

Supplementary file of “Neural Net-Enhanced Competitive Swarm Optimizer for Large-scale Multiobjective Optimization”

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1. Supplementary Figures and Tables

1.1 Figures:

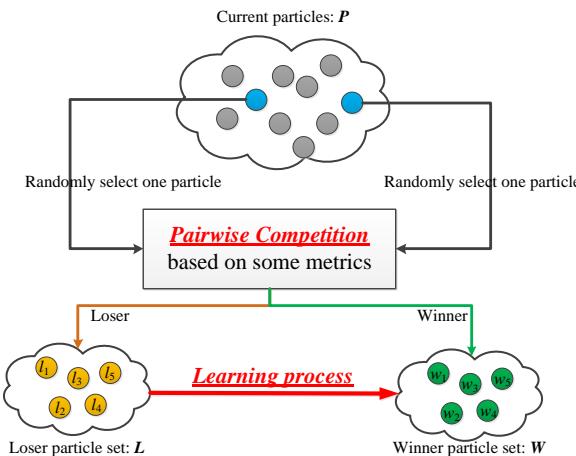
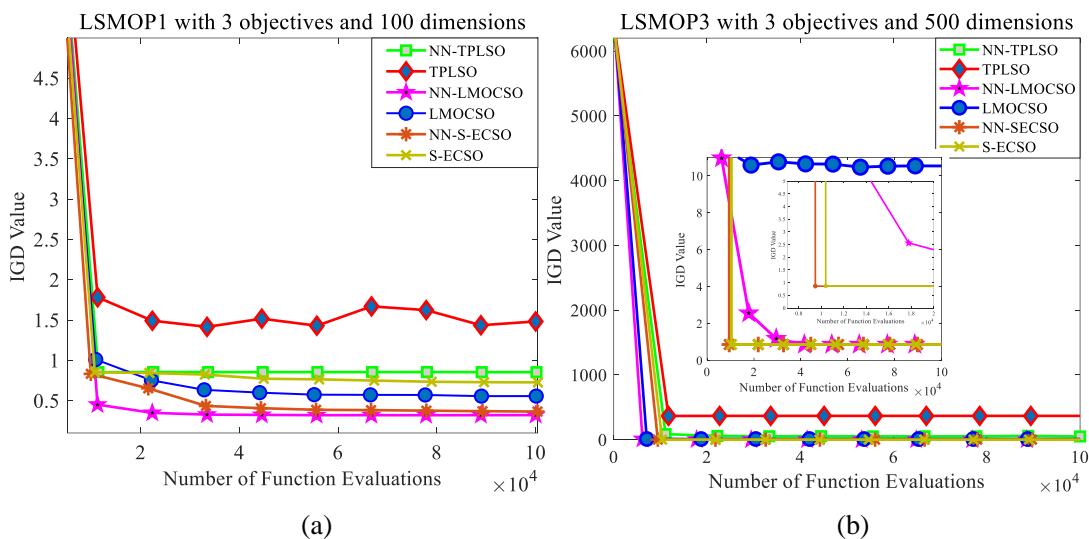


Fig. A. 1 The schematic of the pairwise competition and learning process of CSO.



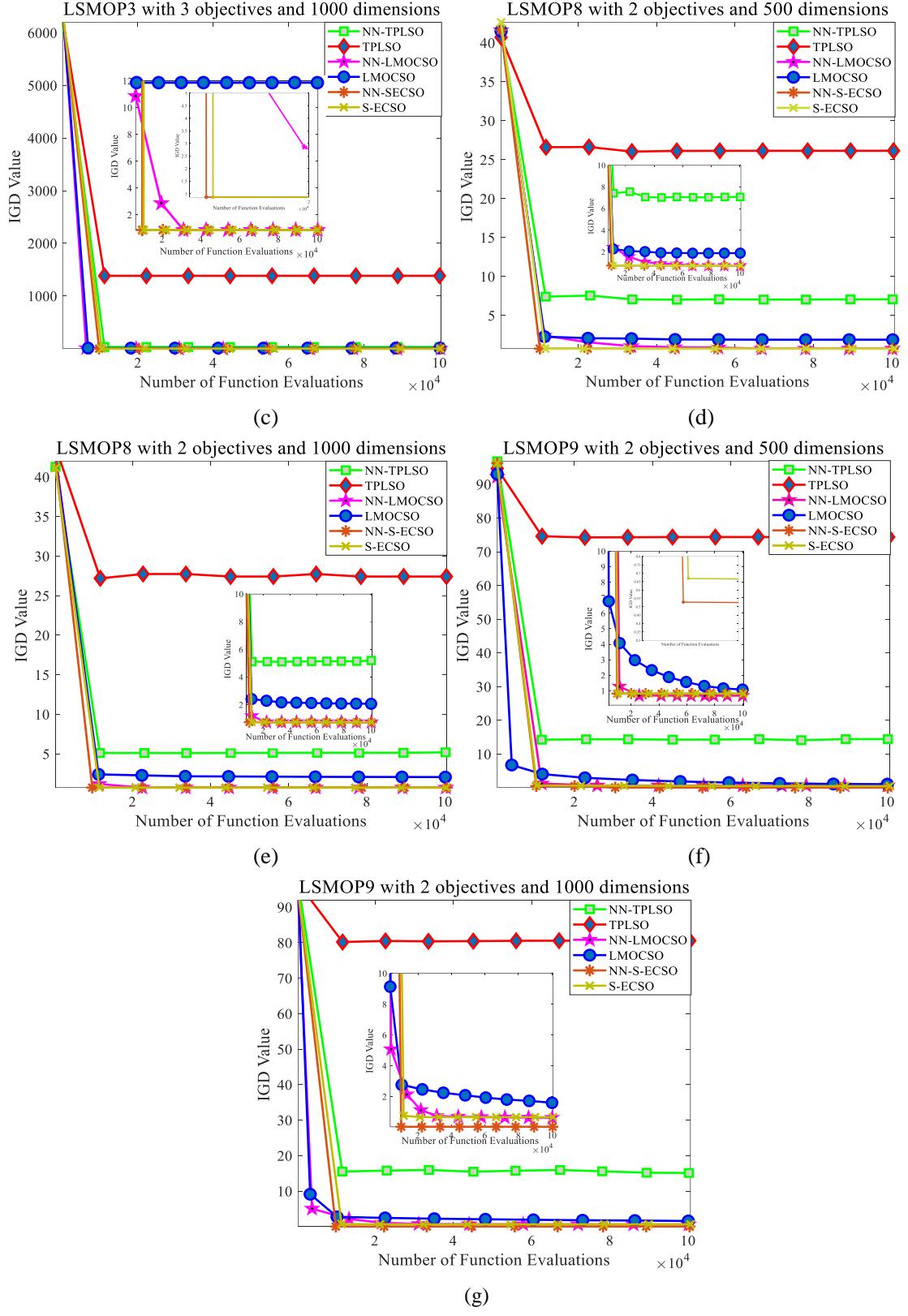


Fig. A.2. The convergence profiles of six compared algorithms on a) LSMOP1 with 3 objectives and 100 decision variables, b) LSMOP3 with 3 objectives and 500 decision variables, c) LSMOP3 with 3 objectives and 1000 decision variables, d) LSMOP8 with 2 objectives and 500 decision variables, e) LSMOP8 with 2 objectives and 1000 decision variables, f) LSMOP9 with 2 objectives and 500 decision variables, and g) LSMOP9 with 2 objectives and 1000 decision variables, respectively.

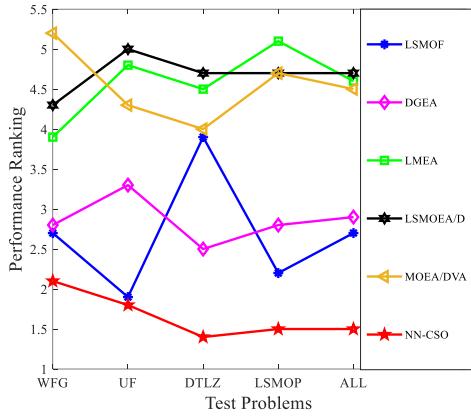


Fig. A. 3. The illustration of the average performance ranks over different test problems.

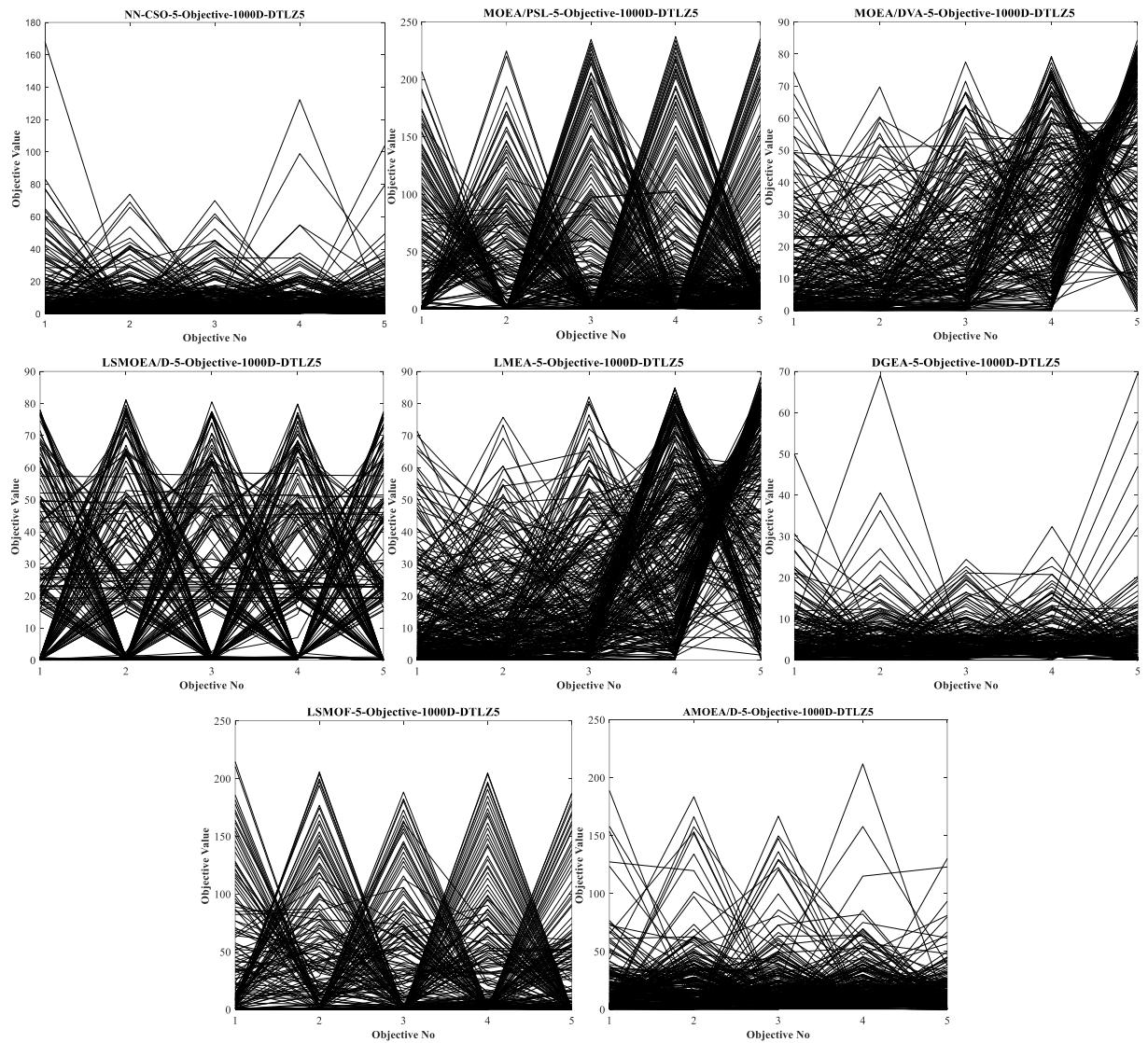


Fig. A. 4. The final population sets obtained by eight compared algorithms on 5-objective DTLZ5 with 1000 decision variables.

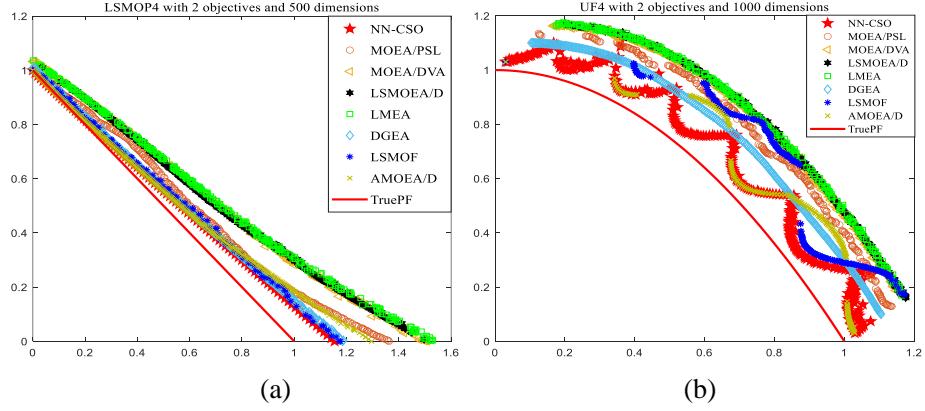


Fig. A. 5. The final population sets obtained by eight compared algorithms on a) 2-objective LSMOP4 with 500 decision variables, and b) 2-objective UF4 with 1000 decision variables.

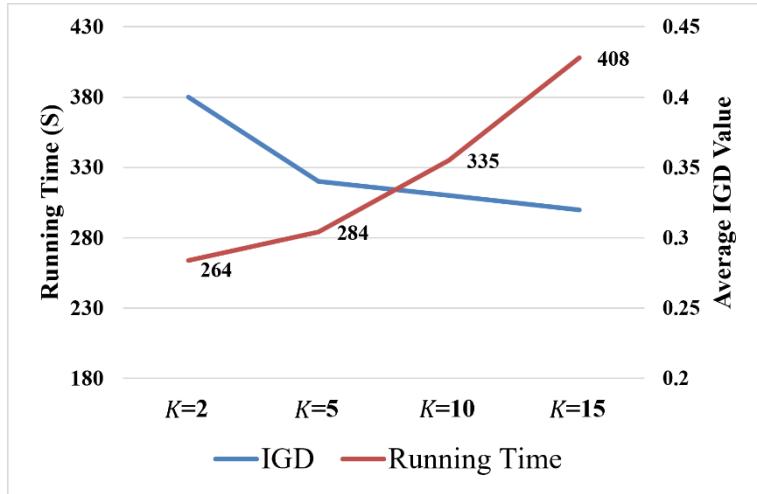


Fig. A. 6. The average IGD values and running time of NN-CSO with different values of K in solving 2-objective LSMOP1 with 1000 decision variables.

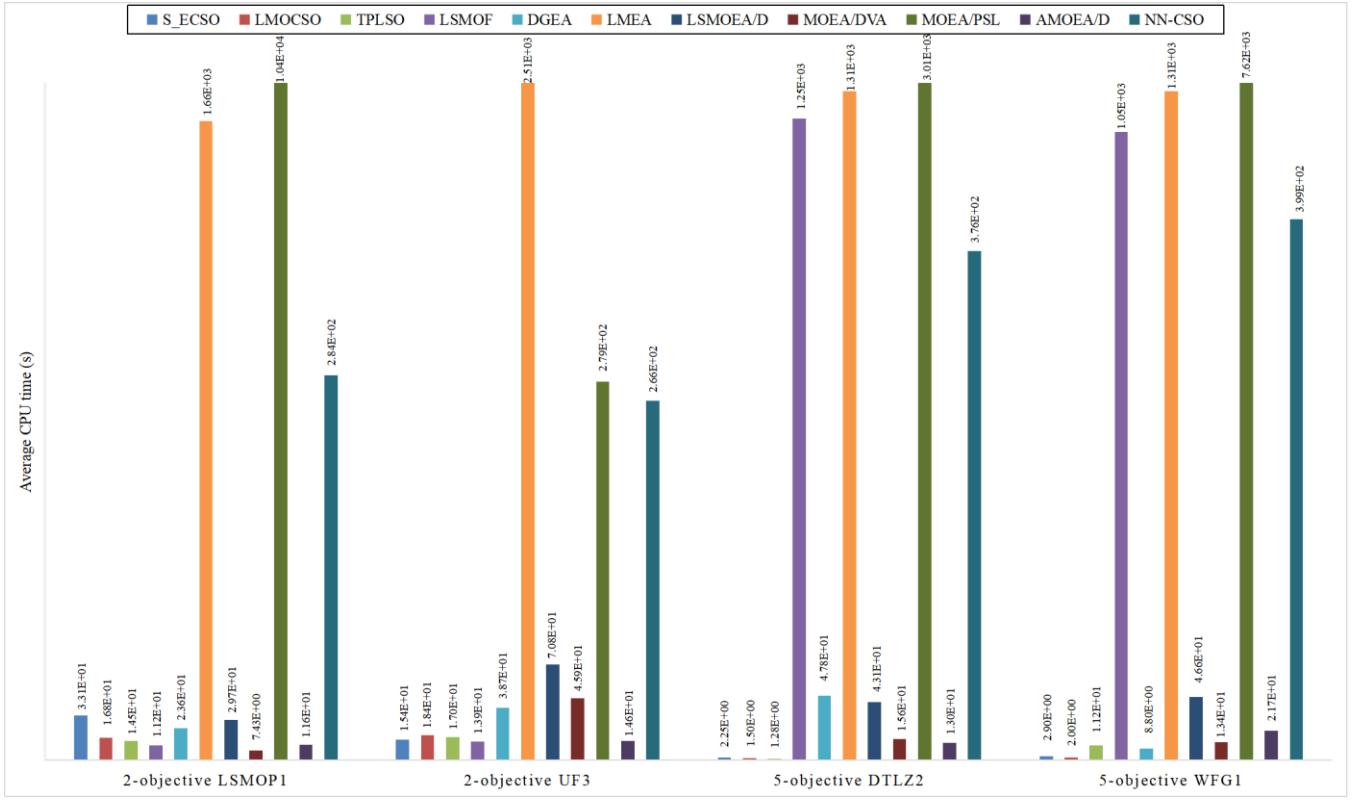


Fig. A. 7. The average CPU running times of NN-CSO and other compared algorithms on 2-objective LSMOP1, 2-objective UF3, 5-objective DTLZ2 and 5-objective WFG1 problems with 1000 decision variables.

