCURRENCE` | 10 | 3.43 | 3 | 12.2 | 239 | 3.84 | 4.77 | 10.87 | 12.87 | 54 | 41 | 3.62 | 4.33 |
| `DLD-FIL` | 3 | 2.88 | 3 | 7.5 | 294 | 4.29 | 4.36 | 12.43 | 12.74 | 54 | 46 | 3.61 | 3.69 |
| `DLD-PREFERENCE` | 4 | 4.05 | 4 | 8.2 | 101 | 1.86 | 4.60 | 2.26 | 7.62 | 54 | 47 | 0.61 | 2.12 |
| `DLD-OCCURRENCE` | 0 | 3.20 | 0 | 5.5 | 235 | 3.62 | 4.46 | 5.98 | 7.95 | 54 | 45 | 1.84 | 2.57 |
| `DDD-FIL` | 3 | 2.88 | 2 | 7.5 | 283 | 4.07 | 4.27 | 14.37 | 15.31 | 54 | 46 | 3.97 | 4.23 |
| `DDD-PREFERENCE` | 2 | 4.00 | 2 | 6.9 | 66 | 0.85 | 4.13 | 0.05 | 4.24 | 54 | 46 | 0 | 1.30 |
| `DDD-OCCURRENCE` | 2 | 3.32 | 1 | 7.5 | 32 | 0.92 | 4.41 | 0.43 | 9.74 | 54 | 46 | 0,10 | 2.59 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 14: *Results for Data-set 8.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ( $\times 10^3$ ) best solution | BT ( $\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| `SLD-FIL` | 13 | 2.85 | 3 | 9.2 | 230 | 2.56 | 3.26 | 6.42 | 8.14 | 54 | 39 | 2.44 | 3.19 |
| `SLD-PREFERENCE` | 14 | 4.04 | 2 | 8.5 | 17 | 0.51 | 4.29 | 0.96 | 32.12 | 54 | 41 | 0.47 | 14.63 |
| `SLD-OCCURRENCE` | 10 | 3.49 | 1 | 8.2 | 270 | 4.38 | 4.85 | 13.08 | 14.00 | 54 | 38 | 5.56 | 5.98 |
| `SDD-FIL` | 13 | 2.85 | 3 | 9.2 | 146 | 2.53 | 5.02 | 6.42 | 12.54 | 54 | 38 | 2.44 | 5.08 |
| `SDD-PREFERENCE` | 14 | 4.04 | 2 | 8.5 | 17 | 0.51 | 4.26 | 0.96 | 32.44 | 54 | 41 | 0.47 | 14.76 |
| `SDD-OCCURRENCE` | 10 | 3.49 | 1 | 8.2 | 271 | 4.41 | 4.87 | 13.08 | 13.96 | 54 | 38 | 5.56 | 5.96 |
| `DLD-FIL` | 3 | 3.22 | 0 | 3.5 | 278 | 3.54 | 3.82 | 15.18 | 16.38 | 54 | 44 | 6.29 | 6.81 |
| `DLD-PREFERENCE` | 4 | 3.82 | 2 | 4.2 | 23 | 0.70 | 4.46 | 0.30 | 10.73 | 54 | 46 | 0.08 | 3.49 |
| `DLD-OCCURRENCE` | 0 | 3.22 | 0 | 1.5 | 25 | 0.75 | 4.39 | 0.29 | 8.96 | 54 | 43 | 0.11 | 3.32 |
| `DDD-FIL` | 5 | 2.86 | 0 | 4.8 | 290 | 4.33 | 4.45 | 16.10 | 16.90 | 54 | 44 | 5.60 | 5.93 |
| `DDD-PREFERENCE` | 1 | 3.62 | 0 | 2.5 | 87 | 1.56 | 4.40 | 2.98 | 10.67 | 54 | 42 | 1.17 | 4.21 |
| `DDD-OCCURRENCE` | 2 | 3.33 | 0 | 3.5 | 42 | 0.95 | 3.70 | 1.64 | 34.91 | 54 | 44 | 0.68 | 18.89 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 15: *Results for Data-set 9.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ( $\times 10^3$ ) best solution | BT ( $\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 7 | 3.00 | 3 | 10.7 | 299 | 4.23 | 4.24 | 49.17 | 49.31 | 59 | 43 | 28.54 | 28.62 |
| SLD-PREFERENCE | 7 | 4.05 | 3 | 10.0 | 11 | 0.58 | 4.03 | 0.05 | 42.44 | 59 | 48 | 0 | 19.59 |
| SLD-OCCURRENCE | 9 | 3.05 | 3 | 11.3 | 38 | 1.00 | 4.92 | 1.68 | 17.49 | 59 | 49 | 0.58 | 6.27 |
| SDD-FIL | 7 | 3.00 | 3 | 10.7 | 299 | 4.23 | 4.23 | 49.17 | 49.20 | 59 | 43 | 28.54 | 28.55 |
| SDD-PREFERENCE | 7 | 4.05 | 3 | 10.0 | 11 | 0.58 | 4.02 | 0.05 | 43.04 | 59 | 48 | 0 | 20.03 |
| SDD-OCCURRENCE | 9 | 3.05 | 3 | 11.3 | 38 | 1.00 | 4.92 | 1.68 | 1.74 | 59 | 49 | 0.58 | 6.27 |
| DLD-FIL | 2 | 2.77 | 1 | 7.5 | 216 | 3.23 | 4.26 | 19.19 | 27.32 | 59 | 50 | 5.91 | 8.64 |
| DLD-PREFERENCE | 2 | 3.67 | 1 | 7.0 | 18 | 0.78 | 2.98 | 0.05 | 69.07 | 59 | 51 | 0 | 18.99 |
| DLD-OCCURRENCE | 5 | 3.01 | 1 | 7.7 | 18 | 0.80 | 3.32 | 0.09 | 56.64 | 59 | 52 | 0.01 | 15.30 |
| DDD-FIL | 1 | 2.77 | 2 | 6.5 | 253 | 3.40 | 3.96 | 27.92 | 31.81 | 59 | 51 | 8.35 | 9.46 |
| DDD-PREFERENCE | 4 | 3.71 | 0 | 8.3 | 17 | 0.75 | 3.89 | 0.05 | 53.12 | 59 | 50 | 0 | 22.22 |
| DDD-OCCURRENCE | 6 | 3.16 | 0 | 8.7 | 18 | 0.80 | 3.39 | 0.09 | 62.82 | 59 | 52 | 0.0 | 20.89 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 16: *Results for Data-set 10.*

| Ordering heuristics | Unassigned Courses | Solution Quality | Unused GTAs | Available Resources | Time [sec] | CC ( $\times 10^8$ ) best solution | CC ( $\times 10^8$ ) 5 mins | NV ( $\times 10^3$ ) best solution | NV ( $\times 10^3$ ) 5 mins | Depth of search tree | Shallowest BT level | BT ( $\times 10^3$ ) best solution | BT ( $\times 10^3$ ) 5 mins |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 11 | 2.61 | 1 | 6.5 | 191 | 3.06 | 4.73 | 30.96 | 44.93 | 59 | 41 | 17.86 | 25.68 |
| SLD-PREFERENCE | 11 | 4.15 | 0 | 3.3 | 6 | 0.34 | 4.24 | 0.05 | 62.24 | 59 | 42 | 0 | 36.42 |
| SLD-OCCURRENCE | 11 | 2.90 | 0 | 5.3 | 8 | 0.38 | 4.18 | 0.12 | 57.31 | 59 | 43 | 0.03 | 32.18 |
| SDD-FIL | 11 | 2.61 | 1 | 6.5 | 198 | 3.06 | 4.59 | 30.96 | 43.85 | 59 | 41 | 17.86 | 25.08 |
| SDD-PREFERENCE | 11 | 4.15 | 0 | 3.3 | 6 | 0.34 | 4.14 | 0.05 | 60.18 | 59 | 42 | 0 | 35.21 |
| SDD-OCCURRENCE | 11 | 2.90 | 0 | 5.3 | 8 | 0.38 | 4.03 | 0.12 | 55.01 | 59 | 43 | 0.03 | 30.91 |
| DLD-FIL | 8 | 2.91 | 0 | 6.0 | 271 | 2.82 | 3.08 | 70.92 | 78.48 | 59 | 47 | 37.32 | 41.28 |
| DLD-PREFERENCE | 8 | 3.7 | 0 | 5.0 | 98 | 1.11 | 2.61 | 30.16 | 99.72 | 59 | 48 | 12.58 | 40.80 |
| DLD-OCCURRENCE | 9 | 3.20 | 0 | 4.7 | 32 | 0.65 | 3.17 | 6.94 | 73.50 | 59 | 48 | 3.23 | 38.10 |
| DDD-FIL | 7 | 2.86 | 0 | 3.5 | 162 | 2.27 | 3.73 | 26.29 | 53.98 | 59 | 47 | 13.92 | 28.26 |
| DDD-PREFERENCE | 11 | 3.78 | 0 | 7.7 | 56 | 0.82 | 3.18 | 14.41 | 80.32 | 59 | 47 | 7.09 | 40.53 |
| DDD-OCCURRENCE | 10 | 2.73 | 0 | 6.75 | 16 | 0.52 | 3.39 | 2.07 | 74.62 | 59 | 48 | 1.13 | 41.06 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 17: *Results for Data-set 11.*

| **Ordering heuristics** | **Unassigned Courses** | **Solution Quality** | **Unused GTAs** | **Available Resources** | **Time [sec]** | **CC ( $\times 10^8$ ) best solution** | **CC ( $\times 10^8$ ) 5 mins** | **NV ( $\times 10^3$ ) best solution** | **NV ( $\times 10^3$ ) 5 mins** | **Depth of search tree** | **Shallowest BT level** | **BT ($\times 10^3$ ) best solution** | **BT ($\times 10^3$ ) 5 mins** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 16 | 3.17 | 7 | 15.5 | 17 | 0.91 | 5.80 | 0.12 | 11.93 | 64 | 49 | 0.02 | 4.67 |
| SLD-PREFERENCE | 13 | 4.59 | 4 | 12.1 | 62 | 1.43 | 4.98 | 8.00 | 21.71 | 64 | 49 | 3.42 | 9.02 |
| SLD-OCCURRENCE | 18 | 3.17 | 5 | 16.1 | 149 | 3.34 | 6.12 | 3.06 | 5.82 | 64 | 47 | 0.99 | 2.01 |
| SDD-FIL | 16 | 3.17 | 7 | 15.5 | 17 | 0.91 | 5.74 | 0.12 | 11.66 | 64 | 49 | 0.02 | 4.56 |
| SDD-PREFERENCE | 13 | 4.59 | 4 | 12.1 | 61 | 1.43 | 5.00 | 8.00 | 21.78 | 64 | 49 | 3.42 | 9.05 |
| SDD-OCCURRENCE | 18 | 3.17 | 5 | 16.1 | 150 | 3.35 | 6.11 | 3.06 | 5.80 | 64 | 47 | 0.99 | 2.01 |
| DLD-FIL | 4 | 2.83 | 1 | 6.9 | 201 | 3.71 | 5.17 | 4.43 | 6.15 | 64 | 53 | 1.47 | 2.11 |
| DLD-PREFERENCE | 1 | 4.40 | 2 | 5.86 | 30 | 1.27 | 4.89 | 0.09 | 7.13 | 64 | 55 | 0.0 | 2.31 |
| DLD-OCCURRENCE | 10 | 3.23 | 2 | 9.5 | 286 | 5.05 | 5.25 | 7.18 | 7.57 | 64 | 55 | 1.98 | 2.07 |
| DDD-FIL | 4 | 2.52 | 2 | 8.2 | 138 | 2.64 | 5.01 | 7.57 | 11.45 | 64 | 55 | 1.86 | 2.98 |
| DDD-PREFERENCE | 2 | 3.80 | 3 | 6.9 | 44 | 1.49 | 5.18 | 0.67 | 5.99 | 64 | 45 | 0.18 | 2.16 |
| DDD-OCCURRENCE | 6 | 2.89 | 2 | 8.9 | 45 | 1.53 | 4.88 | 0.96 | 12.17 | 64 | 57 | 0.20 | 2.73 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