1.2 Tables:

TABLE A. 1
SEARCH STRATEGIES AND PARAMETERS SETTINGS OF ALL THE COMPARED ALGORITHMS.

Algorithms	Search Strategies	Parameter settings
LMCSO	Proposed CSO+PM	$p_m = 1/D, n_m = 20, \alpha = 2$
S_ECSO	Proposed CSO+Proposed Convex Sparse Operator	$\lambda_{initial} = 0.35, w = 0.7968, c_1 = 1.4962, c_2 = 1.4962$
MOEA/DVA	Variable Analysis + DE +PM	$CR = 1.0, F = 0.5, p_m = 1/D, n_m = 20, NCA = 20, NIA = 6$
LMEA	Proposed Clustering Variable Analysis + SBX +PM	$p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, nSel = 2, nPer = 4, nCor = 6$
LSMOF	Problem Transformation + NSGAII + DE +PM	$CR = 1.0, F = 0.5, p_m = 1/D, n_m = 20, r = 10, SubN = 30$
DGEA	Direction-guided SBX +PM	$p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, RefNo = 10$
LSMOEA/D	Proposed Clustering Variable Analysis + SBX +PM	$p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, T = 0.1 \times N, nSel = 2, nPer = 4, K = 10$
MOEA/PSL	Dimension Reduction + SBX +PM	$p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, epochs = 10, \eta = 0.1, momentum = 0.5$
AMOEAD	AES + MOEA/D +PM	$p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, epochs = 1, \eta = 0.1, momentum = 0, T = 10, nr = 2, type = "Tch", \delta = 0.9$
NN-CSO	Neural Network Model + corresponding CSO	$K=5, E_{min} = 0.01, lr = 0.01, epochs = 20$

TABLE A. 2

THE IGD COMPARISON RESULTS OF EMBEDDING NN MODEL INTO THREE WELL-KNOWN CSOS ON UF1-UF10 TEST PROBLEMS WITH 2-3 OBJECTIVES AND 100-1000 DECISION VARIABLES.

Problem	M	D	S_ECSO	NN-SECSO	LMOCSO	NN-LMOCSO	TPLSO	NN-TPLSO
UF1	2	100	2.7767e-1 (6.00e-17) -	1.5004e-1 (8.05e-3)	4.3227e-1 (1.02e-1) -	2.4318e-1 (1.16e-2)	1.3293e+0 (8.16e-2) -	5.3793e-1 (1.12e-1)
UF1	2	200	6.8069e-1 (0.00e+0) -	2.1947e-1 (0.00e+0)	9.3333e-1 (7.43e-2) -	5.0663e-1 (6.26e-1)	1.4299e+0 (8.70e-2) -	9.1826e-1 (1.77e-1)
UF1	2	500	9.6696e-1 (1.20e-16) -	2.4656e-1 (3.00e-17)	1.2596e+0 (2.58e-2) -	2.8877e-1 (4.73e-3)	1.4901e+0 (1.72e-2) =	1.3702e+0 (1.27e-1)
UF1	2	1000	1.1464e+0 (2.40e-16) -	2.6651e-1 (0.00e+0)	1.3440e+0 (1.27e-2) -	2.9360e-1 (5.83e-3)	1.4573e+0 (2.80e-2) -	1.1978e+0 (8.41e-2)
UF2	2	100	1.0418e-1 (1.50e-17) +	1.0737e-1 (3.79e-16)	9.6931e-2 (4.29e-3) -	8.3317e-2 (4.18e-3)	3.5019e-1 (4.15e-3) -	1.9961e-1 (2.78e-2)
UF2	2	200	1.2616e-1 (3.00e-17) +	1.2745e-1 (0.00e+0)	1.2577e-1 (3.13e-3) -	1.1017e-1 (4.73e-2)	3.8327e-1 (4.45e-2) -	2.1185e-1 (3.71e-2)
UF2	2	500	1.3181e-1 (0.00e+0) -	1.3095e-1 (0.00e+0)	1.4446e-1 (2.31e-3) -	9.2597e-2 (3.54e-3)	3.8499e-1 (1.89e-2) =	4.5739e-1 (1.37e-1)
UF2	2	1000	1.3608e-1 (0.00e+0) -	1.3324e-1 (0.00e+0)	1.5013e-1 (2.26e-3) -	9.6263e-2 (4.00e-3)	3.6869e-1 (8.11e-3) -	2.6458e-1 (9.07e-2)
UF3	2	100	2.2227e-1 (0.00e+0) +	2.2306e-1 (2.14e-13)	2.3434e-1 (7.81e-3) -	1.8399e-1 (7.77e-3)	4.2276e-1 (7.65e-3) -	2.3409e-1 (5.97e-3)
UF3	2	200	1.8220e-1 (3.00e-17) -	1.7934e-1 (3.00e-17)	2.4819e-1 (4.51e-3) -	1.5620e-1 (3.36e-3)	4.0538e-1 (5.93e-3) -	1.8749e-1 (8.97e-3)
UF3	2	500	1.5452e-1 (0.00e+0) -	1.5322e-1 (0.00e+0)	2.9174e-1 (5.61e-3) -	1.3442e-1 (1.11e-3)	3.9247e-1 (3.22e-3) -	3.8234e-1 (4.18e-3)
UF3	2	1000	1.4609e-1 (0.00e+0) -	1.4466e-1 (3.00e-17)	3.2107e-1 (3.19e-3) -	1.2473e-1 (7.05e-4)	3.9053e-1 (1.49e-3) =	3.3499e-1 (1.44e-1)
UF4	2	100	8.8048e-2 (0.00e+0) -	6.0168e-2 (2.26e-3)	1.1709e-1 (3.34e-3) -	5.8690e-2 (1.95e-4)	5.0950e-1 (1.18e-2) -	1.6123e-1 (1.61e-2)
UF4	2	200	1.0927e-1 (1.50e-17) -	5.9350e-2 (7.49e-18)	1.2692e-1 (3.46e-3) -	5.9575e-2 (5.51e-4)	5.2456e-1 (3.46e-2) -	1.7091e-1 (2.06e-2)
UF4	2	500	1.2983e-1 (0.00e+0) -	6.0084e-2 (7.49e-18)	1.3324e-1 (1.78e-3) -	6.1020e-2 (1.79e-3)	5.1904e-1 (2.62e-2) =	5.1298e-1 (5.24e-2)
UF4	2	1000	1.3462e-1 (0.00e+0) -	6.7637e-2 (0.00e+0)	1.3453e-1 (1.96e-3) -	6.0001e-2 (5.24e-4)	5.1421e-1 (2.58e-2) -	2.0133e-1 (1.37e-2)
UF5	2	100	2.1814e+0 (4.80e-16) -	2.0164e+0 (8.74e-3)	2.4396e+0 (3.02e-1) -	1.1267e+0 (1.73e-1)	5.0672e+0 (1.11e-1) -	3.3533e+0 (2.92e-1)
UF5	2	200	3.2064e+0 (4.80e-16) -	2.6166e+0 (4.80e-16)	3.1744e+0 (3.29e-1) -	2.3209e+0 (3.11e-1)	5.2051e+0 (1.84e-1) -	4.1857e+0 (4.42e-1)
UF5	2	500	4.3456e+0 (0.00e+0) -	2.8916e+0 (4.80e-16)	4.4265e+0 (3.43e-1) -	3.0021e+0 (6.99e-2)	5.3495e+0 (7.11e-2) +	5.5828e+0 (1.82e-1)
UF5	2	1000	4.7957e+0 (0.00e+0) -	2.9851e+0 (0.00e+0)	5.0455e+0 (2.67e-1) -	3.0914e+0 (6.43e-2)	5.4747e+0 (9.98e-2) -	4.7815e+0 (4.52e-1)
UF6	2	100	1.2282e+0 (0.00e+0) -	5.7319e-1 (4.49e-2)	5.0983e-1 (5.26e-2) =	5.1688e-1 (9.19e-2)	4.7766e+0 (2.14e-1) -	1.6452e+0 (1.87e-1)
UF6	2	200	2.7402e+0 (4.80e-16) -	8.1212e-1 (1.20e-16)	1.9724e+0 (1.46e-1) -	7.1853e-1 (2.07e-1)	5.3293e+0 (2.74e-1) -	3.2343e+0 (1.10e+0)
UF6	2	500	3.5589e+0 (4.80e-16) -	9.7202e-1 (1.20e-16)	4.1239e+0 (1.69e-1) -	1.1645e+0 (6.83e-2)	5.5181e+0 (1.12e-1) =	5.1312e+0 (5.26e-1)
UF6	2	1000	4.6431e+0 (0.00e+0) -	1.0401e+0 (0.00e+0)	5.0234e+0 (2.55e-1) -	1.1917e+0 (4.72e-2)	5.6845e+0 (7.38e-2) -	5.0618e+0 (8.41e-1)
UF7	2	100	2.5015e-1 (6.00e-17) -	1.5828e-1 (2.13e-3)	5.2836e-1 (1.24e-1) -	3.5681e-1 (3.58e-1)	1.3947e+0 (7.19e-2) -	5.0603e-1 (6.63e-2)
UF7	2	200	4.5348e-1 (0.00e+0) -	2.2781e-1 (0.00e+0)	9.6944e-1 (7.65e-2) -	2.6931e-1 (1.08e-2)	1.4383e+0 (3.89e-2) -	8.6521e-1 (1.46e-1)
UF7	2	500	9.6546e-1 (1.20e-16) -	2.5504e-1 (0.00e+0)	1.3137e+0 (2.72e-2) -	3.0180e-1 (6.16e-3)	1.5581e+0 (9.65e-2) =	1.4410e+0 (1.75e-1)
UF7	2	1000	1.1596e+0 (2.40e-16) -	2.7819e-1 (0.00e+0)	1.3950e+0 (1.68e-2) -	3.0113e-1 (1.01e-2)	1.5491e+0 (2.29e-2) -	1.2384e+0 (2.59e-1)
UF8	3	100	5.4070e-1 (0.00e+0) +	5.4091e-1 (0.00e+0)	3.4625e-1 (1.43e-2) =	3.4881e-1 (1.46e-2)	7.4071e-1 (5.78e-2) -	6.5623e-1 (3.42e-2)
UF8	3	200	5.4109e-1 (0.00e+0) -	5.4033e-1 (1.20e-16)	4.3478e-1 (2.54e-2) =	4.1731e-1 (3.11e-2)	7.5722e-1 (2.64e-2) =	7.6013e-1 (1.04e-1)
UF8	3	500	5.4409e-1 (1.20e-16) -	5.4188e-1 (0.00e+0)	5.0121e-1 (1.91e-2) -	4.8100e-1 (1.45e-2)	7.8375e-1 (3.52e-2) =	8.5866e-1 (1.97e-1)
UF8	3	1000	5.4619e-1 (0.00e+0) -	5.4530e-1 (1.20e-16)	5.2899e-1 (6.76e-3) =	4.9542e-1 (2.93e-2)	7.7331e-1 (3.09e-2) +	9.7375e-1 (1.37e-1)
UF9	3	100	7.2863e-1 (1.20e-16) +	7.3860e-1 (0.00e+0)	5.0372e-1 (4.06e-2) =	5.0989e-1 (4.59e-3)	7.6222e-1 (6.08e-2) =	7.2748e-1 (5.94e-2)
UF9	3	200	8.3139e-1 (0.00e+0) -	7.7337e-1 (0.00e+0)	5.8528e-1 (2.11e-2) -	5.6101e-1 (7.41e-3)	7.9747e-1 (3.10e-2) =	7.6732e-1 (1.06e-1)
UF9	3	500	8.8950e-1 (0.00e+0) =	8.8950e-1 (0.00e+0)	6.9416e-1 (9.90e-3) -	6.1365e-1 (1.26e-2)	8.3073e-1 (2.33e-2) =	8.7738e-1 (1.46e-1)
UF9	3	1000	8.8950e-1 (0.00e+0) =	8.8950e-1 (0.00e+0)	7.6722e-1 (1.35e-2) -	6.6051e-1 (1.66e-2)	8.1963e-1 (3.83e-2) +	1.2086e+0 (3.54e-1)
UF10	3	100	5.0030e-1 (0.00e+0) +	5.0218e-1 (9.06e-17)	1.9738e+0 (3.04e-1) =	1.8287e+0 (1.87e-1)	4.2100e+0 (4.14e-1) =	4.5354e+0 (4.63e-1)
UF10	3	200	6.9022e-1 (1.20e-16) -	5.1564e-1 (1.20e-16)	3.4774e+0 (4.29e-1) =	3.1637e+0 (3.38e-1)	4.6197e+0 (3.89e-1) =	4.8671e+0 (3.87e-1)
UF10	3	500	5.3874e-1 (0.00e+0) +	5.4396e-1 (1.20e-16)	3.4774e+0 (4.29e-1) =	3.1637e+0 (3.38e-1)	5.0241e+0 (4.75e-1) =	6.2307e+0 (1.25e+0)
UF10	3	1000	5.4029e-1 (0.00e+0) +	5.4370e-1 (0.00e+0)	4.3418e+0 (2.98e-1) -	3.7282e+0 (2.54e-1)	4.9915e+0 (3.54e-1) +	8.0570e+0 (2.02e+0)
+/-=			8/30/2		0/32/8		4/22/14	