Table 18: *Results for Data-set 12.*

| **Ordering heuristics** | **Unassigned Courses** | **Solution Quality** | **Unused GTAs** | **Available Resources** | **Time [sec]** | **CC ( $\times 10^8$ ) best solution** | **CC ( $\times 10^8$ ) 5 mins** | **NV ( $\times 10^3$ ) best solution** | **NV ( $\times 10^3$ ) 5 mins** | **Depth of search tree** | **Shallowest BT level** | **BT ($\times 10^3$ ) best solution** | **BT ($\times 10^3$ ) 5 mins** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SLD-FIL | 15 | 2.55 | 3 | 10.5 | 75 | 1.77 | 5.42 | 5.30 | 21.79 | 64 | 49 | 2.54 | 10.73 |
| SLD-PREFERENCE | 13 | 4.36 | 2 | 8.1 | 92 | 1.67 | 3.98 | 15.43 | 61.64 | 64 | 49 | 7.98 | 31.84 |
| SLD-OCCURRENCE | 18 | 3.24 | 3 | 12.1 | 189 | 3.99 | 6.02 | 5.20 | 8.08 | 64 | 46 | 2.05 | 3.22 |
| SDD-FIL | 15 | 2.55 | 3 | 10.5 | 76 | 1.79 | 5.44 | 5.30 | 21.44 | 64 | 49 | 2.54 | 10.57 |
| SDD-PREFERENCE | 13 | 4.36 | 2 | 8.13 | 93 | 1.70 | 4.01 | 15.43 | 60.93 | 64 | 49 | 7.98 | 31.46 |
| SDD-OCCURRENCE | 18 | 3.24 | 3 | 12.1 | 192 | 4.00 | 5.97 | 5.20 | 8.00 | 64 | 46 | 2.05 | 3.18 |
| DLD-FIL | 6 | 3.08 | 0 | 4.17 | 296 | 5.10 | 5.14 | 8.07 | 8.23 | 64 | 53 | 2.84 | 2.90 |
| DLD-PREFERENCE | 2 | 4.15 | 0 | 2.7 | 25 | 1.07 | 4.64 | 0.08 | 13.92 | 64 | 55 | 0.00 | 5.28 |
| DLD-OCCURRENCE | 10 | 3.21 | 0 | 5.5 | 117 | 2.39 | 5.13 | 3.94 | 9.39 | 64 | 54 | 1.43 | 3.29 |
| DDD-FIL | 6 | 2.92 | 0 | 4.2 | 191 | 3.44 | 4.93 | 10.24 | 17.97 | 64 | 50 | 4.67 | 8.45 |
| DDD-PREFERENCE | 6 | 3.78 | 0 | 4.2 | 24 | 1.09 | 5.13 | 0.13 | 8.76 | 64 | 55 | 0.03 | 3.42 |
| DDD-OCCURRENCE | 5 | 2.81 | 0 | 3.9 | 294 | 4.86 | 4.93 | 11.35 | 11.68 | 64 | 54 | 3.60 | 3.73 |

Time: CPU run time needed to reach best solution.
CC: Number of constraint checks.
NV: Number of nodes visited.
BT: Number of backtracks.

# 4 Solution quality distributions of LS, ERA, RGR and RDGR

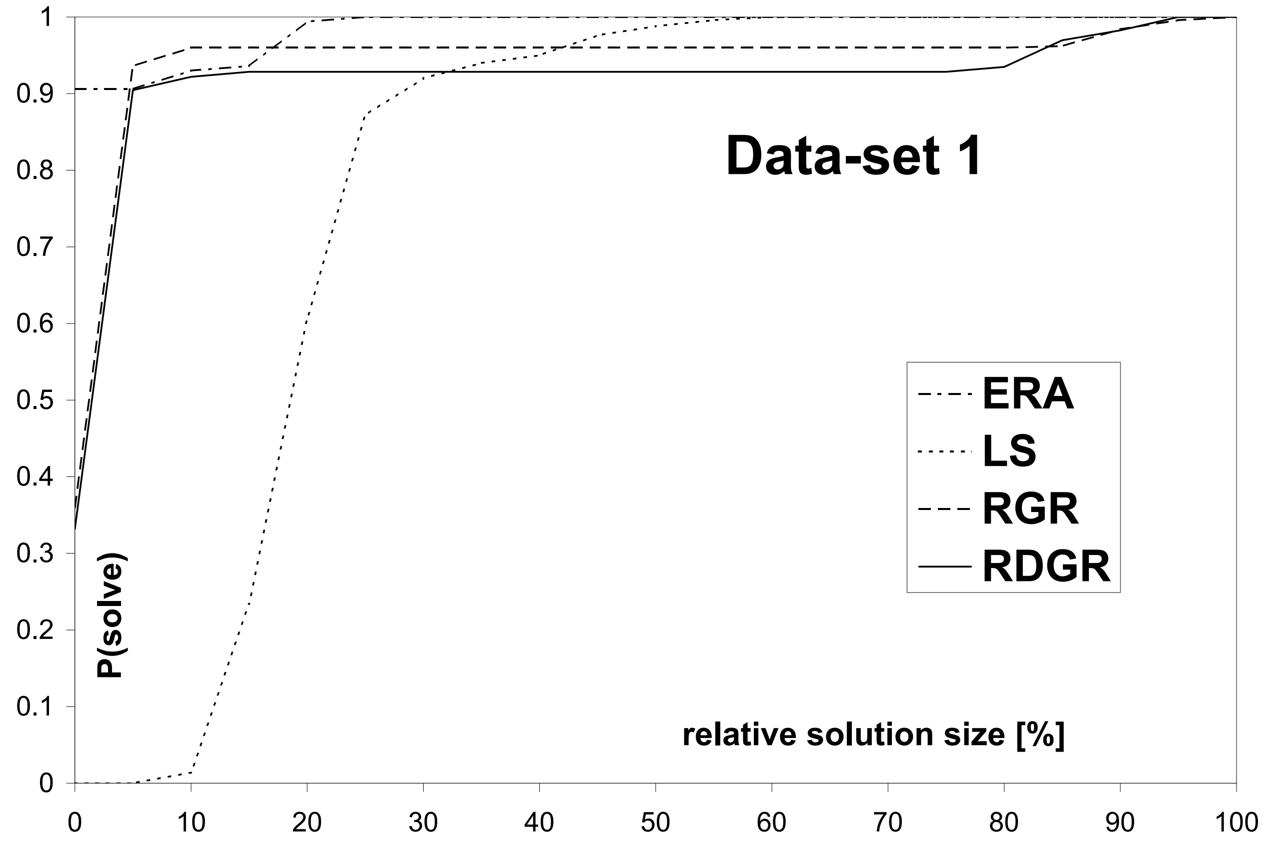


Figure 1: *SQD for Data-set 1 (solvable, 500 runs, 5 min each).*

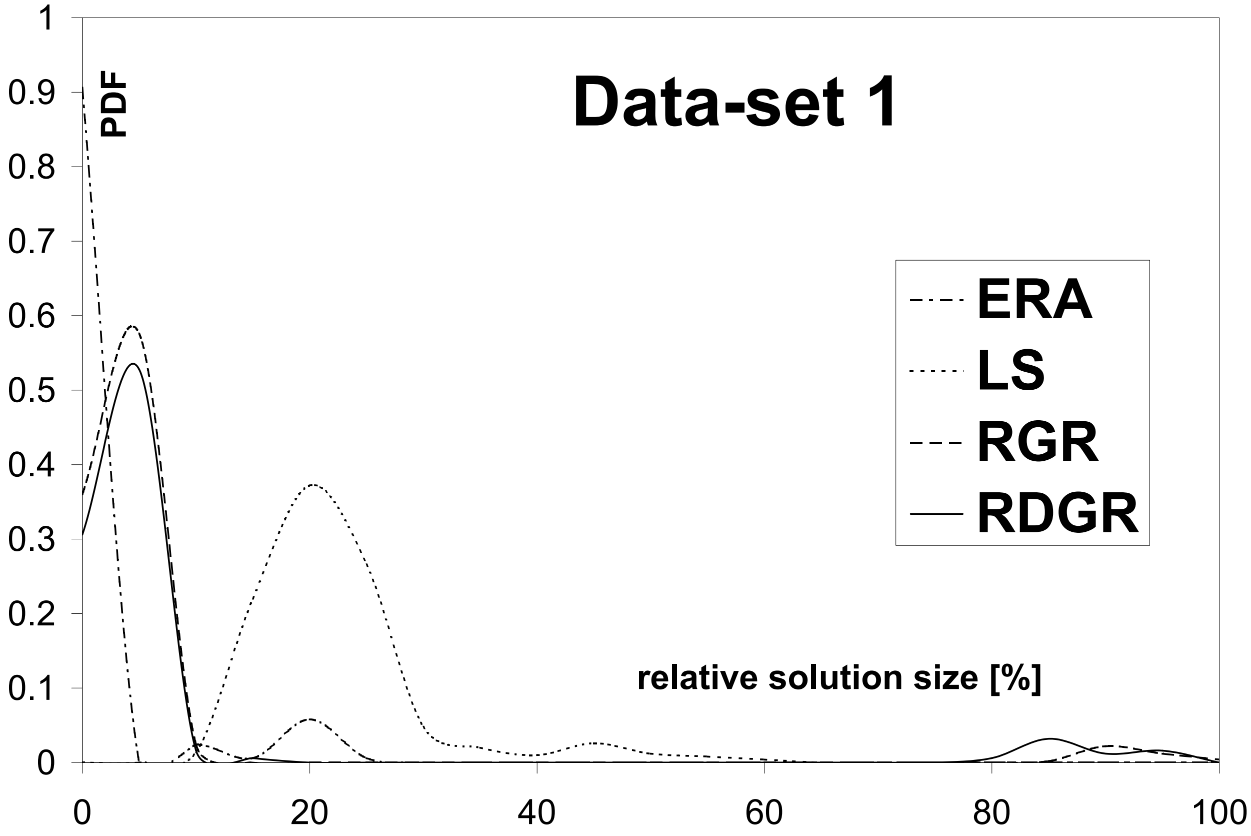


Figure 2: *PDF of the relative solution size for Data-set 1 (solvable, 500 runs, 5 min each).*

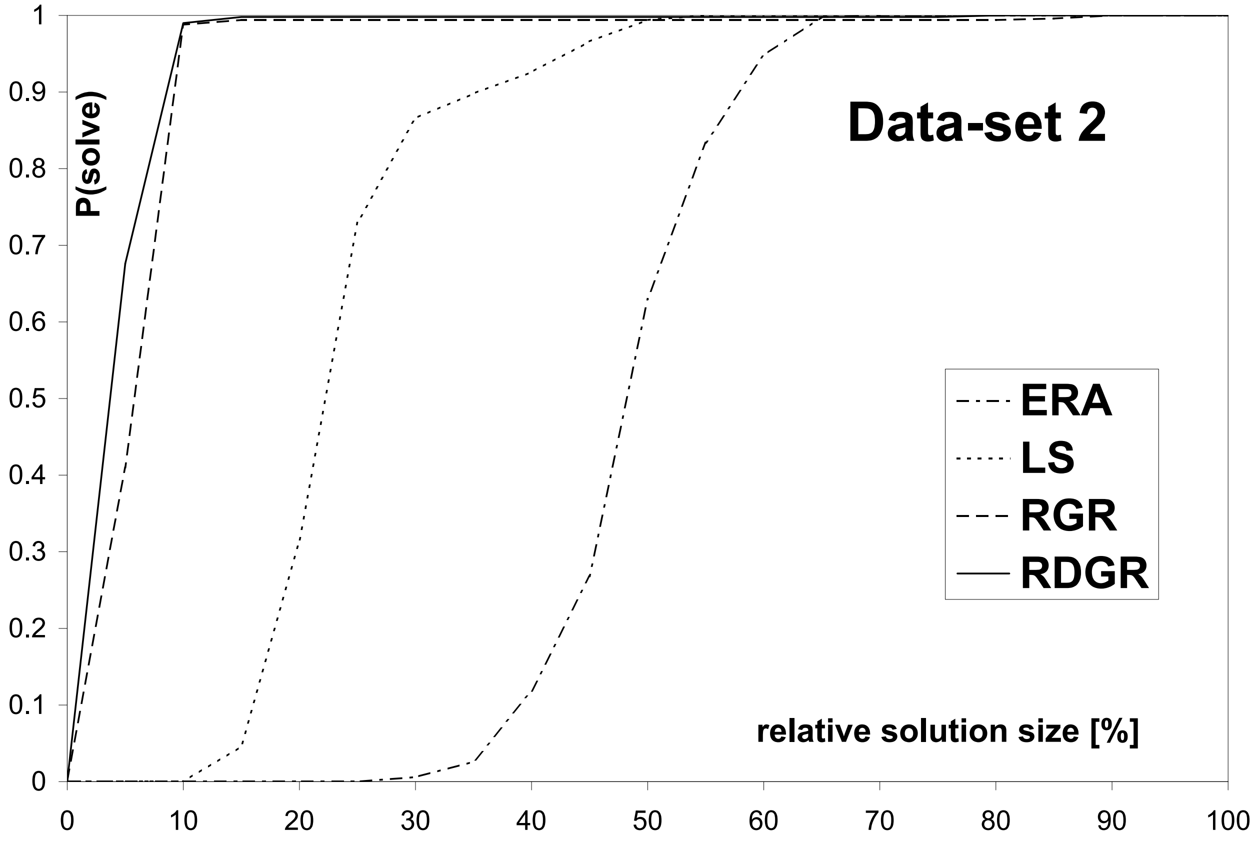


Figure 3: *SQD for Data-set 2 (unsolvable, 500 runs, 5 min each).*

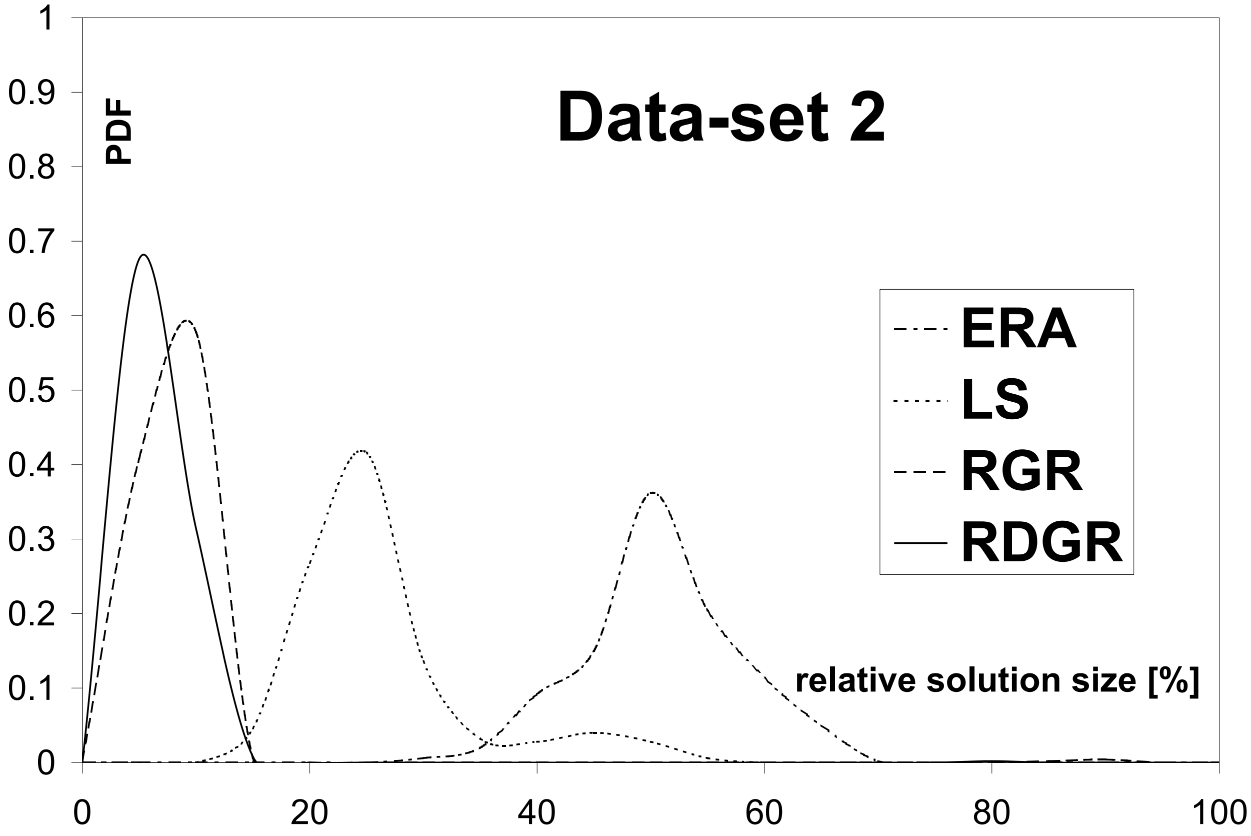


Figure 4: *PDF of the relative solution size for Data-set 2 (unsolvable, 500 runs, 5 min each).*

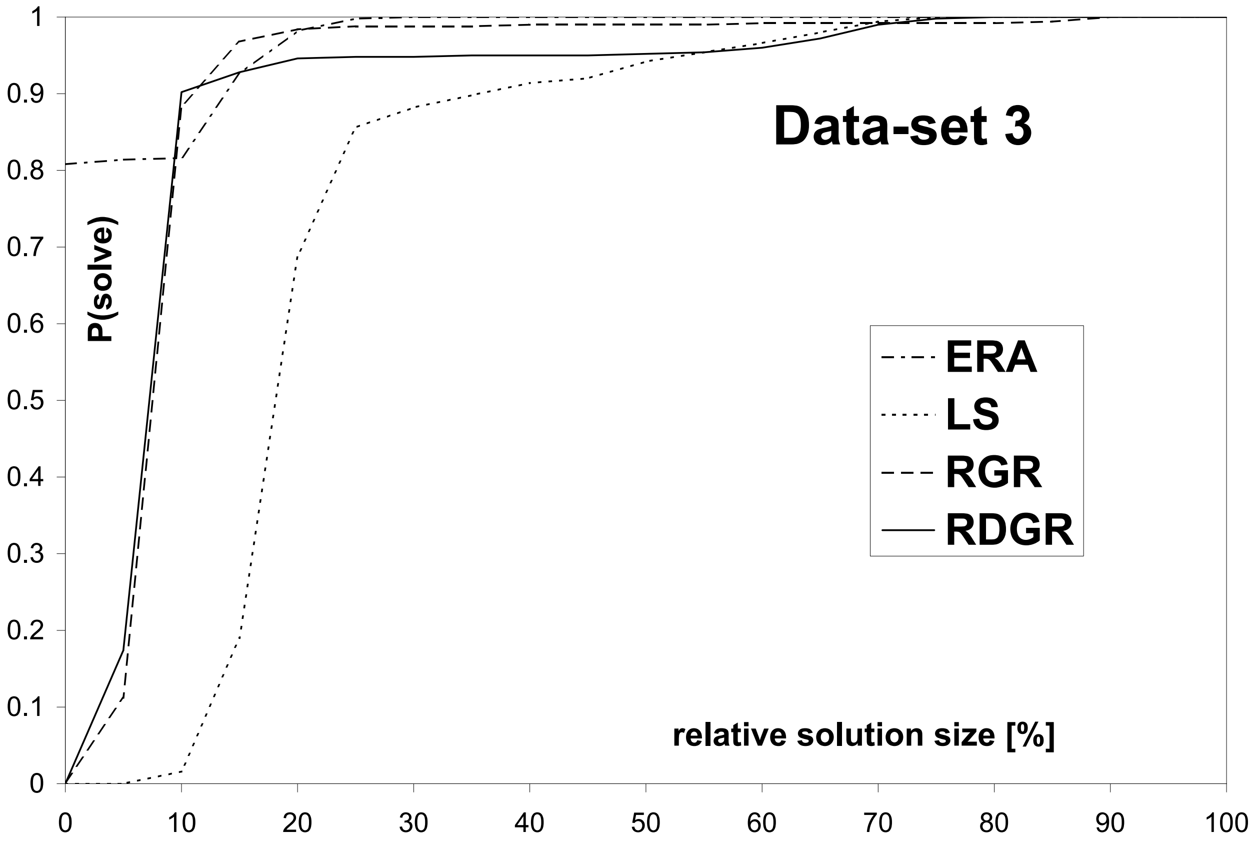


Figure 5: *SQD for Data-set 3 (solvable, 500 runs, 5 min each).*

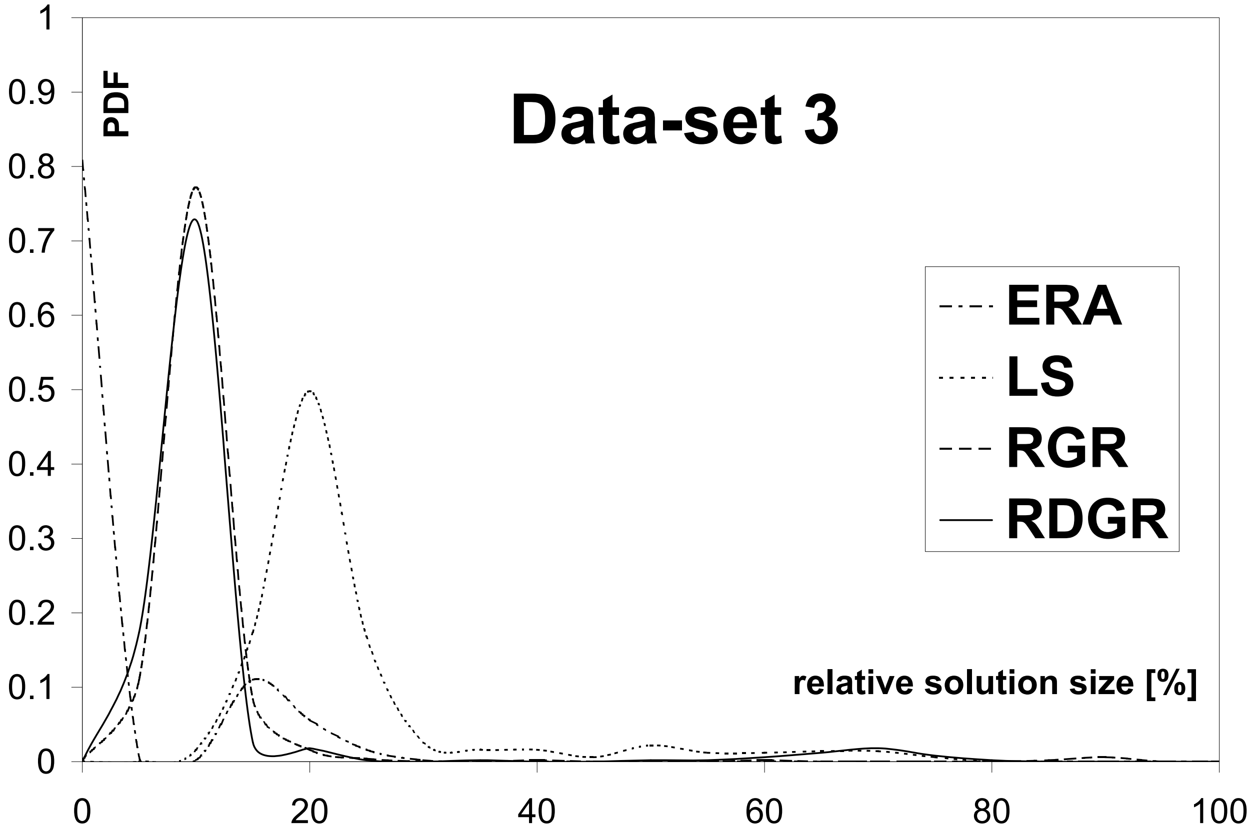


Figure 6: *PDF of the relative solution size for Data-set 3 (solvable, 500 runs, 5 min each).*