LSMOP6	2	200	2.9550e-1 (0.00e+0) -	2.4937e-1 (3.00e-17)	8.6313e-1 (2.15e-2) -	7.5911e-1 (5.40e-3)	2.5096e+5 (8.79e+4) -	5.0882e+2 (1.31e+3)
LSMOP6	2	500	6.6594e-1 (1.20e-16) -	1.9458e-1 (0.00e+0)	8.0319e-1 (9.18e-3) -	7.5233e-1 (9.55e-4)	3.3901e+5 (1.37e+5) -	5.2394e+2 (1.38e+3)
LSMOP6	2	1000	1.8151e-1 (3.00e-17) +	1.8647e-1 (0.00e+0)	7.3024e-1 (1.13e-1) +	7.5010e-1 (1.79e-3)	4.2942e+5 (1.10e+5) -	4.7739e+4 (9.42e+4)
LSMOP6	3	100	1.1164e+0 (0.00e+0) -	7.0211e-1 (0.00e+0)	5.8326e+0 (2.75e+0) -	9.8301e-1 (1.86e-1)	2.1166e+4 (4.41e+4) -	1.4892e+0 (8.32e-3)
LSMOP6	3	200	1.2296e+0 (0.00e+0) -	7.9934e-1 (1.20e-16)	4.7678e+1 (1.74e+1) -	1.2356e+0 (1.98e-3)	3.8443e+5 (7.06e+5) =	7.5235e+3 (6.59e+3)
LSMOP6	3	500	1.2932e+0 (0.00e+0) -	7.9218e-1 (1.20e-16)	1.6032e+2 (3.23e+1) -	1.2959e+0 (3.85e-4)	7.8085e+4 (1.95e+5) -	2.1073e+3 (1.46e+3)
LSMOP6	3	1000	1.3137e+0 (0.00e+0) -	9.5277e-1 (1.20e-16)	3.2570e+2 (6.76e+1) -	1.3168e+0 (1.48e-3)	3.0925e+4 (5.62e+4) =	1.9602e+4 (1.41e+4)
LSMOP7	2	100	1.4525e+0 (0.00e+0) -	1.4456e+0 (5.78e-4)	1.5336e+1 (2.37e+0) -	1.4577e+0 (7.35e-4)	3.8320e+4 (8.43e+4) -	1.4956e+0 (9.31e-2)
LSMOP7	2	200	1.4892e+0 (2.40e-16) -	1.4868e+0 (0.00e+0)	1.4712e+2 (2.01e+1) -	1.4916e+0 (5.54e-4)	1.7010e+5 (1.70e+5) =	6.2242e+3 (1.40e+3)
LSMOP7	2	500	1.5063e+0 (2.40e-16) -	1.5058e+0 (0.00e+0)	5.3070e+2 (3.89e+1) -	1.5109e+0 (1.83e-3)	7.1037e+4 (1.04e+5) =	1.2130e+4 (4.38e+3)
LSMOP7	2	1000	1.5122e+0 (2.40e-16) -	1.5114e+0 (2.40e-16)	6.9017e+2 (3.09e+1) -	1.5156e+0 (2.36e-3)	4.5189e+4 (8.23e+4) =	1.2226e+4 (5.94e+3)
LSMOP7	3	100	1.0551e+0 (0.00e+0) -	1.0128e+0 (0.00e+0)	1.1817e+0 (2.84e-1) =	9.1842e-1 (9.45e-2)	1.9666e+5 (7.81e+4) -	1.6932e+0 (2.58e-1)
LSMOP7	3	200	9.6224e-1 (1.20e-16) -	9.3829e-1 (0.00e+0)	1.3861e+0 (1.08e-1) -	1.0253e+0 (5.64e-2)	2.0937e+5 (6.18e+4) -	1.7604e+0 (2.98e-1)
LSMOP7	3	500	8.8607e-1 (0.00e+0) +	9.0102e-1 (1.20e-16)	1.1727e+0 (3.68e-2) -	9.2035e-1 (8.90e-2)	2.8266e+5 (6.72e+4) -	6.9584e+4 (4.97e+4)
LSMOP7	3	1000	8.5404e-1 (0.00e+0) -	7.5817e-1 (1.20e-16)	1.0547e+0 (1.82e-2) -	9.5474e-1 (2.46e-2)	2.2596e+5 (8.99e+4) -	2.5884e+4 (6.00e+4)
LSMOP8	2	100	7.4209e-1 (1.20e-16) -	6.8302e-1 (4.31e-3)	4.8960e-1 (1.33e-1) -	2.9998e-1 (5.28e-2)	3.7057e+1 (1.56e+1) -	8.8840e-1 (3.39e-1)
LSMOP8	2	200	7.4209e-1 (1.20e-16) =	7.4209e-1 (1.20e-16)	1.2261e+0 (1.30e-1) -	6.5133e-1 (6.66e-2)	3.9945e+1 (3.89e+0) -	3.7061e+0 (2.18e+0)
LSMOP8	2	500	7.4209e-1 (1.20e-16) =	7.4209e-1 (1.20e-16)	1.8998e+0 (7.52e-2) -	7.4209e-1 (1.20e-16)	3.7846e+1 (1.33e+1) -	7.3759e+0 (2.41e+0)
LSMOP8	2	1000	7.4209e-1 (1.20e-16) =	7.4209e-1 (1.20e-16)	2.1493e+0 (6.18e-2) -	7.4209e-1 (1.20e-16)	3.9088e+1 (1.69e+1) -	6.7657e+0 (1.02e+0)
LSMOP8	3	100	3.3293e-1 (6.00e-17) -	2.1409e-1 (3.00e-17)	6.9062e-1 (2.33e-2) -	2.2384e-1 (2.52e-2)	2.7022e+1 (6.19e+0) -	6.6111e-1 (4.75e-2)
LSMOP8	3	200	3.3004e-1 (0.00e+0) -	2.1709e-1 (0.00e+0)	6.2168e-1 (3.77e-2) -	1.6963e-1 (1.16e-2)	3.9854e+1 (1.11e+1) -	9.4899e-1 (8.25e-2)
LSMOP8	3	500	2.9704e-1 (6.00e-17) -	1.3784e-1 (3.00e-17)	5.4697e-1 (7.39e-3) -	1.5592e-1 (1.80e-2)	4.5812e+1 (1.33e+1) -	1.9801e+1 (1.15e+1)
LSMOP8	3	1000	3.2267e-1 (0.00e+0) -	9.8708e-2 (1.50e-17)	5.3239e-1 (1.08e-2) -	1.6270e-1 (3.69e-2)	3.8762e+1 (8.61e+0) -	3.0909e+0 (3.20e+0)
LSMOP9	2	100	8.1004e-1 (0.00e+0) =	8.1004e-1 (0.00e+0)	6.6243e-1 (5.98e-2) +	8.1004e-1 (5.64e-16)	5.4380e+1 (1.76e+1) -	8.1140e-1 (3.59e-3)
LSMOP9	2	200	8.1004e-1 (0.00e+0) =	8.1004e-1 (0.00e+0)	5.2370e-1 (2.68e-2) +	8.0603e-1 (5.30e-3)	6.9717e+1 (1.50e+1) -	2.7705e+0 (2.36e+0)
LSMOP9	2	500	8.1004e-1 (0.00e+0) =	8.1004e-1 (0.00e+0)	9.8356e-1 (6.58e-2) -	6.6887e-1 (1.24e-1)	8.1691e+1 (1.97e+1) -	1.4433e+1 (7.11e+0)
LSMOP9	2	1000	6.6102e-1 (0.00e+0) -	3.3542e-2 (0.00e+0)	2.0274e+0 (5.77e-1) -	6.6516e-1 (7.38e-2)	8.9887e+1 (1.75e+1) -	1.3884e+1 (8.31e+0)
LSMOP9	3	100	7.8445e-1 (0.00e+0) -	6.6450e-1 (1.20e-16)	8.7886e-1 (1.57e-1) -	5.9295e-1 (2.15e-3)	1.1261e+2 (1.85e+1) -	1.5379e+0 (7.47e-6)
LSMOP9	3	200	9.2054e-1 (1.20e-16) +	9.7553e-1 (1.20e-16)	1.3020e+0 (2.83e-1) -	6.7195e-1 (2.09e-1)	1.4692e+2 (4.24e+1) -	3.4512e+0 (4.70e+0)
LSMOP9	3	500	5.9161e-1 (0.00e+0) +	5.9282e-1 (1.20e-16)	1.5168e+0 (9.85e-2) -	5.8631e-1 (1.58e-2)	1.6372e+2 (3.73e+1) =	1.1557e+2 (5.44e+1)
LSMOP9	3	1000	1.5379e+0 (2.40e-16) -	5.9079e-1 (0.00e+0)	2.0343e+1 (1.59e+1) -	2.5451e+0 (1.34e-0)	1.5828e+2 (3.36e+1) -	6.4018e+1 (2.68e+1)
+/-=		4/55/13			3/68/1		0/61/11	

WFG8	5	1000	2.2099e+0 (0.00e+0) +	2.2671e+0 (0.00e+0)	1.3328e+0 (4.49e-2) =	1.3015e+0 (1.09e-2)	4.8314e+0 (4.06e-1) -	2.1983e+0 (1.76e-1)
WFG8	8	100	3.7693e+0 (0.00e+0) -	3.6733e+0 (4.80e-16)	3.2325e+0 (5.31e-2) =	3.2508e+0 (6.18e-2)	1.0840e+1 (5.66e-1) -	5.5627e+0 (2.29e-1)
WFG8	8	200	3.9034e+0 (4.80e-16) +	3.9079e+0 (0.00e+0)	3.2252e+0 (1.33e-2) =	3.2326e+0 (2.47e-2)	1.0089e+1 (6.22e-1) -	5.7691e+0 (6.91e-1)
WFG8	8	500	6.6102e+0 (0.00e+0) -	6.2815e+0 (9.59e-16)	3.2526e+0 (2.44e-2) -	3.1741e+0 (4.80e-3)	1.0015e+1 (1.11e+0) -	5.8039e+0 (7.42e-1)
WFG8	8	1000	6.5402e+0 (9.59e-16) -	5.3579e+0 (9.59e-16)	3.5711e+0 (6.99e-2) -	3.4078e+0 (3.16e-2)	1.0676e+1 (4.83e-1) -	6.1945e+0 (4.52e-1)
WFG8	10	100	5.2256e+0 (0.00e+0) -	5.1787e+0 (9.59e-16)	4.5533e+0 (5.26e-2) =	4.6268e+0 (9.97e-2)	1.3944e+1 (9.85e-1) -	7.3616e+0 (4.19e-1)
WFG8	10	200	5.5224e+0 (9.59e-16) -	5.4163e+0 (0.00e+0)	4.5744e+0 (8.73e-2) =	4.5396e+0 (8.20e-2)	1.3703e+1 (8.28e-1) -	7.6362e+0 (7.20e-1)
WFG8	10	500	8.8712e+0 (0.00e+0) +	9.0618e+0 (0.00e+0)	4.9886e+0 (2.29e-1) -	4.7277e+0 (5.74e-2)	1.3217e+1 (1.13e+0) -	8.2270e+0 (8.96e-1)
WFG8	10	1000	8.3122e+0 (1.92e-15) +	8.4577e+0 (1.92e-15)	4.9095e+0 (1.75e-1) -	4.7367e+0 (1.34e-1)	1.3909e+1 (5.95e-1) -	9.6980e+0 (1.51e+0)
WFG9	5	100	1.6479e+0 (4.80e-16) -	1.2327e+0 (5.46e-3)	1.0465e+0 (4.62e-3) =	1.0434e+0 (9.91e-3)	6.1724e+0 (8.77e-1) -	1.7790e+0 (2.02e-1)
WFG9	5	200	1.5864e+0 (2.40e-16) -	1.1969e+0 (0.00e+0)	1.0518e+0 (1.21e-2) =	1.0619e+0 (9.93e-3)	5.8348e+0 (1.25e+0) -	1.7197e+0 (2.13e-1)
WFG9	5	500	1.4773e+0 (0.00e+0) -	1.2040e+0 (0.00e+0)	1.0707e+0 (1.88e-2) =	1.0759e+0 (1.61e-2)	5.9941e+0 (8.87e-1) -	1.8112e+0 (3.89e-1)
WFG9	5	1000	1.7663e+0 (0.00e+0) -	1.3882e+0 (0.00e+0)	1.2258e+0 (3.23e-2) -	1.1851e+0 (1.98e-2)	3.6332e+0 (8.31e-1) -	1.7219e+0 (2.06e-1)
WFG9	8	100	4.2186e+0 (0.00e+0) -	3.4774e+0 (0.00e+0)	3.0530e+0 (3.95e-2) =	3.0253e+0 (2.74e-2)	1.1311e+1 (1.79e+0) -	5.9506e+0 (1.12e+0)
WFG9	8	200	4.3916e+0 (0.00e+0) -	3.5301e+0 (4.80e-16)	3.0553e+0 (3.35e-2) =	3.0798e+0 (3.05e-2)	1.1414e+1 (2.34e+0) -	4.2765e+0 (2.05e-1)
WFG9	8	500	4.8454e+0 (0.00e+0) -	3.9756e+0 (9.59e-16)	3.1083e+0 (6.30e-2) =	3.0605e+0 (3.92e-2)	7.0927e+0 (6.13e-1) -	4.2020e+0 (2.51e-1)
WFG9	8	1000	4.8297e+0 (0.00e+0) -	3.9591e+0 (0.00e+0)	3.6744e+0 (8.79e-2) -	3.4628e+0 (6.34e-2)	6.7029e+0 (5.93e-1) -	4.0383e+0 (2.66e-1)
WFG9	10	100	5.8096e+0 (0.00e+0) -	4.9432e+0 (0.00e+0)	4.4941e+0 (1.34e-1) +	4.6532e+0 (4.89e-2)	1.3715e+1 (2.32e+0) -	6.1342e+0 (4.82e-1)
WFG9	10	200	6.0558e+0 (9.59e-16) -	5.0416e+0 (0.00e+0)	4.5941e+0 (5.51e-2) =	4.6372e+0 (7.13e-2)	1.0972e+1 (1.85e+0) -	6.5802e+0 (8.35e-1)
WFG9	10	500	7.0047e+0 (0.00e+0) -	6.2363e+0 (0.00e+0)	4.8974e+0 (1.89e-1) =	5.0515e+0 (8.17e-2)	8.6738e+0 (6.90e-1) -	5.6362e+0 (6.06e-1)
WFG9	10	1000	7.1895e+0 (9.59e-16) -	5.7497e+0 (9.59e-16)	4.8908e+0 (1.54e-1) =	4.9860e+0 (1.42e-1)	8.4672e+0 (6.53e-1) -	6.5027e+0 (8.18e-1)
+/-=		16/92/0			5/42/61		0/107/1	

LSMOP9	10	500	6.5872e+0 (8.03e-2) =	4.6934e+2 (5.71e+1) -	1.1463e+3 (7.53e+1) -	1.1797e+03(4.52e+01)-	5.6726e+1 (3.61e+0) -	9.6554e+0 (5.41e+0)
LSMOP9	10	1000	6.5525e+0 (1.47e-2) =	4.9535e+2 (6.58e+1) -	1.1996e+3 (3.88e+1) -	1.2022e+03(2.96e+01)-	1.7237e+1 (2.33e-1) -	7.1615e+0 (4.73e+0)
+/-=			20/118/42	8/106/66	4/170/6	4/162/14	15/159/6	

TABLE A. 8

THE IGD RESULTS OF SIX COMPARED ALGORITHMS ON DTLZ1-DTLZ7 TEST PROBLEMS WITH 2-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

Problem	M	D	LSMOF	DGEA	LMEA	LSMOEA/D	MOEADVA	NN-CSO
DTLZ1	2	100	1.2349e+3 (4.85e+0) -	7.6342e+2 (1.61e+2) =	4.2556e+1 (2.17e+0) +	1.5997e+03(1.98e+02)-	9.9615e+2 (4.62e+1) -	5.3793e+2 (2.23e+2)
DTLZ1	2	200	2.4707e+3 (3.99e+1) -	1.5905e+3 (4.04e+2) -	6.8312e+3 (1.58e+2) -	4.6682e+03(1.97e+02)-	1.8906e+3 (7.58e+1) -	1.0141e+3 (2.19e+2)
DTLZ1	2	500	6.2328e+3 (2.47e-1) -	4.2750e+3 (3.06e+2) -	1.7825e+4 (2.43e+2) -	1.5927e+04(5.43e+02)-	2.1093e+3 (4.27e+1) +	2.7736e+3 (8.35e+2)
DTLZ1	2	1000	1.2399e+4 (2.10e+2) -	7.0568e+3 (3.01e+3) =	3.6653e+4 (2.17e+2) -	3.5843e+04(5.74e+02)-	2.1902e+3 (5.48e+1) +	5.7686e+3 (1.47e+3)
DTLZ1	3	100	1.8349e-2 (1.34e-3) +	3.7094e+2 (2.42e+2) =	3.3048e+1 (1.70e+0) +	1.2401e+03(6.89e+01)-	8.3055e+2 (5.71e+1) -	3.7321e+2 (7.74e+1)
DTLZ1	3	200	1.9542e-2 (2.33e-3) +	7.9119e+2 (4.66e+2) =	5.6681e+3 (1.11e+2) -	4.0675e+03(2.65e+02)-	1.6152e+3 (3.84e+1) -	7.5949e+2 (6.39e+1)
DTLZ1	3	500	2.0664e-2 (1.61e-3) +	1.4915e+3 (6.03e+2) =	1.4825e+4 (2.55e+2) -	1.3502e+04(5.05e+02)-	1.7772e+3 (4.04e+1) =	2.1264e+3 (6.16e+2)
DTLZ1	3	1000	2.0328e-2 (4.71e-3) +	4.9175e+3 (2.85e+3) =	3.0213e+4 (3.39e+2) -	2.9282e+04(7.37e+02)-	1.8420e+3 (4.88e+1) +	4.2642e+3 (4.30e+2)
DTLZ1	5	100	1.1497e+2 (3.04e+2) +	2.5896e+2 (4.77e+1) =	2.5706e+1 (1.25e+0) =	1.29e+03(1.23e+02)-	5.86e+02(4.02e+01)-	1.6925e+2 (1.38e+2)
DTLZ1	5	200	1.3726e+2 (3.63e+2) +	6.2035e+2 (2.47e+2) -	4.6919e+3 (1.78e+2) -	3.71e+03(6.11e+01)-	3.08e+03(1.75e+02)-	2.6128e+2 (2.57e+2)
DTLZ1	5	500	7.0610e-2 (1.68e-3) +	9.9795e+2 (3.68e+2) -	1.1943e+4 (3.13e+2) -	1.11e+04(3.23e+02)-	1.09e+04(2.61e+02)-	1.2046e+2 (2.56e+2)
DTLZ1	5	1000	6.7920e+3 (3.58e+3) -	3.3512e+3 (9.18e+2) -	2.4636e+4 (4.20e+2) -	2.40e+04(3.51e+02)-	2.33e+04(3.29e+02)-	2.2002e+2 (2.22e+2)
DTLZ1	8	100	7.6648e+2 (2.53e+2) -	2.7663e+2 (3.61e+1) =	2.1388e+1 (1.66e+0) +	1.07e+03(1.20e+02)-	5.88e+02(3.53e+01)-	2.4699e+2 (6.08e+1)
DTLZ1	8	200	1.2699e+3 (4.24e+2) -	5.3954e+2 (2.06e+2) =	4.3433e+3 (2.03e+2) -	3.08e+03(2.05e+02)-	3.01e+03(1.49e+02)-	4.6851e+2 (1.64e+2)
DTLZ1	8	500	4.7818e+3 (1.92e+3) -	1.8236e+3 (3.20e+2) -	1.0927e+4 (5.73e+2) -	9.19e+03(4.00e+02)-	9.74e+03(3.56e+02)-	4.2218e+2 (6.81e+2)
DTLZ1	8	1000	8.7278e+3 (5.06e+3) -	3.2942e+3 (1.03e+3) -	2.1955e+4 (1.22e+3) -	2.00e+04(5.40e+02)-	2.13e+04(8.95e+02)-	6.8877e+2 (8.48e+2)
DTLZ1	10	100	7.9116e+2 (2.01e+2) -	2.9306e+2 (8.04e+1) =	1.9581e+1 (1.29e+0) +	1.23e+03(1.89e+02)-	6.00e+02(2.79e+01)-	1.9673e+2 (1.55e+2)
DTLZ1	10	200	1.8619e+3 (4.19e+2) -	6.2382e+2 (2.07e+2) =	4.0241e+3 (1.97e+2) -	3.50e+03(1.15e+02)-	3.02e+03(2.42e+02)-	5.3201e+2 (1.79e+2)
DTLZ1	10	500	4.0741e+3 (1.12e+3) -	1.7280e+3 (2.46e+2) -	1.0735e+4 (7.04e+2) -	9.81e+03(4.77e+02)-	9.99e+03(2.63e+02)-	2.7571e+2 (2.80e+2)
DTLZ1	10	1000	1.0145e+4 (3.67e+3) -	3.4907e+3 (9.03e+2) -	2.1843e+4 (1.18e+3) -	1.91e+04(8.19e+02)-	2.06e+04(8.66e+02)-	3.2814e+2 (5.18e+2)
DTLZ2	2	100	4.2806e+0 (2.12e-1) -	3.1493e-1 (4.05e-2) -	2.5887e-3 (7.09e-5) +	2.6609e+00(5.08e-01)-	1.5733e+0 (1.00e-1) -	7.9524e-2 (1.00e-2)
DTLZ2	2	200	8.9595e+0 (1.61e+0) -	1.3810e+0 (2.51e-1) -	1.3741e+1 (4.76e-1) -	9.1270e+00(6.57e-01)-	2.2408e+0 (1.04e-1) -	1.9177e-1 (2.86e-2)
DTLZ2	2	500	2.5889e+1 (1.52e+0) -	5.6270e+0 (1.05e+0) -	3.6733e+1 (7.15e-1) -	3.0979e+01(1.31e+00)-	1.5612e+0 (1.74e-2) -	5.7716e-1 (5.73e-2)
DTLZ2	2	1000	5.5267e+1 (1.88e+0) -	1.2186e+1 (1.46e+0) -	7.6886e+1 (4.76e-1) -	7.3467e+01(2.17e+00)-	9.5973e-1 (1.31e-2) +	1.1890e+0 (1.12e-1)
DTLZ2	3	100	6.1902e-2 (3.23e-2) +	6.9371e-1 (1.43e-1) -	3.3667e-2 (1.04e-3) +	2.9094e+00(4.42e-01)-	1.5818e+0 (8.96e-2) -	1.9668e-1 (1.64e-2)
DTLZ2	3	200	1.1760e-1 (1.73e-1) +	1.7259e+0 (2.56e-1) -	1.3874e+1 (6.02e-1) -	1.0137e+01(5.99e-01)-	2.3487e+0 (3.95e-2) -	3.7337e-1 (4.58e-2)
DTLZ2	3	500	1.0605e+0 (1.74e+0) =	4.3788e+0 (3.97e-1) -	3.6809e+1 (7.84e-1) -	3.3556e+01(7.59e-01)-	1.6008e+0 (3.38e-2) -	9.0447e-1 (5.55e-2)
DTLZ2	3	1000	6.1187e+0 (1.07e+1) =	9.3625e+0 (2.32e+0) -	7.6285e+1 (8.77e-1) -	7.4534e+01(1.43e+00)-	9.9234e-1 (1.28e-2) +	1.5976e+0 (1.43e-1)
DTLZ2	5	100	2.5195e+0 (5.24e-1) -	7.5579e-1 (6.46e-2) -	1.5239e-1 (2.62e-3) +	3.40e+00(2.53e-01)-	1.36e+00(6.10e-02)-	4.9801e-1 (4.04e-2)
DTLZ2	5	200	8.4418e+0 (1.40e+0) -	1.3947e+0 (1.76e-1) -	1.3755e+1 (3.68e-1) -	1.13e+01(7.43e-01)-	7.77e+00(3.11e-01)-	5.6523e-1 (6.63e-2)
DTLZ2	5	500	3.4105e+1 (2.11e+0) -	2.9162e+0 (1.30e-1) -	3.6973e+1 (4.10e-1) -	3.28e+01(1.25e+00)-	3.18e+01(4.62e-01)-	6.9030e-1 (6.45e-2)
DTLZ2	5	1000	5.8958e+1 (1.37e+0) -	5.4007e+0 (5.61e-1) -	7.6754e+1 (6.81e-1) -	7.47e+01(1.03e+00)-	7.23e+01(4.52e-01)-	8.2565e-1 (3.53e-2)
DTLZ2	8	100	1.5534e+1 (1.73e+0) -	1.0453e+0 (8.57e-2) -	3.3266e-1 (6.29e-3) +	5.15e+00(2.42e-01)-	1.70e+00(3.43e-02)-	8.8452e-1 (3.41e-2)
DTLZ2	8	200	2.8831e+1 (5.08e+0) -	1.4586e+0 (1.35e-1) -	1.3718e+1 (3.71e-1) -	1.32e+01(4.94e-01)-	8.68e+00(9.29e-02)-	1.0250e+0 (2.93e-2)
DTLZ2	8	500	4.3349e+1 (7.83e+0) -	3.0779e+0 (3.62e-1) -	3.6929e+1 (4.70e-1) -	3.49e+01(5.79e-01)-	3.22e+01(3.00e-01)-	9.8507e-1 (4.22e-2)
DTLZ2	8	1000	7.8487e+1 (9.76e+0) -	5.8028e+0 (6.06e-1) -	7.6851e+1 (7.09e-1) -	7.55e+01(1.57e+00)-	7.23e+01(9.43e-01)-	9.8649e-1 (2.51e-2)
DTLZ2	10	100	1.0879e+1 (3.04e+0) -	1.1251e+0 (1.02e-1) -	4.1071e-1 (7.33e-3) +	5.30e+00(3.15e-01)-	1.88e+00(7.37e-02)-	9.9078e-1 (2.74e-2)
DTLZ2	10	200	2.7987e+1 (6.08e+0) -	1.5628e+0 (1.20e-1) -	1.3964e+1 (2.71e-1) -	1.29e+01(3.34e-01)-	9.04e+00(2.31e-01)-	1.0680e+0 (5.82e-2)
DTLZ2	10	500	7.7268e+1 (1.60e+1) -	3.1548e+0 (3.94e-1) -	3.6814e+1 (4.76e-1) -	3.51e+01(8.82e-01)-	3.27e+01(4.95e-01)-	1.0921e+0 (9.10e-2)
DTLZ2	10	1000	8.0609e+1 (1.57e+1) -	5.2500e+0 (7.49e-1) -	7.6309e+1 (7.61e-1) -	7.48e+01(2.23e+00)-	7.32e+01(8.43e-01)-	1.0579e+0 (3.91e-2)
DTLZ3	2	100	2.4741e+3 (3.49e-2) -	1.3890e+3 (1.07e+3) =	1.2191e+2 (8.37e+0) +	4.3348e+03(5.47e+02)-	2.6728e+3 (7.81e+1) -	1.3287e+3 (4.97e+2)
DTLZ3	2	200	4.9552e+3 (3.15e+1) -	3.3969e+3 (1.57e+3) =	1.8603e+4 (3.55e+2) -	1.2911e+04(4.98e+02)-	5.0521e+3 (1.39e+2) -	3.0668e+3 (9.45e+2)
DTLZ3	2	500	1.2470e+4 (9.88e-2) -	6.2963e+3 (4.79e+3) =	4.9345e+4 (3.19e+2) -	4.3324e+04(1.08e+03)-	5.8008e+3 (1.29e+2) =	5.8953e+3 (8.19e+2)

DTLZ7	8	200	$3.9158e+0 (1.91e+0) -$	$7.5607e+0 (4.26e+0) -$	$3.0851e+1 (7.47e-1) -$	$2.43e+01(1.28e+00)-$	$2.19e+01(3.67e-01)-$	1.7672e+0 (4.05e-1)
DTLZ7	8	500	$3.6563e+0 (1.22e+0) -$	$6.7727e+0 (5.50e+0) -$	$3.1385e+1 (6.88e-1) -$	$2.37e+01(6.83e-01)-$	$2.84e+01(1.07e+00)-$	1.9336e+0 (3.03e-1)
DTLZ7	8	1000	$4.3311e+0 (7.06e-1) =$	$4.4140e+0 (2.89e+0) =$	$3.1812e+1 (7.22e-1) -$	$2.75e+01(7.45e-01)-$	$3.05e+01(4.30e-01)-$	3.3249e+0 (7.49e-1)
DTLZ7	10	100	$1.0466e+0 (5.41e-2) +$	$2.8808e+0 (1.78e+0) =$	8.8268e-1 (1.63e-2) +	$2.70e+01(3.58e+00)-$	$1.37e+01(1.17e+00)-$	$2.5731e+0 (7.75e-1)$
DTLZ7	10	200	$6.5043e+0 (6.69e-2) -$	$5.5423e+0 (5.07e+0) -$	$3.9233e+1 (5.90e-1) -$	$3.27e+01(9.63e-01)-$	$2.86e+01(9.05e-01)-$	1.9409e+0 (2.96e-1)
DTLZ7	10	500	$6.5031e+0 (8.92e-2) -$	$9.1824e+0 (3.42e+0) -$	$3.9643e+1 (1.06e+0) -$	$3.12e+01(1.76e+00)-$	$3.68e+01(8.30e-01)-$	2.6103e+0 (7.30e-1)
DTLZ7	10	1000	$6.3154e+0 (3.51e-1) -$	$5.8587e+0 (3.34e+0) =$	$3.9957e+1 (4.43e-1) -$	$3.35e+01(6.20e-01)-$	$3.82e+01(8.22e-01)-$	3.1208e+0 (1.39e+0)
+/-=			58/99/23	31/107/42	43/125/12	16/152/12	11/167/2	

WFG9	10	200	5.0573e+0 (1.38e-1) -	4.5220e+0 (5.92e-2) +	4.2430e+0 (2.52e-2) +	8.57e+00(1.35e-01)-	7.85e+00(4.98e-01)-	4.6372e+0 (7.13e-2)
WFG9	10	500	4.9280e+0 (9.57e-2) +	4.5500e+0 (9.32e-2) +	7.7311e+0 (2.11e-1) -	7.11e+00(1.47e+00)-	7.73e+00(1.84e-01)-	5.0515e+0 (8.17e-2)
WFG9	10	1000	4.9003e+0 (8.31e-2) =	4.5806e+0 (7.10e-2) +	7.6145e+0 (2.60e-1) -	5.56e+00(4.71e-01)-	7.82e+00(3.98e-01)-	4.9860e+0 (1.42e-1)
+/-=			58/99/23	31/107/42	43/125/12	16/152/12	11/167/2	

TABLE A. 10

THE IGD COMPARISON RESULTS OF THREE MBEAS ON UF1-UF10 TEST PROBLEMS WITH 2-3 OBJECTIVES AND 100-1000 DECISION VARIABLES.

Problem	M	D	MOEA/PSL	AMOEAD	NN-CSO
UF1	2	100	1.2709e-1 (1.40e-2) +	3.1438e-01(3.77e-02)-	2.4318e-1 (1.16e-2)
UF1	2	200	3.5689e-1 (1.60e-1) =	3.4578e-01(4.15e-02) +	5.0663e-1 (6.26e-1)
UF1	2	500	8.0389e-1 (2.00e-1) -	3.8061e-01(2.34e-02)-	2.8877e-1 (4.73e-3)
UF1	2	1000	1.1247e+0 (7.92e-2) -	3.7534e-01(2.54e-02)-	2.9360e-1 (5.83e-3)
UF2	2	100	1.1203e-1 (5.53e-3) -	1.6544e-01(2.63e-02)-	8.3317e-2 (4.18e-3)
UF2	2	200	1.2227e-1 (4.97e-3) -	1.8545e-01(1.36e-02)-	1.1017e-1 (4.73e-2)
UF2	2	500	1.3049e-1 (2.35e-3) -	1.9848e-01(1.16e-02)-	9.2597e-2 (3.54e-3)
UF2	2	1000	1.3068e-1 (8.96e-4) -	1.8905e-01(2.34e-02)-	9.6263e-2 (4.00e-3)
UF3	2	100	3.8867e-1 (2.29e-1) -	2.8318e-01(1.21e-02)-	1.8399e-1 (7.77e-3)
UF3	2	200	3.1091e-1 (2.34e-1) -	2.4829e-01(9.52e-03)-	1.5620e-1 (3.36e-3)
UF3	2	500	3.2411e-1 (9.66e-2) -	2.3143e-01(8.62e-03)-	1.3442e-1 (1.11e-3)
UF3	2	1000	3.5107e-1 (6.89e-2) -	2.2904e-01(2.46e-02)-	1.2473e-1 (7.05e-4)
UF4	2	100	9.6710e-2 (4.39e-3) -	8.6899e-02(2.92e-03)-	5.8690e-2 (1.95e-4)
UF4	2	200	1.3724e-1 (1.08e-2) -	9.1129e-02(1.33e-03)-	5.9575e-2 (5.51e-4)
UF4	2	500	1.8416e-1 (5.67e-3) -	9.4354e-02(1.19e-03)-	6.1020e-2 (1.79e-3)
UF4	2	1000	1.8519e-1 (1.41e-2) -	9.5332e-02(8.21e-04)-	6.0001e-2 (5.24e-4)
UF5	2	100	7.7277e-1 (3.08e-1) =	2.8931e+00(1.17e-01)-	1.1267e+0 (1.73e-1)
UF5	2	200	1.8020e+0 (4.34e-1) +	3.1123e+00(1.50e-01)-	2.3209e+0 (3.11e-1)
UF5	2	500	2.9519e+0 (3.78e-1) =	3.2946e+00(1.07e-01)-	3.0021e+0 (6.99e-2)
UF5	2	1000	3.8439e+0 (4.62e-1) -	3.3477e+00(2.96e-02)-	3.0914e+0 (6.43e-2)
UF6	2	100	3.2826e-1 (8.01e-2) +	1.2935e+00(1.63e-01)-	5.1688e-1 (9.19e-2)
UF6	2	200	1.0656e+0 (4.29e-1) =	1.4244e+00(1.63e-01)-	7.1853e-1 (2.07e-1)
UF6	2	500	2.6600e+0 (4.09e-1) -	1.4822e+00(2.48e-01)-	1.1645e+0 (6.83e-2)
UF6	2	1000	3.8872e+0 (5.10e-1) -	1.4090e+00(9.69e-02)-	1.1917e+0 (4.72e-2)
UF7	2	100	9.0371e-2 (3.56e-2) +	4.7047e-01(2.65e-02)-	3.5681e-1 (3.58e-1)
UF7	2	200	2.5102e-1 (7.42e-2) =	5.0605e-01(1.27e-02)-	2.6931e-1 (1.08e-2)
UF7	2	500	6.4630e-1 (9.15e-2) -	5.1601e-01(5.89e-03)-	3.0180e-1 (6.16e-3)
UF7	2	1000	9.2322e-1 (6.37e-2) -	5.2132e-01(9.43e-03)-	3.0113e-1 (1.01e-2)
UF8	3	100	2.5888e-1 (5.53e-3) +	5.8996e-01(3.41e-02)-	3.4881e-1 (1.46e-2)
UF8	3	200	2.4945e-1 (3.11e-3) +	6.0723e-01(3.00e-02)-	4.1731e-1 (3.11e-2)
UF8	3	500	2.7351e-1 (1.86e-2) +	6.3433e-01(3.60e-02)-	4.8100e-1 (1.45e-2)
UF8	3	1000	4.7051e-1 (1.74e-2) =	6.3763e-01(2.97e-02)-	4.9542e-1 (2.93e-2)
UF9	3	100	7.1581e-1 (1.63e-1) -	6.5109e-01(4.31e-02)-	5.0989e-1 (4.59e-3)
UF9	3	200	6.7679e-1 (9.77e-2) -	6.7016e-01(4.35e-02)-	5.6101e-1 (7.41e-3)
UF9	3	500	8.0453e-1 (1.06e-1) -	6.7160e-01(1.00e-02)-	6.1365e-1 (1.26e-2)
UF9	3	1000	8.7062e-1 (4.99e-2) -	7.5041e-01(3.46e-02)-	6.6051e-1 (1.66e-2)
UF10	3	100	3.1995e-1 (1.46e-2) +	3.3368e+00(5.73e-01)-	1.8287e+0 (1.87e-1)
UF10	3	200	2.9300e-1 (8.79e-3) +	3.8627e+00(4.33e-01)-	2.4275e+0 (1.72e-1)
UF10	3	500	2.7886e-1 (9.92e-3) +	3.7178e+00(6.11e-02)-	3.1637e+0 (3.38e-1)
UF10	3	1000	2.4254e-1 (4.71e-3) +	3.8734e+00(2.20e-01)=	3.7282e+0 (2.54e-1)
+/-/=			11/23/6	1/38/1	