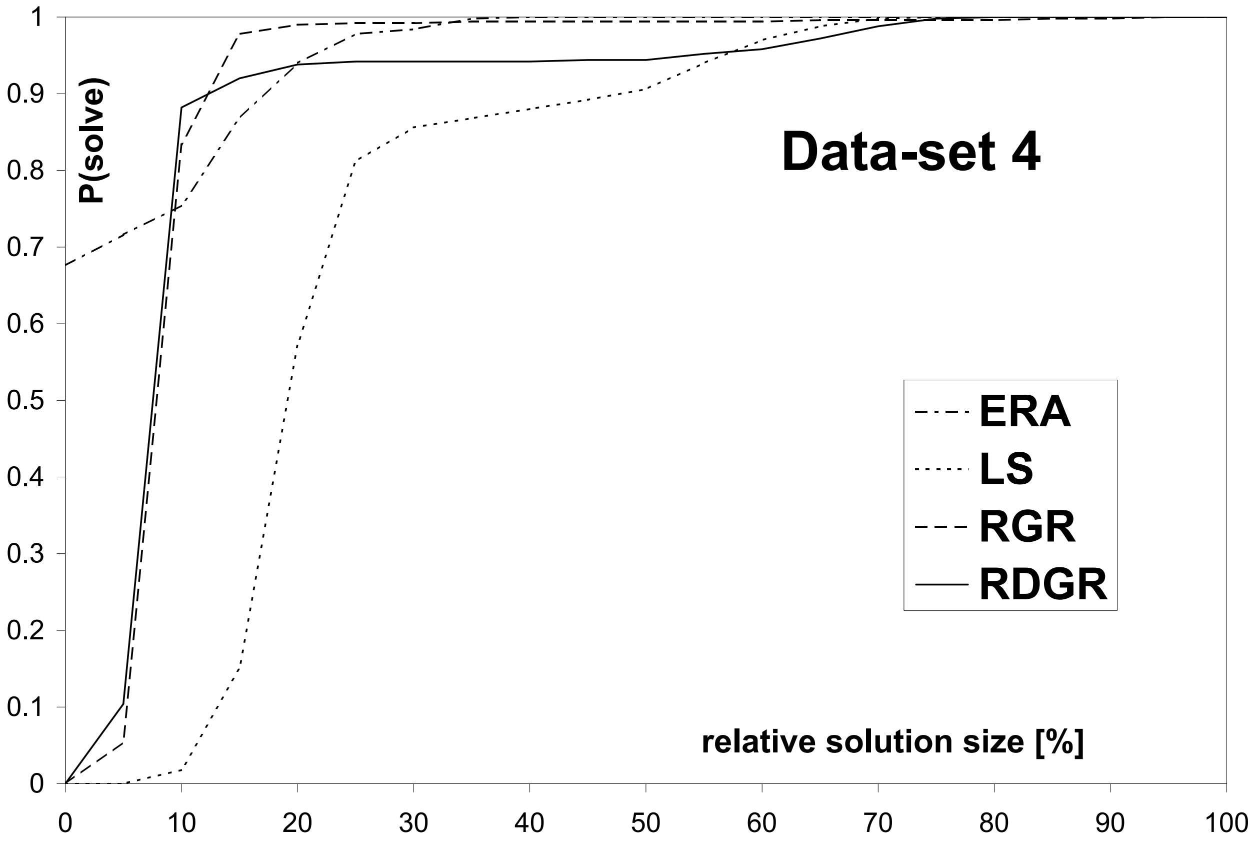


Figure 7: *SQD for Data-set 4 (solvable, 500 runs, 5 min each).*

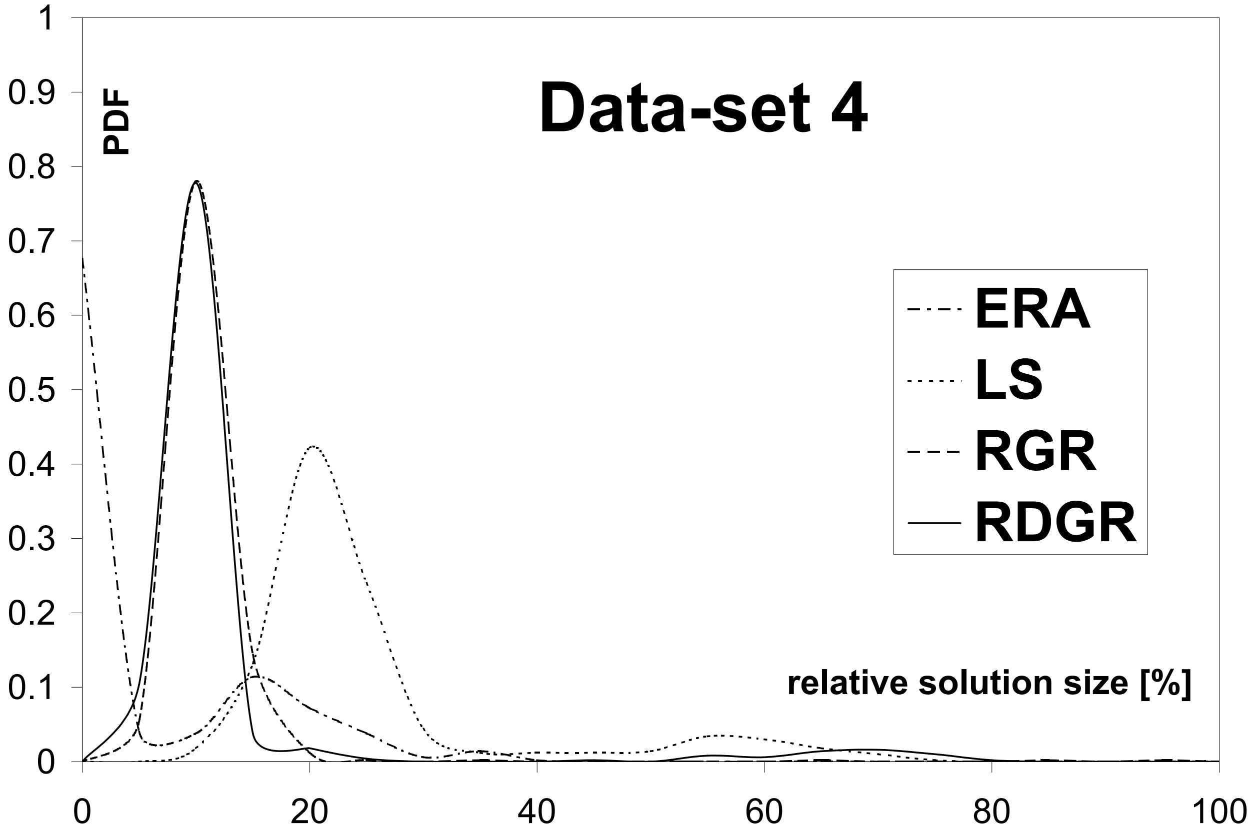


Figure 8: *PDF of the relative solution size for Data-set 4 (solvable, 500 runs, 5 min each).*

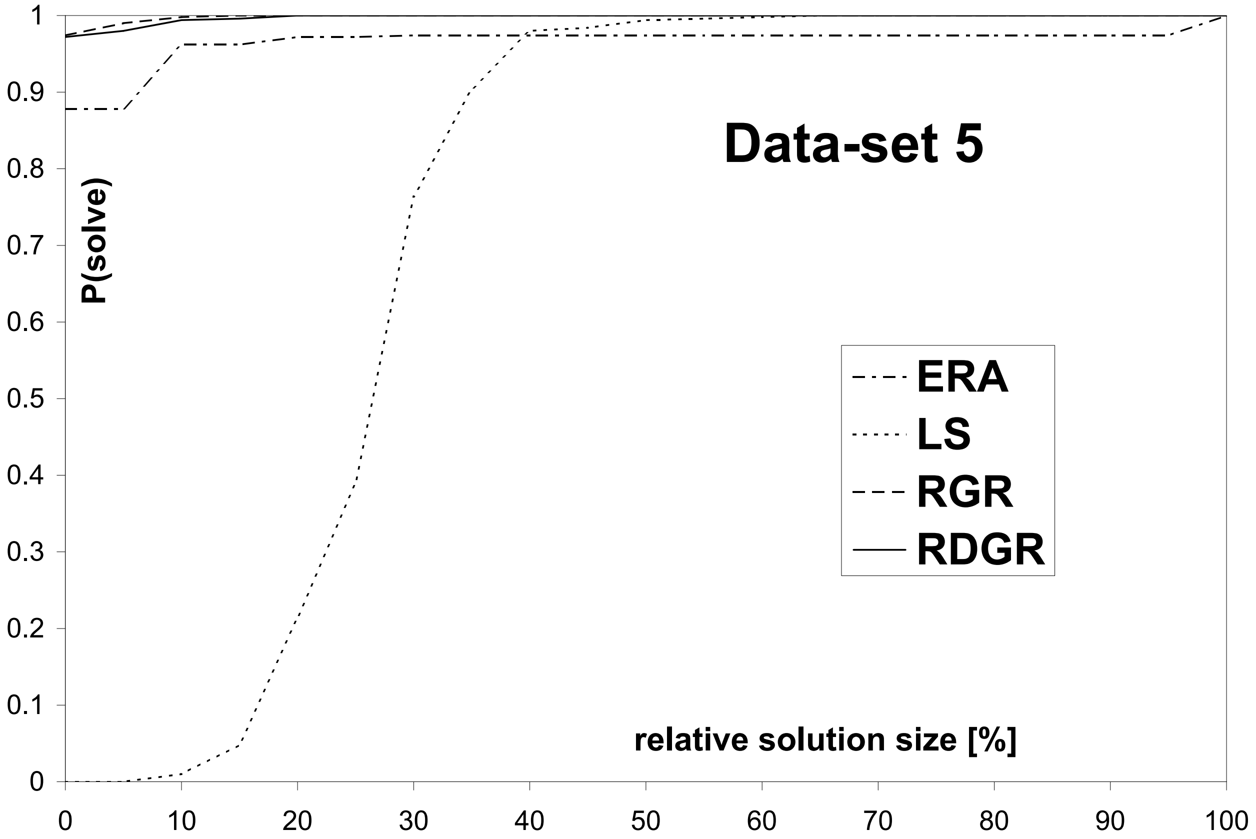


Figure 9: *SQD for Data-set 5 (solvable, 500 runs, 5 min each).*

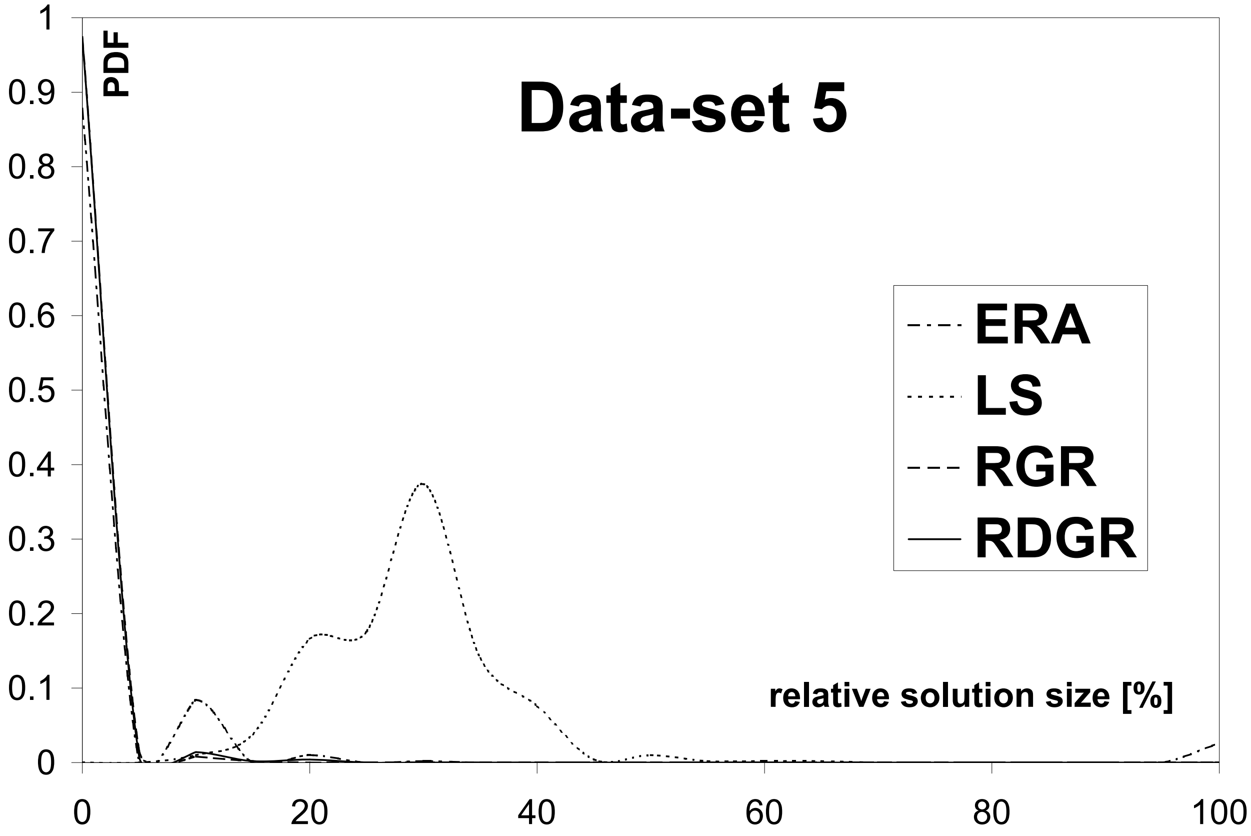


Figure 10: *PDF of the relative solution size for Data-set 5 (solvable, 500 runs, 5 min each).*