TABLE A. 11

THE IGD COMPARISON RESULTS OF THREE MBEAS ON LSMOP1-LSMOP9 TEST PROBLEMS WITH 2-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

Problem	M	D	MOEA/PSL	AMOEA/D	NN-CSO
LSMOP1	2	100	2.9582e-1 (1.11e-2) -	2.9094e-01(2.00e-02)-	2.0217e-1 (1.04e-2)
LSMOP1	2	200	2.9363e-1 (7.84e-3) =	3.2456e-01(2.21e-02)-	2.8176e-1 (1.72e-2)
LSMOP1	2	500	4.5701e-1 (1.93e-1) =	3.3695e-01(4.87e-03)-	3.2321e-1 (1.40e-2)
LSMOP1	2	1000	1.1970e+0 (6.10e-1) -	3.4331e-01(6.56e-03)-	3.3104e-1 (8.72e-3)
LSMOP1	3	100	2.7519e-1 (9.53e-2) +	3.5425e-01(3.50e-02)=	3.2358e-1 (1.05e-2)
LSMOP1	3	200	5.3214e-1 (2.71e-1) -	4.3490e-01(1.78e-02)-	3.4195e-1 (9.75e-3)
LSMOP1	3	500	1.2140e+0 (8.21e-1) -	4.7801e-01(6.52e-02)-	3.5389e-1 (1.61e-2)
LSMOP1	3	1000	1.0723e+0 (5.60e-1) -	4.7109e-01(1.06e-02)-	3.7023e-1 (1.53e-2)
LSMOP1	5	100	8.5612e-1 (6.67e-2) -	3.2082e-01(1.46e-02)+	5.4001e-1 (4.78e-2)
LSMOP1	5	200	9.5883e-1 (1.20e-16) -	4.7501e-01(4.96e-02)+	6.7819e-1 (7.03e-2)
LSMOP1	5	500	9.5883e-1 (1.20e-16) -	6.6987e-01(1.03e-01)+	8.2544e-1 (6.64e-2)
LSMOP1	5	1000	3.7352e+0 (3.15e+0) -	6.0594e-01(3.24e-02)+	8.7563e-1 (5.58e-2)
LSMOP1	8	100	9.9913e-1 (3.41e-2) -	4.8196e-01 (4.94e-02) +	5.8057e-1 (5.93e-2)
LSMOP1	8	200	1.0327e+0 (2.40e-16) -	7.3081e-01(3.65e-02)-	6.6402e-1 (1.61e-2)
LSMOP1	8	500	2.0598e+0 (1.84e+0) =	8.1374e-01(1.68e-01)+	1.2379e+0 (7.37e-2)
LSMOP1	8	1000	3.4025e+0 (3.20e+0) =	8.1963e-01(1.43e-01)+	1.2725e+0 (1.43e-1)
LSMOP1	10	100	1.0071e+0 (2.72e-2) -	5.4592e-01 (3.23e-02) +	6.3258e-1 (2.84e-2)
LSMOP1	10	200	1.0167e+0 (1.38e-2) -	6.0806e-01(3.52e-02)+	7.6043e-1 (8.47e-2)
LSMOP1	10	500	7.2037e+0 (6.01e+0) =	7.8426e-01(1.11e-01)+	1.2403e+0 (4.48e-1)
LSMOP1	10	1000	7.0600e+0 (7.40e+0) =	7.5907e-01(1.16e-02)+	1.2816e+0 (1.35e-1)
LSMOP2	2	100	1.2479e-1 (2.02e-3) -	4.3184e-02(3.04e-03)=	4.2763e-2 (1.64e-3)
LSMOP2	2	200	7.1067e-2 (1.22e-3) -	2.4810e-02(2.64e-03)+	2.8407e-2 (1.27e-3)
LSMOP2	2	500	3.3297e-2 (8.06e-3) -	1.2075e-02(4.67e-04)+	1.3729e-2 (7.39e-4)
LSMOP2	2	1000	1.7062e-2 (4.30e-3) -	6.7946e-03(4.23e-04)+	8.1902e-3 (2.42e-4)
LSMOP2	3	100	2.0131e-1 (4.71e-3) -	7.0854e-02(2.85e-03)+	8.4013e-2 (3.28e-3)
LSMOP2	3	200	1.2051e-1 (2.96e-3) -	5.5983e-02(2.22e-03)=	5.7013e-2 (1.60e-3)
LSMOP2	3	500	6.0650e-2 (9.43e-4) -	3.5935e-02(1.69e-03)+	3.8768e-2 (1.43e-3)
LSMOP2	3	1000	4.2521e-2 (1.05e-3) -	2.8446e-02(5.89e-04)=	2.9433e-2 (1.36e-3)
LSMOP2	5	100	4.1553e-1 (1.49e-2) -	1.6908e-01(3.18e-03)+	2.5799e-1 (8.31e-3)
LSMOP2	5	200	2.5936e-1 (6.66e-3) -	1.4366e-01(1.92e-03)+	2.0205e-1 (1.70e-3)
LSMOP2	5	500	1.6660e-1 (4.99e-3) -	1.1605e-01(1.67e-03)+	1.4269e-1 (9.84e-4)
LSMOP2	5	1000	1.4727e-1 (3.18e-3) -	1.0653e-01(1.33e-03)+	1.2193e-1 (3.36e-4)
LSMOP2	8	100	7.6158e-1 (3.56e-2) -	3.6724e-01 (3.41e-02) -	3.4709e-1 (1.02e-2)
LSMOP2	8	200	4.7250e-1 (1.33e-2) -	3.2450e-01(2.97e-02)-	2.6358e-1 (4.25e-3)
LSMOP2	8	500	2.4124e-1 (3.07e-3) -	3.0939e-01(3.10e-02)-	1.9823e-1 (3.22e-3)
LSMOP2	8	1000	1.9970e-1 (3.72e-3) -	3.1317e-01(2.90e-02)-	1.7017e-1 (4.45e-3)
LSMOP2	10	100	8.5270e-1 (5.39e-2) -	4.5409e-01 (6.42e-02) -	4.3314e-1 (9.88e-3)
LSMOP2	10	200	5.9423e-1 (7.66e-3) -	4.3590e-01(4.92e-02)-	3.5728e-1 (4.56e-3)
LSMOP2	10	500	3.3311e-1 (7.96e-3) -	4.2177e-01(3.45e-02)-	2.9527e-1 (1.28e-2)
LSMOP2	10	1000	2.8094e-1 (6.53e-3) -	3.9732e-01(3.04e-02)-	2.4892e-1 (1.55e-2)
LSMOP3	2	100	6.6670e-1 (1.14e-2) +	1.4572e+00(1.15e-03)=	1.5170e+0 (4.71e-1)
LSMOP3	2	200	3.0502e+0 (4.78e+0) =	1.5232e+00(2.38e-03)+	1.9101e+0 (4.24e-1)

LSMOP3	2	500	8.8387e+0 (9.17e+0) =	1.5658e+00(2.80e-04)+	3.1135e+0 (1.72e+0)
LSMOP3	2	1000	5.7176e+1 (1.09e+2) -	1.5793e+00(9.34e-06)+	2.2104e+0 (1.65e+0)
LSMOP3	3	100	9.8643e-1 (3.67e-1) =	8.6067e-01(1.30e-04)-	8.5877e-1 (5.15e-3)
LSMOP3	3	200	8.6072e-1 (1.20e-16) =	8.6072e-01(1.20e-16)-	8.6072e-1 (1.20e-16)
LSMOP3	3	500	2.6913e+0 (3.72e+0) =	8.6072e-01(1.20e-16)-	8.6072e-1 (1.20e-16)
LSMOP3	3	1000	4.5815e+0 (4.19e+0) =	8.6072e-01(1.20e-16)-	8.6072e-1 (1.20e-16)
LSMOP3	5	100	9.5883e-1 (1.20e-16) =	6.8040e-01(2.90e-02)+	9.4960e-1 (1.59e-2)
LSMOP3	5	200	9.5883e-1 (1.20e-16) =	9.5987e-01(8.65e-03)-	9.5883e-1 (1.20e-16)
LSMOP3	5	500	9.5883e-1 (1.20e-16) =	9.5129e-01(1.41e-02)+	4.2096e+0 (4.07e+0)
LSMOP3	5	1000	3.6559e+0 (4.26e+0) =	9.5660e-01(0.00e+00)+	4.9524e+0 (3.87e+0)
LSMOP3	8	100	1.0183e+0 (3.06e-5) -	6.1433e-01 (8.92e-02) +	9.3540e-1 (1.82e-2)
LSMOP3	8	200	1.4723e+0 (1.08e-2) +	6.3535e-01(1.55e-02)+	5.0341e+0 (1.09e+0)
LSMOP3	8	500	1.1975e+1 (1.28e+1) =	1.5680e+00(3.31e-03)+	9.4167e+0 (1.11e+0)
LSMOP3	8	1000	2.1848e+1 (1.52e+1) =	3.6960e+01(1.84e+01)-	1.2758e+1 (4.89e+0)
LSMOP3	10	100	8.9687e-1 (8.16e-2) -	9.3988e-01 (2.05e-2) -	7.3819e-1 (1.37e-1)
LSMOP3	10	200	1.0228e+0 (1.37e-3) -	1.0054e+00(1.01e-02)-	9.4073e-1 (6.37e-3)
LSMOP3	10	500	1.9586e+1 (1.79e+1) =	1.8013e+00(2.09e-03)+	2.0659e+1 (3.62e+0)
LSMOP3	10	1000	2.3382e+1 (1.68e+1) =	3.8939e+01(1.36e+01)-	1.3028e+1 (7.65e+0)
LSMOP4	2	100	2.2679e-1 (1.26e-2) -	1.3002e-01(8.85e-03)-	6.7048e-2 (2.28e-2)
LSMOP4	2	200	1.4341e-1 (5.40e-3) -	9.2449e-02(6.05e-03)-	8.3159e-2 (6.00e-3)
LSMOP4	2	500	7.4994e-2 (1.99e-3) -	5.3733e-02(2.03e-03)-	4.4418e-2 (9.30e-4)
LSMOP4	2	1000	4.8117e-2 (7.53e-4) -	3.1687e-02(1.92e-03)-	2.2817e-2 (5.77e-4)
LSMOP4	3	100	3.2875e-1 (8.66e-3) -	3.1354e-01(1.60e-02)=	2.9903e-1 (1.40e-2)
LSMOP4	3	200	3.0549e-1 (6.38e-3) -	2.1212e-01(4.36e-03)-	1.9584e-1 (7.70e-3)
LSMOP4	3	500	1.7168e-1 (4.66e-3) -	1.1486e-01(2.30e-03)-	1.0064e-1 (2.13e-3)
LSMOP4	3	1000	9.3075e-2 (1.10e-3) -	6.9296e-02(1.05e-03)-	6.1411e-2 (2.39e-3)
LSMOP4	5	100	5.6624e-1 (1.59e-2) -	3.9466e-01(4.48e-03)+	4.6034e-1 (9.30e-3)
LSMOP4	5	200	4.7168e-1 (1.38e-2) -	3.5179e-01(1.75e-02)=	3.5466e-1 (7.19e-3)
LSMOP4	5	500	3.1431e-1 (2.77e-3) -	2.3165e-01(6.47e-03)=	2.3945e-1 (2.52e-3)
LSMOP4	5	1000	2.2760e-1 (6.74e-3) -	1.6872e-01(4.21e-03)+	1.8216e-1 (9.38e-4)
LSMOP4	8	100	7.6079e-1 (5.38e-2) -	4.9274e-01 (8.24e-02) -	4.8784e-1 (1.23e-2)
LSMOP4	8	200	5.0794e-1 (8.99e-3) -	3.7503e-01(3.01e-02)=	3.5284e-1 (2.72e-3)
LSMOP4	8	500	3.1136e-1 (1.17e-2) -	3.3262e-01(3.06e-02)-	2.5310e-1 (6.78e-3)
LSMOP4	8	1000	2.4255e-1 (3.73e-3) -	3.1801e-01(2.38e-02)-	1.9668e-1 (2.24e-3)
LSMOP4	10	100	8.4564e-1 (6.93e-2) -	5.3427e-01 (7.24e-02) =	5.4561e-1 (2.30e-2)
LSMOP4	10	200	6.2401e-1 (4.17e-2) -	3.9784e-01(5.41e-02)=	4.4464e-1 (8.34e-3)
LSMOP4	10	500	4.2994e-1 (1.62e-2) -	4.3142e-01(3.94e-02)-	3.4588e-1 (2.59e-2)
LSMOP4	10	1000	3.2949e-1 (8.29e-3) -	3.9211e-01(3.46e-02)-	2.8738e-1 (1.35e-2)
LSMOP5	2	100	3.3601e-1 (1.64e-2) +	7.4191e-01(4.68e-04)-	6.9839e-1 (3.87e-2)
LSMOP5	2	200	3.5097e-1 (7.03e-2) +	7.4209e-01(0.00e+00)+	7.4209e-1 (1.20e-16)
LSMOP5	2	500	9.6382e-1 (3.81e-1) =	7.4209e-01(0.00e+00)+	7.4209e-1 (3.92e-7)
LSMOP5	2	1000	1.8068e+0 (1.65e+0) =	7.4209e-01(0.00e+00)+	7.4209e-1 (1.20e-16)
LSMOP5	3	100	3.5687e-1 (8.80e-2) =	5.4189e-01(5.19e-05)-	3.8292e-1 (3.63e-2)
LSMOP5	3	200	4.1873e-1 (1.28e-1) =	5.4192e-01(5.36e-05)-	4.7438e-1 (1.44e-2)
LSMOP5	3	500	7.8801e-1 (4.63e-1) =	5.4195e-01(1.27e-05)-	5.1560e-1 (1.36e-2)

LSMOP5	3	1000	1.4174e+0 (1.05e+0) -	5.4191e-01(4.35e-05)-	5.1962e-1 (4.01e-3)
LSMOP5	5	100	5.0602e-1 (3.96e-2) =	2.6447e-01(1.55e-03)+	5.2997e-1 (3.04e-1)
LSMOP5	5	200	5.1366e-1 (2.32e-2) -	3.6148e-01(2.23e-02)-	3.2849e-1 (1.30e-2)
LSMOP5	5	500	4.9990e-1 (2.03e-2) -	4.0800e-01(5.44e-04)-	3.3887e-1 (7.04e-3)
LSMOP5	5	1000	5.3226e-1 (1.03e-1) -	4.0840e-01(3.38e-04)-	3.4478e-1 (1.01e-2)
LSMOP5	8	100	7.6013e-1 (5.53e-2) =	4.5293e-01(1.21e-02) +	7.7934e-1 (2.20e-1)
LSMOP5	8	200	5.7026e-1 (3.99e-2) +	4.1431e-01(1.10e-02)+	1.1120e+0 (8.64e-2)
LSMOP5	8	500	1.0477e+0 (1.32e-1) +	5.1235e-01(4.34e-02)+	2.0608e+0 (4.04e-1)
LSMOP5	8	1000	1.0792e+0 (1.27e-1) +	5.4188e-01(5.33e-02)+	1.9488e+0 (1.50e-1)
LSMOP5	10	100	1.1088e+0 (1.28e-1) -	4.7892e-01(1.28e-02) +	7.7738e-1 (1.52e-1)
LSMOP5	10	200	1.2417e+0 (0.00e+0) -	4.8368e-01(1.87e-02)+	9.0794e-1 (1.97e-1)
LSMOP5	10	500	1.2417e+0 (0.00e+0) +	6.0333e-01(4.01e-02)+	1.7131e+0 (1.45e-1)
LSMOP5	10	1000	1.6696e+0 (8.95e-1) =	5.9637e-01(5.05e-02)+	1.7416e+0 (9.40e-2)
LSMOP6	2	100	7.4848e-1 (8.80e-2) =	7.1384e-01(4.87e-02)=	7.3329e-1 (1.95e-2)
LSMOP6	2	200	7.1130e-1 (1.38e-1) =	6.9806e-01(1.01e-02)+	7.5911e-1 (5.40e-3)
LSMOP6	2	500	7.5438e-1 (3.38e-1) -	6.8505e-01(6.71e-03)+	7.5233e-1 (9.55e-4)
LSMOP6	2	1000	5.9762e-1 (1.43e-1) =	6.7784e-01(2.29e-03)+	7.5010e-1 (1.79e-3)
LSMOP6	3	100	1.1254e+0 (3.80e-3) -	9.2584e-01(1.48e-03)=	9.8301e-1 (1.86e-1)
LSMOP6	3	200	1.2344e+0 (5.76e-4) =	1.1354e+00(7.67e-06)+	1.2356e+0 (1.98e-3)
LSMOP6	3	500	4.3442e+1 (1.12e+2) =	1.2555e+00(5.37e-05)+	1.2959e+0 (3.85e-4)
LSMOP6	3	1000	1.0696e+2 (1.97e+2) =	1.3360e+00(1.08e-01)-	1.3168e+0 (1.48e-3)
LSMOP6	5	100	6.3494e-1 (5.25e-2) =	6.3392e-01(2.19e-02)-	5.9515e-1 (1.92e-2)
LSMOP6	5	200	1.0934e+0 (1.47e-1) =	9.1548e-01(3.67e-02)=	9.9017e-1 (1.00e-1)
LSMOP6	5	500	1.2159e+0 (5.69e-2) =	1.6119e+00(1.23e-01)-	1.2606e+0 (1.37e-1)
LSMOP6	5	1000	1.3234e+0 (8.99e-2) =	1.4780e+00(2.53e-02)-	1.2842e+0 (1.51e-1)
LSMOP6	8	100	8.7986e-1 (1.09e-1) =	9.5032e-01 (1.32e-02) -	8.9782e-1 (3.41e-1)
LSMOP6	8	200	7.8729e-1 (1.74e-2) +	1.0271e+00(3.04e-02)+	1.1391e+0 (1.28e-1)
LSMOP6	8	500	1.5638e+0 (3.09e-1) =	1.4241e+00(4.91e-02)-	1.3731e+0 (2.87e-2)
LSMOP6	8	1000	1.5813e+0 (1.98e-1) -	1.5259e+00(1.43e-01)-	1.3527e+0 (3.66e-2)
LSMOP6	10	100	1.1023e+0 (3.30e-2) =	1.0152e+00 (3.26e-01)=	1.1114e+0 (2.57e-1)
LSMOP6	10	200	1.3363e+0 (2.50e-1) =	1.0848e-01(3.53e-02)+	1.2913e+0 (1.29e-1)
LSMOP6	10	500	1.5168e+0 (1.32e-1) -	1.4712e+00(1.25e-01)-	1.3515e+0 (1.38e-2)
LSMOP6	10	1000	1.5305e+0 (4.17e-2) -	1.3397e+00(2.67e-02)-	1.3027e+0 (1.64e-2)
LSMOP7	2	100	1.4585e+0 (6.06e-3) -	3.3151e+01(8.38e+01)-	1.4577e+0 (7.35e-4)
LSMOP7	2	200	6.4950e+0 (7.99e+0) -	6.1417e+01(1.59e+02)-	1.4916e+0 (5.54e-4)
LSMOP7	2	500	2.0008e+2 (2.93e+2) -	8.4822e+01(2.20e+02)-	1.5109e+0 (1.83e-3)
LSMOP7	2	1000	2.0901e+3 (1.45e+3) -	1.5137e+00(1.45e-05)+	1.5156e+0 (2.36e-3)
LSMOP7	3	100	1.0631e+0 (1.68e-1) =	1.2577e+00(9.48e-03)-	9.1842e-1 (9.45e-2)
LSMOP7	3	200	1.1152e+0 (1.13e-1) =	1.1316e+00(1.52e-02)-	1.0253e+0 (5.64e-2)
LSMOP7	3	500	1.0161e+0 (1.21e-1) =	9.6223e-01(9.07e-03)=	9.2035e-1 (8.90e-2)
LSMOP7	3	1000	1.0779e+0 (2.86e-1) =	8.9385e-01(6.00e-03)+	9.5474e-1 (2.46e-2)
LSMOP7	5	100	1.1237e+0 (1.41e-1) =	1.2724e+00(2.13e-04)-	1.0319e+0 (4.90e-2)
LSMOP7	5	200	1.2444e+0 (3.12e-2) =	1.3841e+00(2.74e-02)-	1.2105e+0 (1.38e-1)
LSMOP7	5	500	1.3071e+0 (1.20e-1) =	1.3726e+00(6.20e-02)-	1.2076e+0 (8.47e-2)
LSMOP7	5	1000	1.2607e+0 (9.44e-2) -	1.2540e+00(5.02e-02)-	1.1337e+0 (2.98e-2)

LSMOP7	8	100	9.5606e-1 (2.72e-2) -	8.7210e-01 (3.22e-02) =	8.8881e-1 (2.77e-2)
LSMOP7	8	200	1.1049e+0 (2.67e-2) +	1.1500e+00(4.91e-01)+	1.6179e+0 (1.55e-1)
LSMOP7	8	500	1.5382e+0 (2.32e-1) +	1.2929e+00(9.00e-02) +	2.4863e+1 (3.93e+1)
LSMOP7	8	1000	1.6936e+0 (1.84e-1) +	1.4272e+00(1.03e-01) +	2.5745e+2 (2.40e+2)
LSMOP7	10	100	9.8536e-1 (6.65e-2) =	9.1646e-01 (2.33e-02) =	9.7143e-1 (1.01e-1)
LSMOP7	10	200	1.5226e+0 (3.27e-1) =	9.6176e-01(2.44e-02) +	1.3870e+0 (4.99e-1)
LSMOP7	10	500	1.7086e+0 (1.52e-1) +	1.2983e+00(4.62e-02) +	1.4840e+2 (3.46e+1)
LSMOP7	10	1000	4.5767e+3 (1.19e+4) =	1.5006e+00(6.50e-02) +	5.0758e+1 (1.82e+1)
LSMOP8	2	100	3.4141e-1 (2.44e-3) -	7.0176e-01(4.81e-02)-	2.9998e-1 (5.28e-2)
LSMOP8	2	200	3.3716e-1 (2.97e-3) +	7.4209e-01(0.00e+00)-	6.5133e-1 (6.66e-2)
LSMOP8	2	500	6.2642e-1 (7.36e-2) +	7.4209e-01(0.00e+00)+	7.4209e-1 (1.20e-16)
LSMOP8	2	1000	1.7660e+0 (9.30e-1) -	7.4136e-01(1.93e-03) +	7.4209e-1 (1.20e-16)
LSMOP8	3	100	3.5624e-1 (2.91e-2) -	1.6280e-01(8.90e-02) +	2.2384e-1 (2.52e-2)
LSMOP8	3	200	3.2780e-1 (4.76e-2) -	2.0737e-01(6.58e-02)=	1.6963e-1 (1.16e-2)
LSMOP8	3	500	2.8134e-1 (8.18e-2) -	1.9925e-01(5.17e-02)=	1.5592e-1 (1.80e-2)
LSMOP8	3	1000	3.8197e-1 (1.11e-1) -	2.1174e-01(2.40e-02)-	1.6270e-1 (3.69e-2)
LSMOP8	5	100	4.2601e-1 (1.07e-2) =	2.4372e-01(1.39e-02) +	5.9321e-1 (3.06e-1)
LSMOP8	5	200	4.1919e-1 (2.26e-2) =	3.2529e-01(1.08e-02) =	5.2508e-1 (3.21e-1)
LSMOP8	5	500	4.1844e-1 (1.51e-2) =	3.0177e-01(1.01e-02) +	5.1970e-1 (2.88e-1)
LSMOP8	5	1000	4.1248e-1 (2.95e-2) =	2.9404e-01(6.46e-03) +	6.7233e-1 (3.37e-1)
LSMOP8	8	100	7.7818e-1 (7.99e-2) =	3.9022e-01 (6.43e-03) +	7.5927e-1 (1.26e-1)
LSMOP8	8	200	4.9423e-1 (1.37e-2) +	3.9529e-01(7.54e-03) +	9.9455e-1 (7.08e-2)
LSMOP8	8	500	1.8822e+0 (2.56e+0) -	4.6483e-01(4.44e-02) +	1.8196e+0 (1.35e-1)
LSMOP8	8	1000	1.7537e+0 (1.34e+0) =	4.9764e-01(4.60e-02) +	1.6755e+0 (9.05e-2)
LSMOP8	10	100	1.0159e+0 (1.52e-1) =	4.5602e-01 (8.23e-02) +	8.6846e-1 (8.60e-2)
LSMOP8	10	200	1.2188e+0 (4.11e-2) -	4.6565e-01(5.50e-03) +	9.3794e-1 (2.23e-1)
LSMOP8	10	500	1.2417e+0 (0.00e+0) +	5.1540e-01(3.64e-02) +	1.7015e+0 (1.86e-1)
LSMOP8	10	1000	1.2245e+0 (4.56e-2) +	5.4290e-01(3.90e-02) +	1.6369e+0 (6.87e-2)
LSMOP9	2	100	8.1004e-1 (0.00e+0) -	8.3300e-01(0.00e+00)-	8.1004e-1 (5.64e-16)
LSMOP9	2	200	8.1336e-1 (1.18e-1) =	8.1584e-01(1.20e-16)-	8.0603e-1 (5.30e-3)
LSMOP9	2	500	8.9836e-1 (2.34e-1) -	8.1098e-01(1.20e-16)-	6.6887e-1 (1.24e-1)
LSMOP9	2	1000	8.1004e-1 (0.00e+0) -	8.1030e-01(0.00e+00)-	6.6516e-1 (7.38e-2)
LSMOP9	3	100	1.5300e+0 (2.09e-2) -	1.1869e+00(5.24e-01)-	5.9295e-1 (2.15e-3)
LSMOP9	3	200	1.5379e+0 (2.53e-10) -	1.4193e+00(3.60e-01)-	6.7195e-1 (2.09e-1)
LSMOP9	3	500	1.4566e+0 (4.94e-2) -	1.4971e+00(8.14e-02)-	5.8631e-1 (1.58e-2)
LSMOP9	3	1000	3.3903e+0 (5.28e+0) =	1.5350e+00(9.63e-03) =	2.5451e+0 (1.34e+0)
LSMOP9	5	100	2.9697e+0 (7.90e-2) -	2.5005e+00(1.19e+00)-	9.2390e-1 (7.70e-2)
LSMOP9	5	200	2.9955e+0 (8.01e-3) -	2.5357e+00(6.70e-01)-	9.0629e-1 (6.71e-2)
LSMOP9	5	500	2.7334e+0 (3.55e-1) -	2.8306e+00(4.84e-01)-	9.5179e-1 (1.73e-1)
LSMOP9	5	1000	8.0796e+0 (1.40e+1) -	2.9638e+00(8.20e-02)-	9.3546e-1 (2.02e-1)
LSMOP9	8	100	5.2880e+0 (9.78e-2) -	2.4131e+01 (5.29e-01) -	3.2921e+0 (2.17e+0)
LSMOP9	8	200	5.1038e+0 (1.82e-2) -	1.0550e+01(8.55e-01)-	2.4936e+0 (1.21e+0)
LSMOP9	8	500	2.8441e+1 (6.20e+1) =	6.0372e+00(1.51e-01)-	3.9986e+0 (2.51e+0)
LSMOP9	8	1000	1.7785e+2 (1.63e+2) -	5.1322e+00(4.73e-01)-	3.2940e+0 (2.01e+0)
LSMOP9	10	100	6.3944e+0 (2.86e-1) -	4.0891e+01 (5.54e-01) -	2.2616e+0 (7.04e-1)

LSMOP9	10	200	6.5110e+0 (5.48e-2) =	2.8588e+01(6.62e-01)-	4.4422e+0 (2.40e+0)
LSMOP9	10	500	1.4217e+1 (2.17e+1) =	8.1759e+00(7.42e-01)=	9.6554e+0 (5.41e+0)
LSMOP9	10	1000	7.2247e+1 (1.28e+2) =	3.0315e+01(3.55e+0)-	7.1615e+0 (4.73e+0)
+/-/=			19/96/65	73/84/23	

TABLE A. 12

THE IGD COMPARISON RESULTS OF THREE MBEAS ON DTLZ1-DTLZ7 TEST PROBLEMS WITH 2-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

Problem	M	D	MOEA/PSL	AMOEAD	NN-CSO
DTLZ1	2	100	4.9452e+2 (4.71e+1) =	6.9551e+02(5.37e+01)=	5.3793e+2 (2.23e+2)
DTLZ1	2	200	1.4470e+3 (8.33e+1) -	1.5341e+03(4.04e+01)-	1.0141e+3 (2.19e+2)
DTLZ1	2	500	4.1530e+3 (9.70e+1) -	3.8707e+03(8.19e+01)-	2.7736e+3 (8.35e+2)
DTLZ1	2	1000	8.6408e+3 (1.59e+2) -	7.9529e+03(5.42e+02)-	5.7686e+3 (1.47e+3)
DTLZ1	3	100	7.0205e+2 (4.44e+0) -	5.4639e+02(3.84e+01)-	3.7321e+2 (7.74e+1)
DTLZ1	3	200	1.4302e+3 (7.02e+0) -	1.2142e+03(1.24e+02)-	7.5949e+2 (6.39e+1)
DTLZ1	3	500	3.6550e+3 (2.01e+1) -	3.2095e+03(2.02e+02)-	2.1264e+3 (6.16e+2)
DTLZ1	3	1000	7.3421e+3 (5.71e+1) -	6.3517e+03(4.10e+02)-	4.2642e+3 (4.30e+2)
DTLZ1	5	100	7.2856e+2 (1.16e+2) -	4.4253e+02(3.66e+01)-	1.6925e+2 (1.38e+2)
DTLZ1	5	200	1.5155e+3 (1.78e+2) -	9.7879e+02(5.22e+01)-	2.6128e+2 (2.57e+2)
DTLZ1	5	500	3.9613e+3 (5.35e+2) -	2.5888e+03(2.86e+02)-	1.2046e+2 (2.56e+2)
DTLZ1	5	1000	7.0760e+3 (4.45e+2) -	5.2562e+03(5.95e+02)-	2.2002e+2 (2.22e+2)
DTLZ1	8	100	1.0651e+3 (2.01e+2) -	3.7153e+02(4.77e+01)-	2.4699e+2 (6.08e+1)
DTLZ1	8	200	2.3936e+3 (8.38e+0) -	8.3303e+02(7.78e+01)-	4.6851e+2 (1.64e+2)
DTLZ1	8	500	4.3716e+3 (1.30e+3) -	2.1452e+03(2.38e+02)-	4.2218e+2 (6.81e+2)
DTLZ1	8	1000	8.8377e+3 (3.34e+3) -	4.6588e+03(4.68e+02)-	6.8877e+2 (8.48e+2)
DTLZ1	10	100	1.1141e+3 (8.11e+0) -	5.5770e+02(6.26e+01)-	1.9673e+2 (1.55e+2)
DTLZ1	10	200	2.0345e+3 (4.19e+2) -	1.2635e+03(1.42e+02)-	5.3201e+2 (1.79e+2)
DTLZ1	10	500	4.7056e+3 (1.03e+3) -	3.2867e+03(2.64e+02)-	2.7571e+2 (2.80e+2)
DTLZ1	10	1000	8.7259e+3 (2.22e+3) -	6.8853e+03(4.82e+02)-	3.2814e+2 (5.18e+2)
DTLZ2	2	100	9.1083e-3 (2.63e-3) +	1.5422e-01(9.19e-03)-	7.9524e-2 (1.00e-2)
DTLZ2	2	200	1.8132e-1 (6.65e-2) =	2.5846e-01(1.99e-02)-	1.9177e-1 (2.86e-2)
DTLZ2	2	500	5.8848e+0 (1.78e+0) -	4.7510e-01(2.12e-02)+	5.7716e-1 (5.73e-2)
DTLZ2	2	1000	7.0643e+0 (1.59e+0) -	7.1036e-01(3.94e-02)+	1.1890e+0 (1.12e-1)
DTLZ2	3	100	6.8307e-2 (1.82e-3) +	3.1118e-01(3.43e-02)-	1.9668e-1 (1.64e-2)
DTLZ2	3	200	2.5303e-1 (7.51e-2) +	4.8618e-01(2.82e-02)-	3.7337e-1 (4.58e-2)
DTLZ2	3	500	4.4493e+0 (9.25e-1) -	7.8005e-01(1.22e-01)=	9.0447e-1 (5.55e-2)
DTLZ2	3	1000	8.4162e+0 (2.68e+0) -	1.2174e+00(1.37e-01)+	1.5976e+0 (1.43e-1)
DTLZ2	5	100	1.7650e+0 (3.56e-1) -	7.0225e-01(3.43e-02)-	4.9801e-1 (4.04e-2)
DTLZ2	5	200	9.8608e+0 (1.25e+0) -	1.0013e+00(1.57e-01)-	5.6523e-1 (6.63e-2)
DTLZ2	5	500	1.2971e+1 (1.09e+0) -	1.6527e+00(3.63e-01)-	6.9030e-1 (6.45e-2)
DTLZ2	5	1000	4.5996e+0 (5.02e-1) -	3.3971e+00(5.99e-01)-	8.2565e-1 (3.53e-2)
DTLZ2	8	100	1.3662e+1 (9.75e-1) -	1.0194e+00(4.18e-02)-	8.8452e-1 (3.41e-2)
DTLZ2	8	200	2.7553e+1 (3.46e+0) -	1.4215e+00(1.56e-01)-	1.0250e+0 (2.93e-2)
DTLZ2	8	500	5.9495e+1 (1.48e+1) -	2.1628e+00(7.79e-01)-	9.8507e-1 (4.22e-2)
DTLZ2	8	1000	9.6193e+1 (3.39e+1) -	3.9883e+00(1.50e+00)-	9.8649e-1 (2.51e-2)
DTLZ2	10	100	1.4908e+1 (6.50e-1) -	1.1938e+00(1.20e-01)-	9.9078e-1 (2.74e-2)
DTLZ2	10	200	2.9448e+1 (2.48e+0) -	1.7872e+00(3.97e-01)-	1.0680e+0 (5.82e-2)
DTLZ2	10	500	6.5537e+1 (1.17e+1) -	3.4608e+00(4.91e-01)-	1.0921e+0 (9.10e-2)
DTLZ2	10	1000	1.4289e+2 (6.90e+0) -	6.8488e+00(1.45e+00)-	1.0579e+0 (3.91e-2)
DTLZ3	2	100	1.2317e+3 (8.36e+1) =	2.0330e+03(9.53e+01)-	1.3287e+3 (4.97e+2)
DTLZ3	2	200	3.8443e+3 (2.24e+2) =	4.2208e+03(1.15e+02)-	3.0668e+3 (9.45e+2)