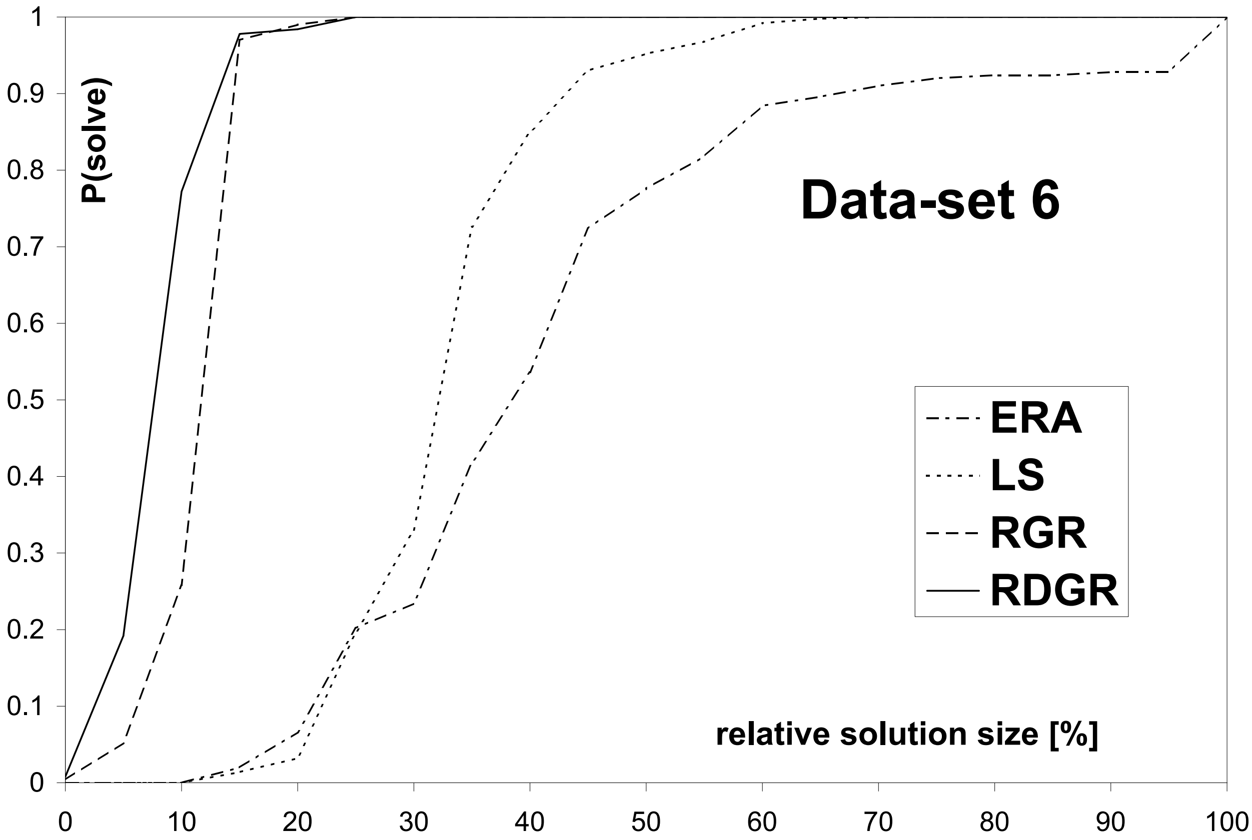


Figure 11: *SQD for Data-set 6 (unsolvable, 500 runs, 5 min each).*

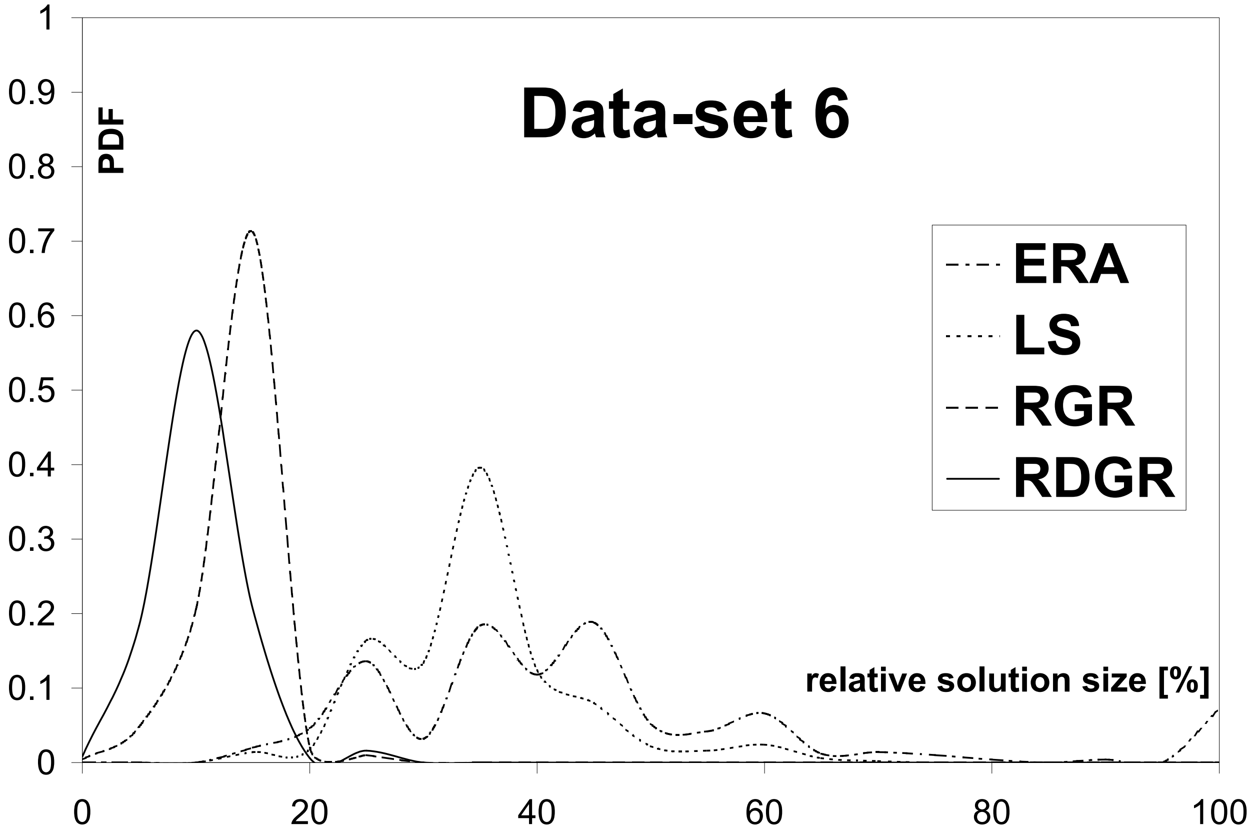


Figure 12: *PDF of the relative solution size for Data-set 6 (unsolvable, 500 runs, 5 min each).*