DTLZ3	2	500	1.1482e+4 (2.85e+2) -	1.0846e+04(5.39e+02)-	5.8953e+3 (8.19e+2)
DTLZ3	2	1000	2.3903e+4 (5.83e+2) -	2.1843e+04(1.78e+03)-	1.3700e+4 (3.68e+3)
DTLZ3	3	100	2.2510e+3 (3.27e+1) -	1.6377e+03(2.47e+02)-	1.2512e+3 (2.07e+2)
DTLZ3	3	200	4.8020e+3 (1.45e+1) -	3.8947e+03(2.90e+02)-	2.4816e+3 (3.06e+2)
DTLZ3	3	500	1.2318e+4 (2.33e+1) -	1.0682e+04(6.16e+02)-	6.4010e+3 (4.86e+2)
DTLZ3	3	1000	2.4809e+4 (4.00e+1) -	1.9983e+04(9.95e+02)-	1.3679e+4 (1.34e+3)
DTLZ3	5	100	2.3237e+3 (1.51e+1) -	1.7029e+03(1.27e+02)-	7.6616e+2 (4.86e+2)
DTLZ3	5	200	4.8417e+3 (1.62e+1) -	3.5750e+03(2.67e+02)-	7.4980e+2 (1.01e+3)
DTLZ3	5	500	1.2352e+4 (1.25e+1) -	9.2075e+03(7.85e+02)-	3.8409e+2 (6.12e+2)
DTLZ3	5	1000	2.4802e+4 (2.25e+1) -	2.0143e+04(1.73e+03)-	1.3701e+3 (1.40e+3)
DTLZ3	8	100	2.2822e+3 (1.41e+1) -	1.6884e+03(6.59e+01)-	1.0390e+3 (2.46e+2)
DTLZ3	8	200	4.7776e+3 (1.61e+1) -	3.7491e+03(1.17e+02)-	1.6571e+3 (8.85e+2)
DTLZ3	8	500	1.2294e+4 (2.06e+1) -	9.9074e+03(5.30e+02)-	4.8984e+2 (4.86e+2)
DTLZ3	8	1000	2.4976e+4 (2.70e+2) -	1.9655e+04(1.54e+03)-	4.2066e+2 (4.91e+2)
DTLZ3	10	100	2.2446e+3 (1.10e+1) -	2.0504e+03(1.25e+02)-	1.1943e+3 (1.02e+2)
DTLZ3	10	200	4.7401e+3 (1.12e+1) -	4.9530e+03(1.43e+02)-	1.8951e+3 (1.32e+3)
DTLZ3	10	500	1.2425e+4 (4.28e+2) -	1.3176e+04(3.14e+02)-	1.0827e+3 (1.58e+3)
DTLZ3	10	1000	2.4763e+4 (1.75e+1) -	2.7440e+04(1.08e+03)-	2.2712e+3 (1.98e+3)
DTLZ4	2	100	1.1478e-1 (2.79e-1) +	7.9286e-01(1.01e-02)-	2.1880e-1 (2.81e-2)
DTLZ4	2	200	6.0132e-1 (5.04e-1) =	8.6221e-01(3.38e-02)-	8.0161e-1 (5.73e-2)
DTLZ4	2	500	5.8059e+0 (1.90e+0) -	1.1057e+00(8.84e-02) +	2.5251e+0 (3.29e-1)
DTLZ4	2	1000	7.0333e+0 (1.54e+0) =	1.5635e+00(1.78e-01) +	5.4437e+0 (9.45e-1)
DTLZ4	3	100	6.9196e-2 (4.19e-3) +	9.9473e-01(1.74e-02)=	9.7413e-1 (1.95e-1)
DTLZ4	3	200	2.1556e-1 (2.86e-2) +	1.0660e+00(2.71e-02)+	2.1691e+0 (1.65e-1)
DTLZ4	3	500	4.4686e+0 (2.07e+0) =	1.4035e+00(1.10e-01) +	4.8555e+0 (1.03e+0)
DTLZ4	3	1000	9.4844e+0 (2.79e+0) =	1.8117e+00(3.05e-01) +	7.6875e+0 (1.52e+0)
DTLZ4	5	100	1.5329e+0 (5.92e-1) =	1.1696e+00(3.13e-02)-	9.0123e-1 (2.29e-1)
DTLZ4	5	200	7.3735e+0 (1.41e+0) -	1.3135e+00(1.15e-01)-	1.1041e+0 (7.73e-3)
DTLZ4	5	500	1.2205e+1 (2.01e+0) -	1.4930e+00(2.03e-01)-	1.1081e+0 (7.96e-7)
DTLZ4	5	1000	1.0211e+1 (2.09e+0) -	2.7637e+00(6.27e-01)-	1.2318e+0 (3.14e-2)
DTLZ4	8	100	1.0653e+1 (1.41e+0) -	1.3483e+00(9.12e-02)-	1.1920e+0 (1.04e-2)
DTLZ4	8	200	2.2867e+1 (2.61e+0) -	1.5047e+00(2.35e-01)-	1.2133e+0 (2.39e-3)
DTLZ4	8	500	2.5836e+1 (6.51e+0) -	2.0397e+00(6.61e-01)-	1.3757e+0 (7.06e-2)
DTLZ4	8	1000	6.6311e+1 (3.84e+1) -	3.6938e+00(1.55e+00)-	1.3439e+0 (3.91e-2)
DTLZ4	10	100	1.3200e+1 (1.31e+0) -	1.5892e+00(2.10e-01)-	1.2250e+0 (1.20e-2)
DTLZ4	10	200	2.7421e+1 (3.52e+0) -	1.9333e+00(3.91e-01)-	1.3963e+0 (1.14e-1)
DTLZ4	10	500	3.9763e+1 (1.47e+1) -	4.0322e+00(2.02e+00)-	1.3750e+0 (8.46e-2)
DTLZ4	10	1000	7.4709e+1 (3.69e+1) -	6.7995e+00(3.01e+00)-	1.3390e+0 (6.47e-2)
DTLZ5	2	100	8.9707e-3 (2.75e-3) +	1.4512e-01(8.60e-03)-	8.3136e-2 (9.22e-3)
DTLZ5	2	200	5.7317e-1 (1.99e-1) -	2.5496e-01(1.30e-02)-	1.8608e-1 (1.68e-2)
DTLZ5	2	500	7.0648e+0 (2.05e+0) -	4.7348e-01(3.29e-02) +	6.0724e-1 (6.90e-2)
DTLZ5	2	1000	7.5447e+0 (8.92e-1) -	7.4041e-01(2.61e-02) +	1.1779e+0 (9.17e-2)
DTLZ5	3	100	1.1921e-2 (1.47e-3) +	2.3542e-01(4.29e-02) +	2.9437e-1 (2.36e-2)
DTLZ5	3	200	1.5536e-1 (1.02e-1) +	4.2015e-01(6.81e-02)+	4.8664e-1 (3.20e-2)
DTLZ5	3	500	4.5808e+0 (1.21e+0) -	7.5291e-01(1.81e-01) =	9.2839e-1 (6.35e-2)

DTLZ5	3	1000	6.6934e+0 (1.34e+0) -	1.3876e+00(2.58e-01)+	1.6843e+0 (1.71e-1)
DTLZ5	5	100	4.9192e+0 (3.56e-1) -	4.5117e-01(1.58e-01)=	3.1277e-1 (1.93e-2)
DTLZ5	5	200	1.1055e+1 (1.27e+0) -	7.3997e-01(2.25e-01)-	3.5304e-1 (2.71e-2)
DTLZ5	5	500	2.5985e+1 (3.57e+0) -	1.7117e+00(3.55e-01)-	3.7765e-1 (2.68e-2)
DTLZ5	5	1000	3.4502e+1 (5.82e+0) -	3.2755e+00(7.47e-01)-	4.8973e-1 (3.81e-2)
DTLZ5	8	100	1.2341e+1 (2.08e+0) -	6.8692e-01(2.30e-01)-	3.1610e-1 (2.27e-2)
DTLZ5	8	200	2.8370e+1 (2.44e+0) -	1.1053e+00(3.51e-01)-	3.7485e-1 (1.02e-2)
DTLZ5	8	500	6.1112e+1 (1.73e+1) -	2.6759e+00(5.45e-01)-	3.9319e-1 (2.00e-2)
DTLZ5	8	1000	1.2943e+2 (2.29e+1) -	3.8000e+00(9.69e-01)-	4.4120e-1 (5.98e-2)
DTLZ5	10	100	1.2204e+1 (1.80e+0) -	1.0511e+00(2.70e-01)-	3.3800e-1 (4.47e-2)
DTLZ5	10	200	2.8411e+1 (3.25e+0) -	1.5554e+00(3.71e-01)-	4.5488e-1 (3.23e-2)
DTLZ5	10	500	7.1164e+1 (8.47e+0) -	3.5867e+00(1.01e+00)-	5.1257e-1 (7.28e-2)
DTLZ5	10	1000	1.3384e+2 (2.48e+1) -	5.1221e+00(2.34e+00)-	5.0542e-1 (5.40e-2)
DTLZ6	2	100	4.1425e-1 (7.34e-5) +	1.3187e-03(1.05e-06)+	2.0551e+1 (6.02e+0)
DTLZ6	2	200	4.1422e-1 (8.17e-6) +	1.3188e-03(9.68e-07)+	5.4776e+1 (9.58e+0)
DTLZ6	2	500	4.1422e-1 (2.22e-6) +	1.0719e-01(2.80e-01)+	1.2901e+2 (3.16e+1)
DTLZ6	2	1000	4.1423e-1 (2.32e-5) +	1.0719e-01(2.80e-01)+	3.0210e+2 (5.79e+1)
DTLZ6	3	100	7.3207e-1 (4.44e-5) +	2.0085e-02(6.54e-04)+	3.1633e+1 (3.50e+0)
DTLZ6	3	200	1.7311e-3 (3.86e-5) +	2.0369e-02(3.97e-04)+	7.4758e+1 (6.53e+0)
DTLZ6	3	500	7.3206e-1 (6.36e-6) +	2.0313e-02(7.21e-04)+	1.9931e+2 (1.93e+1)
DTLZ6	3	1000	7.3205e-1 (3.66e-6) +	1.9571e-02(9.27e-04)+	4.1347e+2 (7.43e+1)
DTLZ6	5	100	1.2681e+0 (8.73e-1) =	5.3456e-02(4.66e-03)+	1.1439e+0 (1.24e-1)
DTLZ6	5	200	1.5408e+0 (9.32e-1) =	5.2170e-02(3.19e-03)+	7.4977e+0 (1.30e+1)
DTLZ6	5	500	1.2014e+1 (1.49e+1) +	5.3763e-02(1.73e-03)+	1.2555e+2 (6.86e+1)
DTLZ6	5	1000	3.3020e+0 (2.26e+0) +	1.4052e-01(2.33e-01)+	4.4290e+2 (5.97e+1)
DTLZ6	8	100	2.6796e+1 (8.72e+0) -	9.4780e-02(4.60e-03)+	1.4865e+0 (1.14e-1)
DTLZ6	8	200	5.9047e+1 (1.81e+1) -	9.4046e-02(5.23e-03)+	5.5756e+0 (9.93e+0)
DTLZ6	8	500	1.4237e+2 (5.48e+1) =	9.4737e-02(3.73e-03)+	1.8481e+2 (8.36e+1)
DTLZ6	8	1000	3.1340e+2 (1.63e+2) +	8.6028e-02(7.19e-03)+	4.6411e+2 (2.03e+1)
DTLZ6	10	100	3.2701e+1 (7.34e+0) -	8.4353e-01(3.75e-01)+	1.8316e+0 (1.90e-1)
DTLZ6	10	200	7.8389e+1 (6.98e+0) -	1.4679e+00(7.65e-01)+	3.4666e+0 (2.95e+0)
DTLZ6	10	500	1.8170e+2 (4.52e+1) =	6.4159e+00(4.90e+00)+	1.9093e+2 (8.34e+1)
DTLZ6	10	1000	4.2400e+2 (1.38e+1) +	1.3364e+01(1.01e+01)+	4.7408e+2 (1.61e+1)
DTLZ7	2	100	1.7000e-3 (6.11e-5) +	2.1219e-03(1.85e-05)+	9.4690e-2 (1.32e-1)
DTLZ7	2	200	1.6650e-3 (2.57e-5) +	2.1210e-03(1.54e-05)+	2.4954e-1 (2.18e-1)
DTLZ7	2	500	1.6951e-3 (2.20e-5) +	2.1237e-03(1.95e-05)+	3.3772e-1 (1.65e-1)
DTLZ7	2	1000	1.7094e-3 (3.17e-5) +	2.1281e-03(2.88e-05)+	6.3712e-1 (4.44e-1)
DTLZ7	3	100	4.2005e-2 (9.18e-4) +	5.7391e-02(5.67e-04)+	1.1238e+0 (1.22e+0)
DTLZ7	3	200	4.3711e-2 (1.02e-3) +	5.7832e-02(1.49e-03)+	2.2019e+0 (2.21e+0)
DTLZ7	3	500	4.5009e-2 (1.57e-3) +	5.8036e-02(1.18e-03)+	3.8856e+0 (3.38e+0)
DTLZ7	3	1000	4.6727e-2 (1.97e-3) +	5.6467e-02(1.71e-03)+	8.3253e+0 (2.63e+0)
DTLZ7	5	100	3.0846e-1 (1.02e-2) +	6.6965e-01(4.94e-01)-	5.2470e-1 (4.62e-3)
DTLZ7	5	200	3.1596e-1 (7.79e-3) +	4.8310e-01(1.97e-02)+	5.2269e-1 (9.85e-3)
DTLZ7	5	500	3.1750e-1 (1.15e-2) +	5.4412e-01(1.55e-01)=	5.3577e-1 (5.48e-2)
DTLZ7	5	1000	2.8680e-1 (6.01e-3) +	8.6825e-01(4.54e-01)=	1.0133e+0 (1.57e-1)

DTLZ7	8	100	8.2068e-1 (1.45e-2) +	1.4371e+00(5.72e-01)+	1.6240e+0 (2.70e-2)
DTLZ7	8	200	8.2253e-1 (4.03e-3) +	1.7506e+00(9.77e-01)=	1.7672e+0 (4.05e-1)
DTLZ7	8	500	8.0712e-1 (3.63e-2) +	1.8283e+00(1.35e+00)+	1.9336e+0 (3.03e-1)
DTLZ7	8	1000	9.0229e-1 (7.11e-2) +	1.9210e+00(1.20e+00)=	3.3249e+0 (7.49e-1)
DTLZ7	10	100	1.1458e+0 (2.49e-2) +	3.5572e+00(7.61e-01)-	2.5731e+0 (7.75e-1)
DTLZ7	10	200	1.1578e+0 (1.50e-2) +	3.5443e+00(1.26e+00)-	1.9409e+0 (2.96e-1)
DTLZ7	10	500	1.8062e+0 (1.74e+0) +	3.2224e+00(9.83e-01)=	2.6103e+0 (7.30e-1)
DTLZ7	10	1000	1.1753e+0 (5.73e-2) +	2.7656e+00(9.35e-01)=	3.1208e+0 (1.39e+0)
+/-=			41/86/13	44/85/11	

TABLE A. 13

THE IGD COMPARISON OF RESULTS OF THREE MBEAS ON WFG1-WFG9 TEST PROBLEMS WITH 2-20 OBJECTIVES AND 100-1000 DECISION VARIABLES.