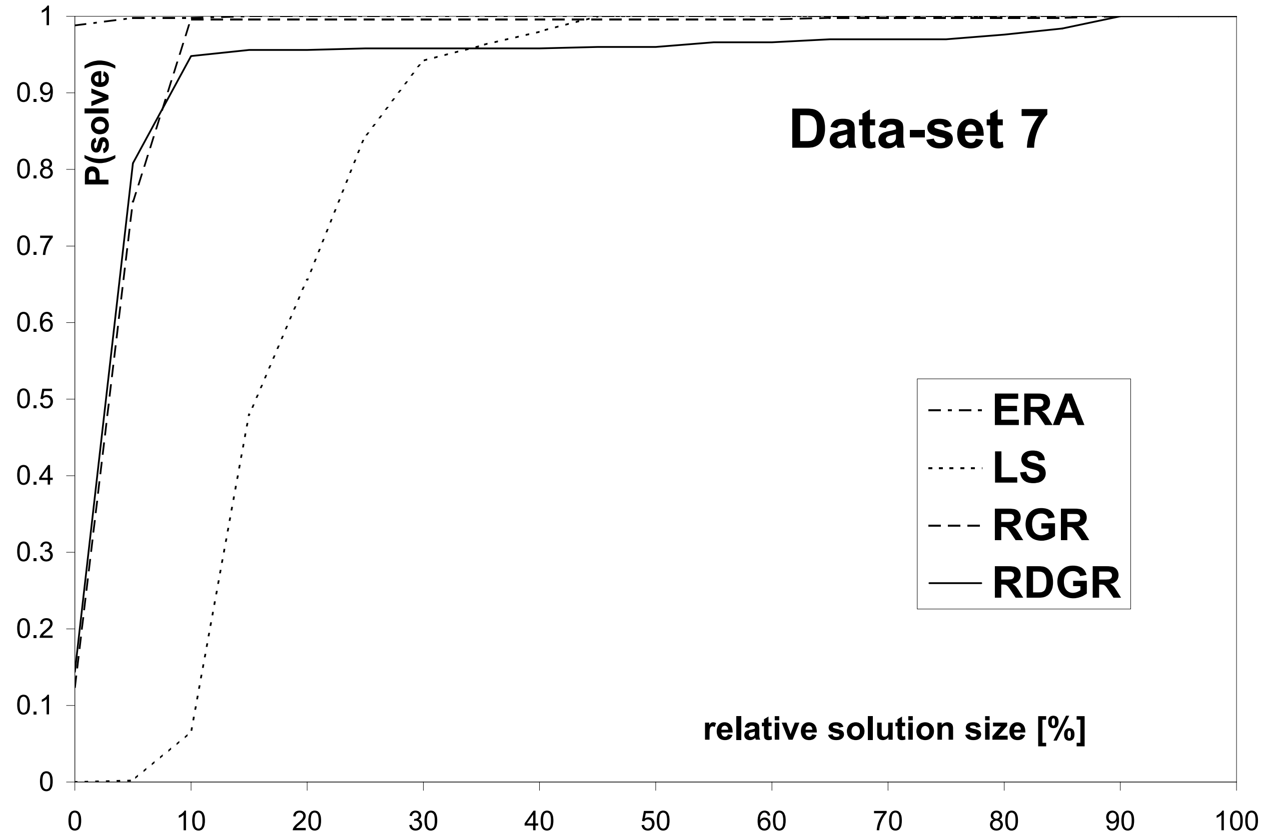


Figure 13: *SQD for Data-set 7 (solvable, 500 runs, 5 min each).*

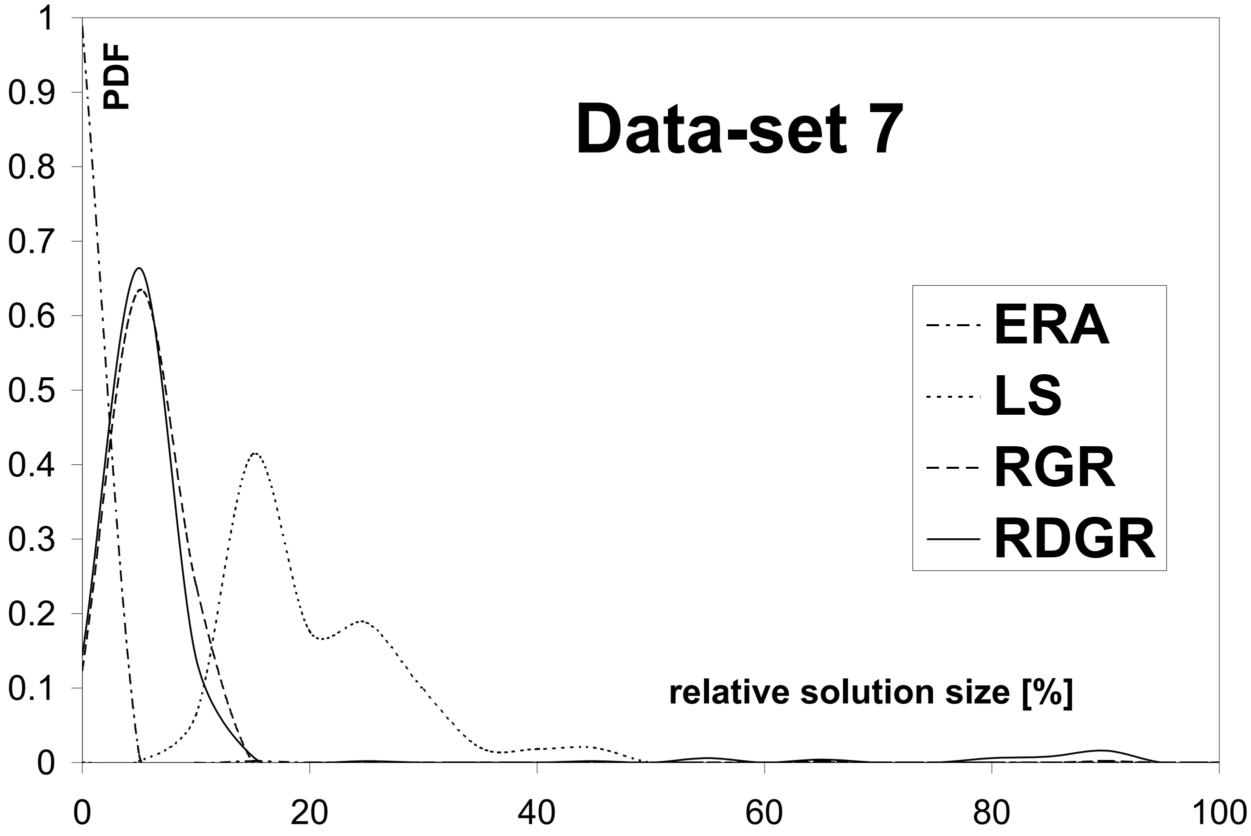


Figure 14: *PDF of the relative solution size for Data-set 7 (solvable, 500 runs, 5 min each).*

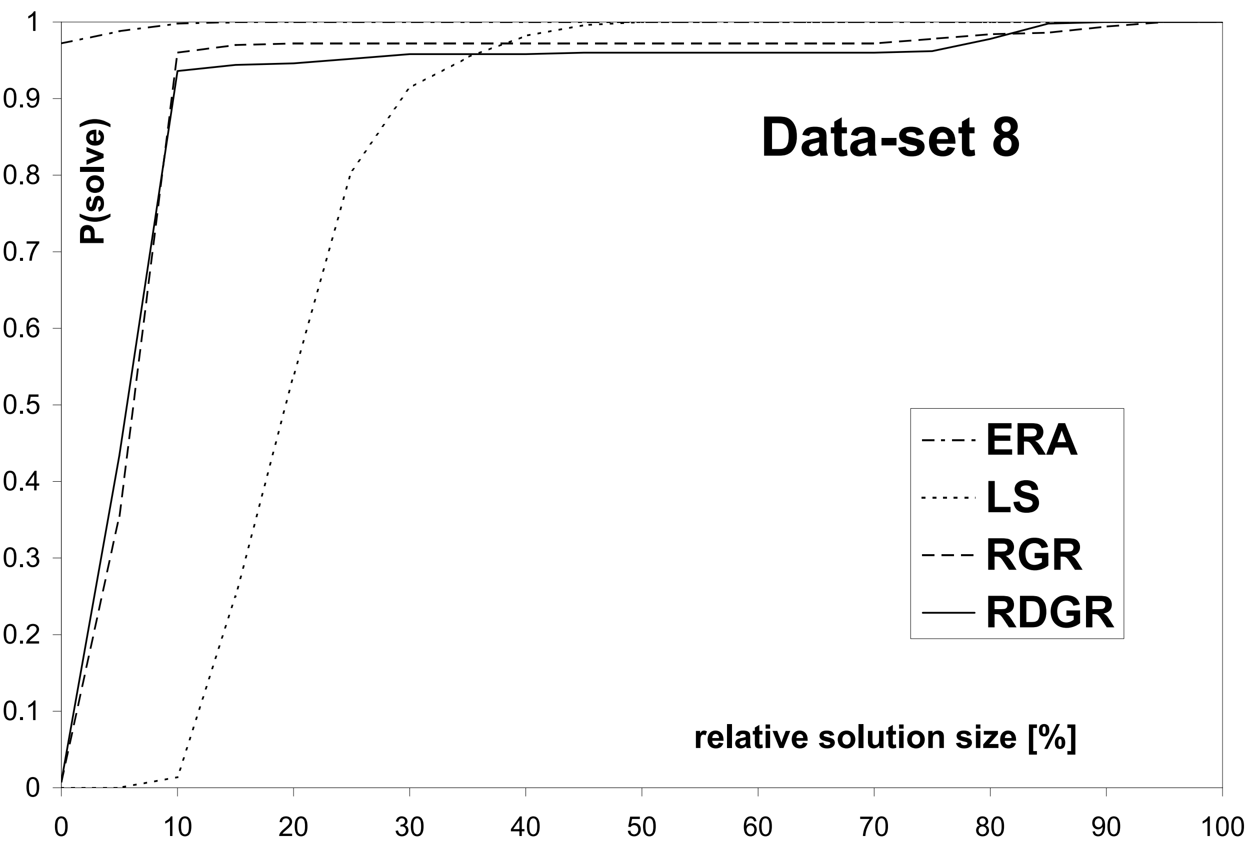


Figure 15: *SQD for Data-set 8 (solvable, 500 runs, 5 min each).*

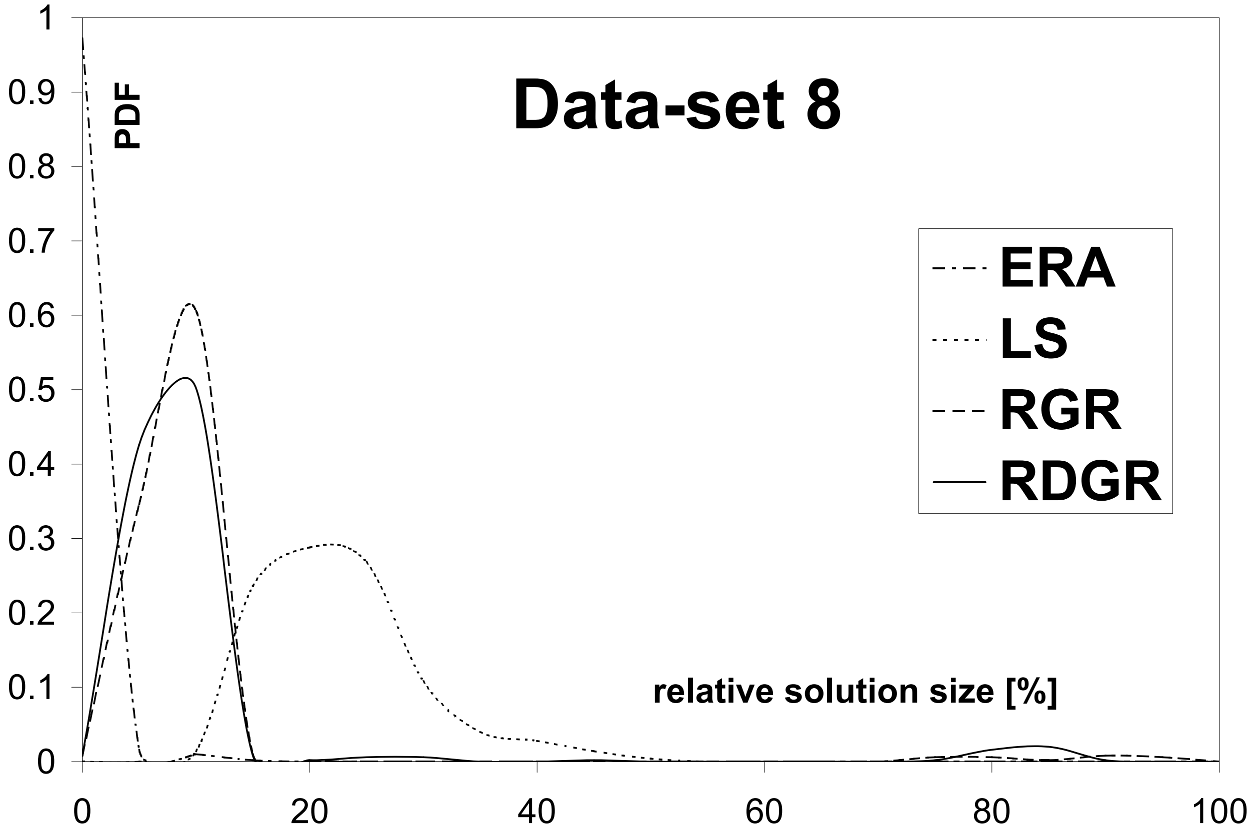


Figure 16: *PDF of the relative solution size for Data-set 8 (solvable, 500 runs, 5 min each).*

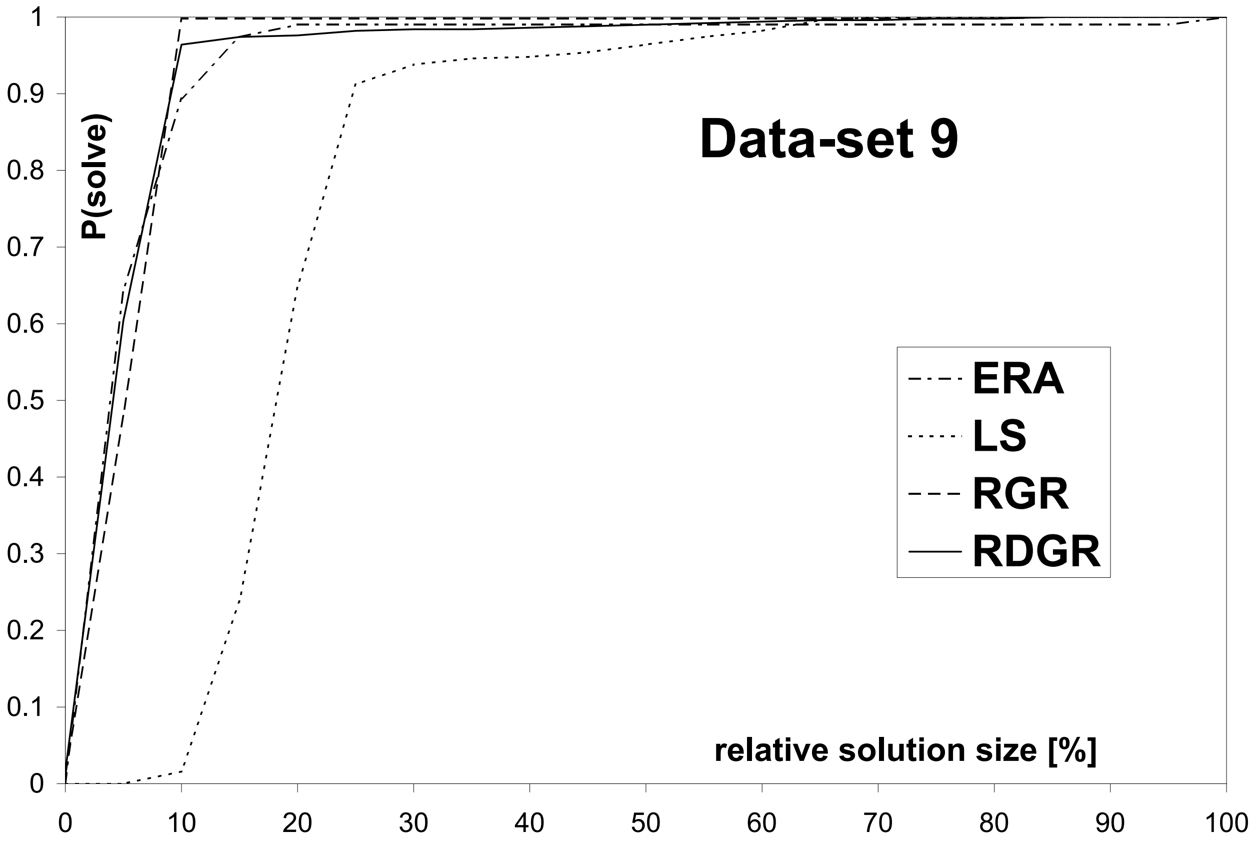


Figure 17: *SQD for Data-set 9 (unsolvable, 500 runs, 5 min each).*

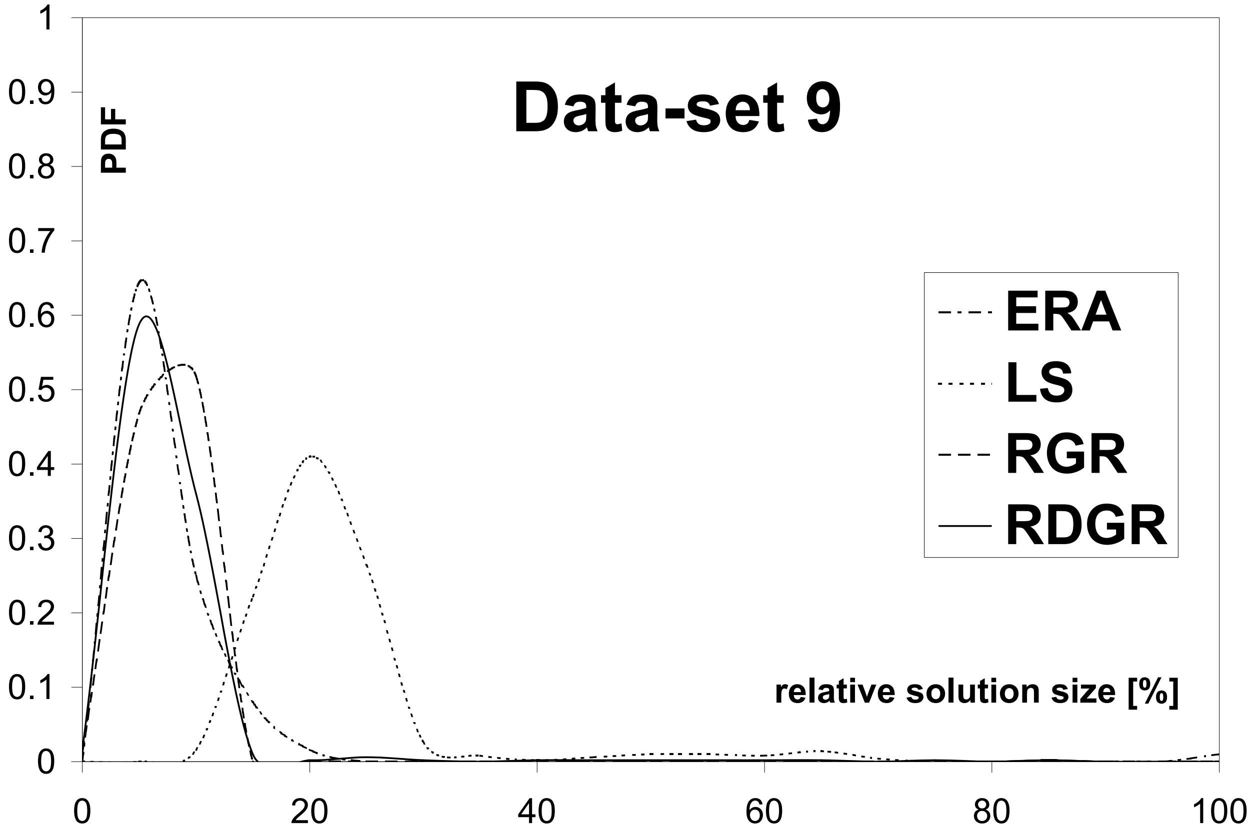


Figure 18: *PDF of the relative solution size for Data-set 9 (unsolvable, 500 runs, 5 min each).*

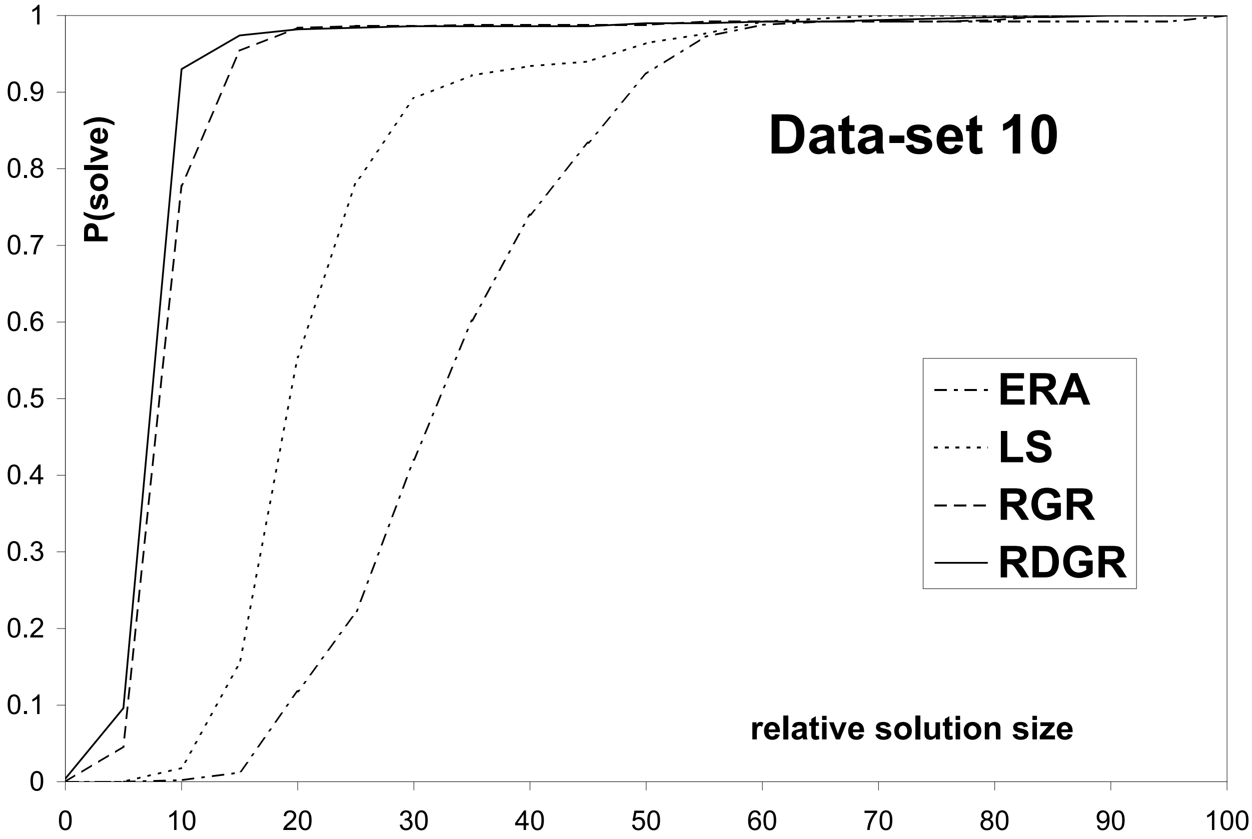


Figure 19: *SQD for Data-set 10 (unsolvable, 500 runs, 5 min each).*

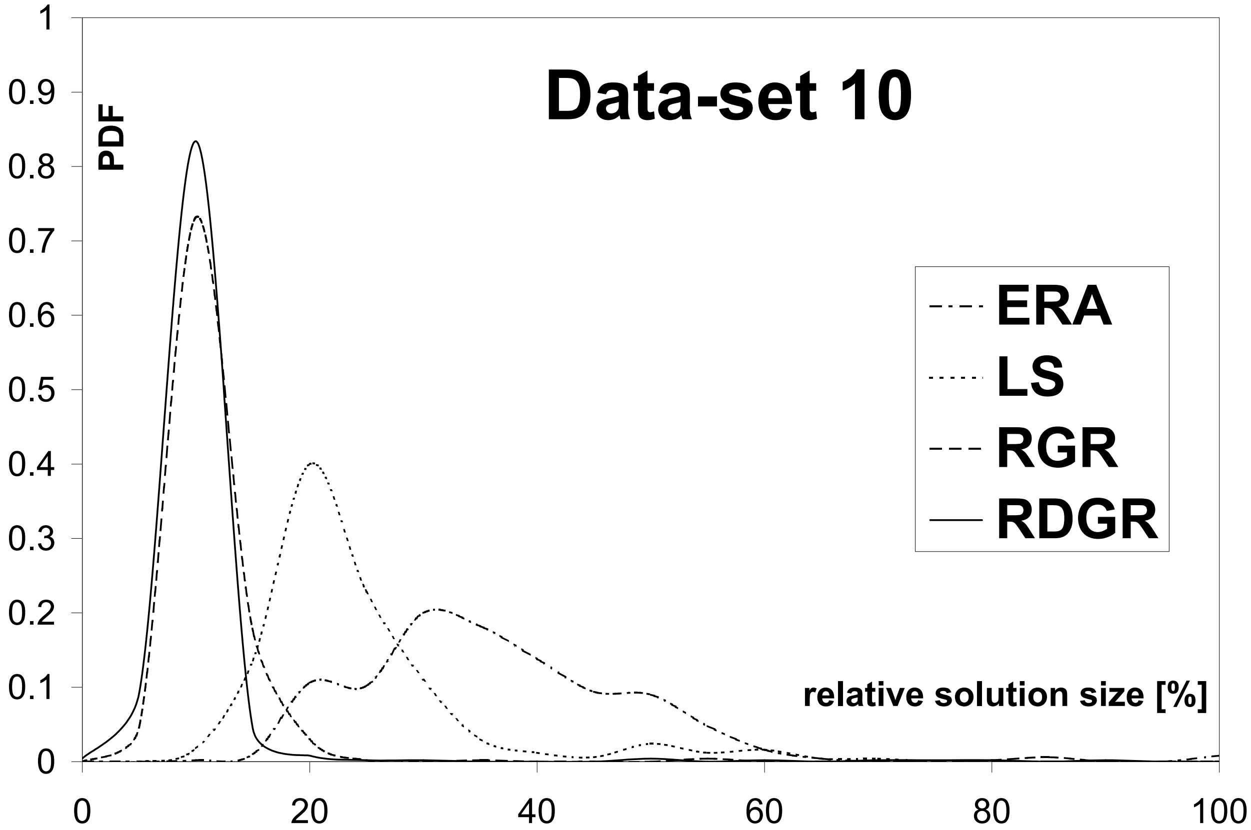


Figure 20: *PDF of the relative solution size for Data-set 10 (unsolvable, 500 runs, 5 min each).*

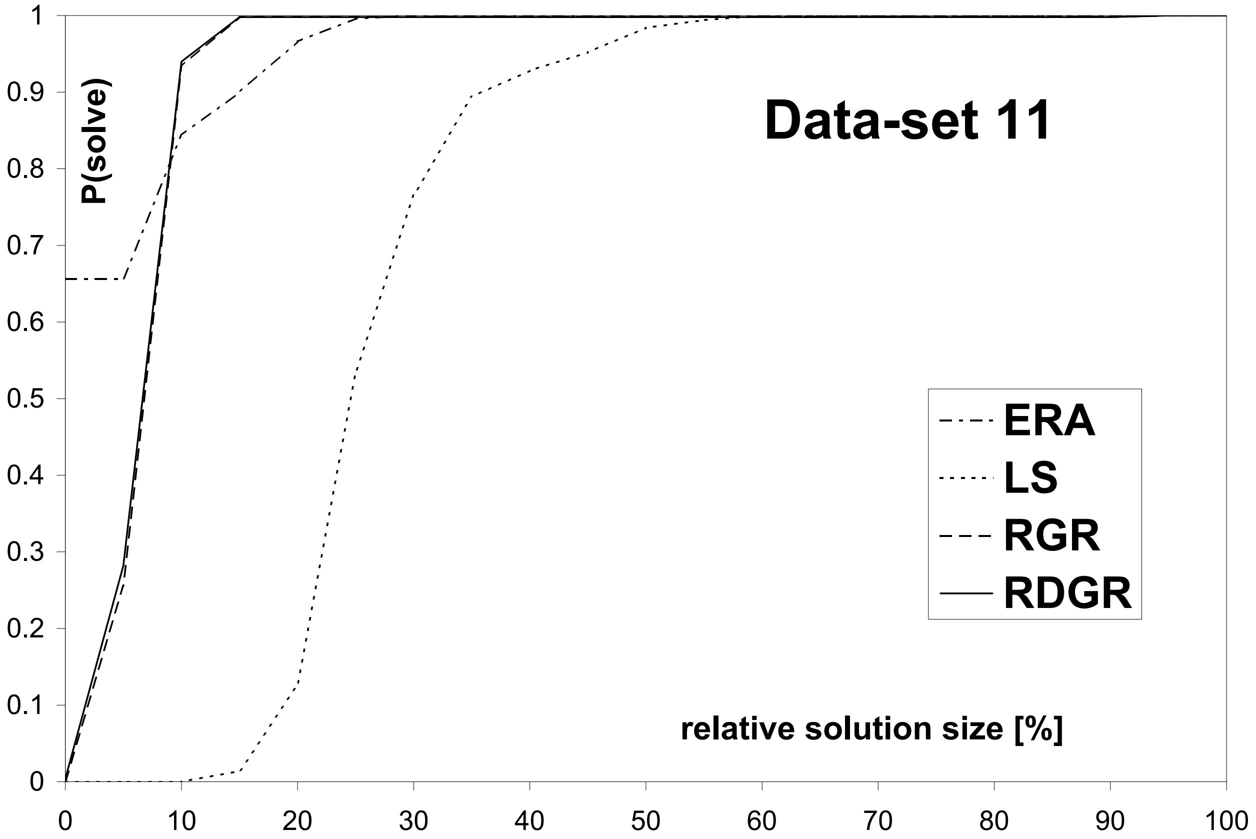


Figure 21: *SQD for Data-set 11 (solvable, 500 runs, 5 min each).*

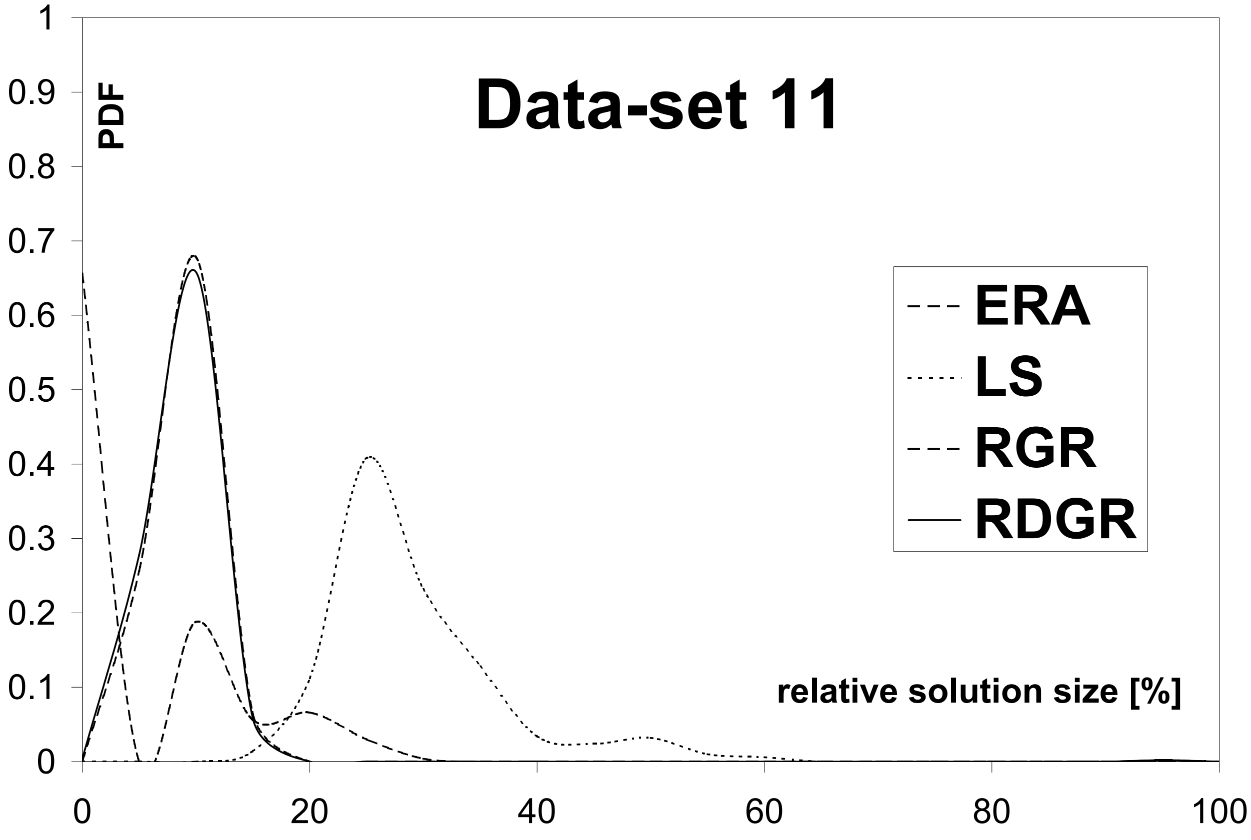


Figure 22: *PDF of the relative solution size for Data-set 11 (solvable, 500 runs, 5 min each).*

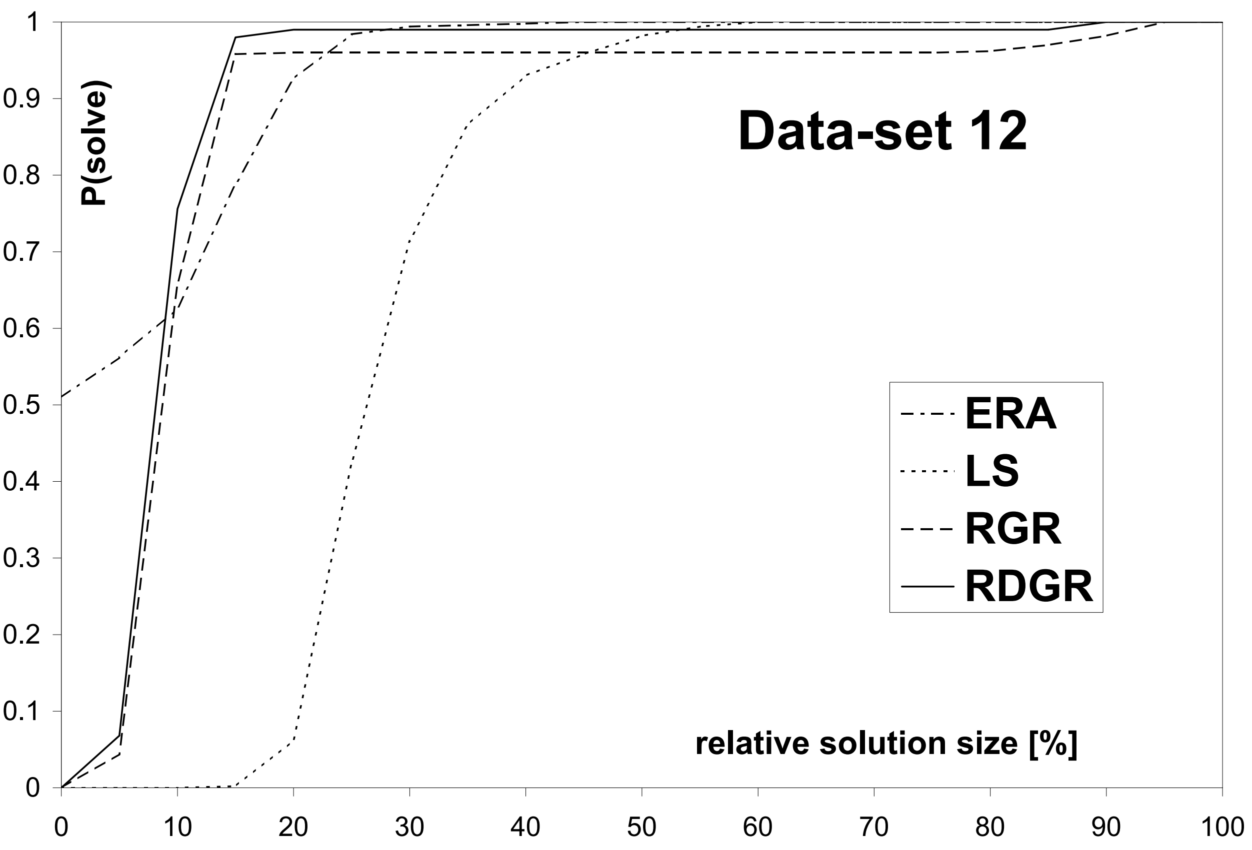


Figure 23: *SQD for Data-set 12 (solvable, 500 runs, 5 min each).*

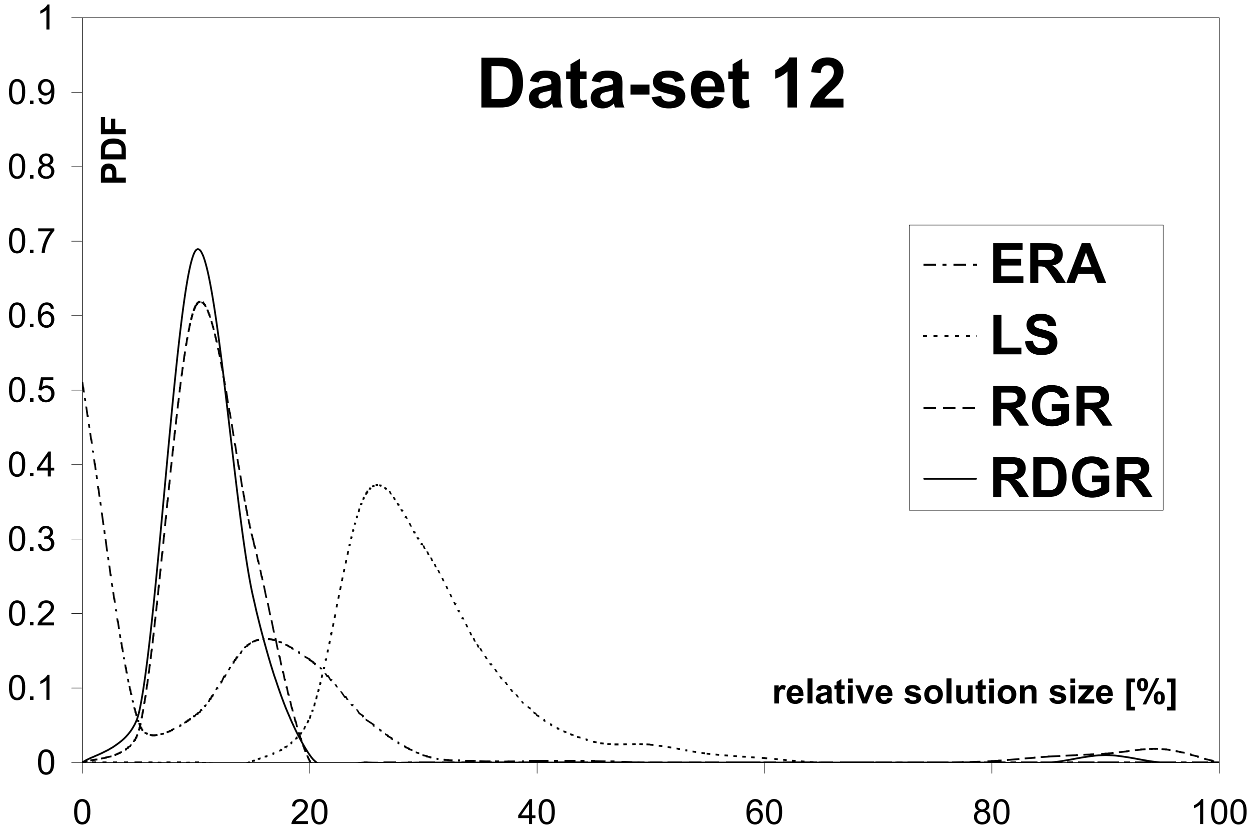


Figure 24: *PDF of the relative solution size for Data-set 12 (solvable, 500 runs, 5 min each).*