Problem	M	D	MOEA/PSL	AMOEAD	NN-CSO
WFG1	2	100	5.6487e-1 (2.57e-2) +	1.6980e+00(3.53e-02)-	1.3861e+0 (1.73e-2)
WFG1	2	200	8.1189e-1 (1.45e-2) +	1.6976e+00(3.23e-02)-	1.3920e+0 (2.54e-2)
WFG1	2	500	1.0850e+0 (3.78e-3) +	1.7081e+00(3.26e-02)-	1.3805e+0 (2.37e-2)
WFG1	2	1000	1.2092e+0 (2.03e-2) +	1.7368e+00(3.00e-02)-	1.3864e+0 (2.13e-2)
WFG1	3	100	1.3825e+0 (2.62e-2) +	1.7742e+00(2.16e-02)-	1.5872e+0 (1.67e-2)
WFG1	3	200	1.4901e+0 (8.74e-3) +	1.7787e+00(1.14e-02)-	1.5829e+0 (7.51e-3)
WFG1	3	500	1.5120e+0 (6.94e-3) +	1.7724e+00(9.97e-03)-	1.5991e+0 (9.23e-3)
WFG1	3	1000	1.5079e+0 (4.51e-3) +	1.7811e+00(1.76e-02)-	1.5903e+0 (1.19e-2)
WFG1	5	100	2.1122e+0 (3.38e-2) -	2.1318e+00(2.36e-02)-	2.0110e+0 (2.93e-2)
WFG1	5	200	2.0830e+0 (4.76e-2) -	2.1339e+00(3.06e-02)-	2.0071e+0 (1.28e-2)
WFG1	5	500	2.1208e+0 (3.18e-2) -	2.1447e+00(2.60e-02)-	2.0096e+0 (2.30e-2)
WFG1	5	1000	1.9982e+0 (3.01e-2) +	2.1200e+00(2.75e-02)+	2.1607e+0 (3.70e-2)
WFG1	8	100	2.7112e+0 (2.38e-2) -	2.8745e+00(5.06e-02)-	2.6508e+0 (2.50e-2)
WFG1	8	200	2.7211e+0 (3.64e-2) -	2.8563e+00(6.43e-02)-	2.6401e+0 (2.00e-2)
WFG1	8	500	2.8153e+0 (6.01e-2) -	2.8508e+00(2.55e-02)-	2.6538e+0 (3.33e-2)
WFG1	8	1000	2.8165e+0 (2.72e-2) =	2.8484e+00(4.04e-02)=	2.8140e+0 (5.60e-2)
WFG1	10	100	3.0821e+0 (5.26e-2) =	3.4354e+00(1.36e-01)-	3.0278e+0 (2.83e-2)
WFG1	10	200	3.0674e+0 (3.18e-2) =	3.4922e+00(6.61e-02)-	3.0462e+0 (2.01e-2)
WFG1	10	500	3.2152e+0 (5.08e-2) -	3.4473e+00(1.22e-01)-	3.0566e+0 (2.62e-2)
WFG1	10	1000	3.1960e+0 (5.75e-2) =	3.4637e+00(1.06e-01)-	3.1995e+0 (4.98e-2)
WFG2	2	101	4.9124e-2 (8.29e-3) +	2.0187e-01(1.88e-02)-	1.6965e-1 (5.99e-3)
WFG2	2	201	1.1277e-1 (8.55e-3) +	1.9319e-01(2.51e-02)=	1.8455e-1 (1.00e-2)
WFG2	2	501	2.0690e-1 (5.70e-2) =	1.8632e-01(1.23e-02)=	1.8244e-1 (7.91e-3)
WFG2	2	1001	2.4098e-1 (2.40e-2) -	2.0907e-01(2.68e-02)-	1.7151e-1 (1.05e-2)
WFG2	3	100	2.1042e-1 (2.19e-2) +	4.3528e-01(6.86e-02)-	2.7215e-1 (1.11e-2)
WFG2	3	200	2.6159e-1 (1.44e-2) +	4.8381e-01(5.64e-02)-	2.8162e-1 (1.20e-2)
WFG2	3	500	3.2830e-1 (1.92e-2) -	4.6578e-01(3.73e-02)-	3.0717e-1 (1.69e-2)
WFG2	3	1000	3.5707e-1 (8.92e-3) -	4.6163e-01(5.09e-02)-	3.2326e-1 (1.45e-2)
WFG2	5	100	7.8136e-1 (5.04e-2) -	1.8722e+00(8.23e-01)-	5.0634e-1 (1.48e-2)
WFG2	5	200	8.8675e-1 (7.01e-2) -	2.2128e+00(7.60e-01)-	5.5282e-1 (1.92e-2)
WFG2	5	500	9.7600e-1 (7.38e-2) -	2.1876e+00(6.74e-01)-	5.7927e-1 (1.76e-2)
WFG2	5	1000	9.5845e-1 (5.53e-2) -	2.2469e+00(9.61e-01)-	7.2980e-1 (2.70e-2)
WFG2	8	101	1.5378e+0 (6.40e-2) -	4.3127e+00(1.05e+00)-	1.1968e+0 (2.06e-2)
WFG2	8	201	1.5346e+0 (6.39e-2) -	5.2802e+00(1.41e+00)-	1.2357e+0 (2.93e-2)
WFG2	8	501	1.4939e+0 (5.47e-2) -	5.4225e+00(1.52e+00)-	1.2865e+0 (3.89e-2)
WFG2	8	1001	1.4369e+0 (5.65e-2) =	5.0449e+00(1.07e+00)-	1.3762e+0 (4.31e-2)
WFG2	10	101	1.8060e+0 (9.99e-2) -	6.5905e+00(1.99e+00)-	1.4342e+0 (4.64e-2)
WFG2	10	201	1.8197e+0 (9.21e-2) -	6.7680e+00(2.00e+00)-	1.4897e+0 (6.34e-2)
WFG2	10	501	1.8437e+0 (1.52e-1) -	6.8893e+00(1.75e+00)-	1.5601e+0 (8.69e-2)
WFG2	10	1001	1.9247e+0 (1.50e-1) =	6.8256e+00(1.99e+00)-	1.7821e+0 (1.27e-1)
WFG3	2	101	8.0930e-2 (8.67e-3) +	1.4147e-01(6.19e-03)-	1.2736e-1 (7.83e-3)
WFG3	2	201	1.8363e-1 (1.40e-2) -	1.4324e-01(5.36e-03)=	1.3611e-1 (8.30e-3)
WFG3	2	501	2.8589e-1 (1.07e-2) -	1.5221e-01(1.11e-02)-	1.3523e-1 (6.16e-3)
WFG3	2	1001	3.1522e-1 (2.72e-2) -	1.4853e-01(5.41e-03)-	1.3520e-1 (1.02e-2)
WFG3	3	100	2.7218e-1 (2.67e-2) +	2.5985e-01(1.69e-02)+	3.2416e-1 (1.59e-2)

WFG3	3	200	3.5619e-1 (2.24e-2) =	2.9367e-01(2.05e-02)+	3.4552e-1 (1.73e-2)
WFG3	3	500	4.7541e-1 (2.26e-2) -	2.9218e-01(2.33e-02)+	3.7091e-1 (2.00e-2)
WFG3	3	1000	4.0861e-1 (9.46e-3) -	2.8121e-01(1.84e-02)+	3.6457e-1 (7.98e-3)
WFG3	5	100	1.0615e+0 (8.44e-2) -	9.8838e-01(1.25e-01)-	5.9375e-1 (3.14e-2)
WFG3	5	200	1.1097e+0 (4.68e-2) -	9.5496e-01(1.53e-01)-	6.3256e-1 (4.62e-2)
WFG3	5	500	1.1070e+0 (8.24e-2) -	9.8040e-01(9.85e-02)-	6.8104e-1 (9.27e-2)
WFG3	5	1000	9.7353e-1 (8.32e-2) =	1.0419e+00(1.15e-01)-	9.2953e-1 (3.72e-2)
WFG3	8	101	2.0577e+0 (8.00e-2) +	3.5018e+00(4.12e-01)-	2.2319e+0 (5.89e-2)
WFG3	8	201	2.0274e+0 (1.21e-1) =	3.4152e+00(3.36e-01)-	2.1652e+0 (1.93e-1)
WFG3	8	501	1.5024e+0 (1.15e-1) +	3.6173e+00(2.24e-01)-	2.0726e+0 (1.50e-1)
WFG3	8	1001	1.5075e+0 (1.68e-1) +	3.2482e+00(4.10e-01)-	2.5123e+0 (6.40e-2)
WFG3	10	101	2.6346e+0 (1.26e-1) +	2.0492e+00(2.66e-01)+	3.0854e+0 (1.81e-1)
WFG3	10	201	2.5373e+0 (1.28e-1) +	2.0302e+00(1.16e-01)+	3.0089e+0 (3.13e-1)
WFG3	10	501	1.8946e+0 (1.99e-1) +	2.0902e+00(1.25e-01)+	2.8836e+0 (2.04e-1)
WFG3	10	1001	1.4461e+0 (8.69e-2) +	2.0090e+00(1.55e-01)+	3.0806e+0 (1.78e-1)
WFG4	2	100	5.3378e-2 (5.38e-3) +	1.0807e-01(2.94e-03)+	1.2645e-1 (3.86e-3)
WFG4	2	200	7.6977e-2 (8.43e-3) +	1.1856e-01(4.05e-03)+	1.2845e-1 (2.49e-3)
WFG4	2	500	1.1765e-1 (7.13e-3) +	1.2543e-01(3.80e-03)+	1.3101e-1 (3.24e-3)
WFG4	2	1000	1.1100e-1 (1.28e-3) +	1.3032e-01(2.56e-03)=	1.2881e-1 (3.76e-3)
WFG4	3	100	2.8974e-1 (7.27e-3) -	2.2346e-01(5.06e-03)=	2.3064e-1 (8.49e-3)
WFG4	3	200	3.6853e-1 (1.86e-2) -	2.2849e-01(5.12e-03)+	2.3747e-1 (6.72e-3)
WFG4	3	500	3.4295e-1 (9.59e-3) -	2.3857e-01(1.46e-02)=	2.4558e-1 (9.02e-3)
WFG4	3	1000	2.8636e-1 (7.94e-3) -	2.2918e-01(8.23e-03)+	2.4896e-1 (5.19e-3)
WFG4	5	100	1.2040e+0 (3.03e-2) -	1.0367e+00(6.04e-03)+	1.0561e+0 (5.97e-3)
WFG4	5	200	1.1459e+0 (1.32e-2) -	1.0458e+00(1.59e-02)=	1.0542e+0 (6.35e-3)
WFG4	5	500	1.0759e+0 (1.34e-2) =	1.0455e+00(1.42e-02)+	1.1859e+0 (3.20e-1)
WFG4	5	1000	1.0521e+0 (1.66e-2) +	1.0387e+00(1.14e-02)+	1.1353e+0 (1.69e-2)
WFG4	8	100	3.3154e+0 (3.84e-2) -	3.6061e+00(1.37e-01)-	3.1920e+0 (3.04e-2)
WFG4	8	200	3.3462e+0 (4.62e-2) -	3.5379e+00(8.20e-02)-	3.2079e+0 (2.39e-2)
WFG4	8	500	3.2293e+0 (3.08e-2) -	3.6328e+00(1.60e-01)-	3.1822e+0 (1.84e-2)
WFG4	8	1000	3.2436e+0 (6.05e-2) =	3.6028e+00(9.70e-02)-	3.2678e+0 (4.27e-2)
WFG4	10	100	4.5792e+0 (3.93e-2) +	4.4687e+00(5.82e-02)+	4.7190e+0 (1.23e-1)
WFG4	10	200	4.5845e+0 (4.52e-2) =	4.4689e+00(5.22e-02)+	4.6203e+0 (9.04e-2)
WFG4	10	500	4.6422e+0 (3.09e-2) =	4.4920e+00(5.26e-02)+	4.6596e+0 (9.84e-2)
WFG4	10	1000	4.6462e+0 (5.32e-2) -	4.4566e+00(5.99e-02)+	4.5209e+0 (3.49e-2)
WFG5	2	100	6.2279e-2 (3.30e-4) +	6.6299e-02(2.90e-03)=	6.9319e-2 (2.45e-3)
WFG5	2	200	6.2247e-2 (1.12e-4) +	6.4943e-02(3.24e-03)+	7.0663e-2 (3.27e-3)
WFG5	2	500	6.2467e-2 (1.51e-4) +	6.5780e-02(3.26e-03)+	7.0263e-2 (2.36e-3)
WFG5	2	1000	6.2481e-2 (2.76e-5) +	6.5604e-02(2.42e-03)=	6.8693e-2 (3.12e-3)
WFG5	3	100	1.9131e-1 (4.04e-3) -	1.5703e-01(4.02e-03)=	1.6114e-1 (6.18e-3)
WFG5	3	200	1.9236e-1 (5.49e-3) -	1.5658e-01(1.92e-03)+	1.6242e-1 (3.87e-3)
WFG5	3	500	1.8838e-1 (2.68e-3) -	1.5695e-01(4.09e-03)+	1.6664e-1 (6.54e-3)
WFG5	3	1000	1.8856e-1 (2.60e-3) -	1.5785e-01(3.48e-03)+	1.6605e-1 (6.94e-3)
WFG5	5	100	9.9644e-1 (1.46e-2) +	1.0107e+00(2.47e-02)=	1.0132e+0 (1.34e-3)
WFG5	5	200	9.7488e-1 (1.30e-2) +	1.0164e+00(2.41e-02)=	1.0150e+0 (3.04e-3)
WFG5	5	500	9.7150e-1 (1.35e-2) +	1.0246e+00(2.05e-02)=	1.0134e+0 (3.75e-3)
WFG5	5	1000	9.5339e-1 (1.02e-2) +	1.0278e+00(3.54e-02)+	1.1103e+0 (1.31e-2)
WFG5	8	100	3.1965e+0 (3.12e-2) -	3.7686e+00(7.88e-02)-	3.0526e+0 (4.36e-2)
WFG5	8	200	3.1782e+0 (3.18e-2) -	3.7841e+00(7.27e-02)-	3.0415e+0 (4.23e-2)

WFG5	8	500	3.1840e+0 (4.64e-2) -	3.8085e+00(5.56e-02)-	3.0802e+0 (7.22e-2)
WFG5	8	1000	3.1810e+0 (9.85e-2) +	3.7796e+00(5.70e-02)-	3.4457e+0 (2.78e-2)
WFG5	10	100	4.4908e+0 (5.15e-2) -	5.1854e+00(7.85e-02)-	4.3701e+0 (5.38e-2)
WFG5	10	200	4.4226e+0 (3.33e-2) =	5.1470e+00(1.04e-01)-	4.4166e+0 (6.79e-2)
WFG5	10	500	4.5300e+0 (2.87e-2) =	5.1936e+00(1.37e-01)-	4.5010e+0 (3.98e-2)
WFG5	10	1000	4.6164e+0 (5.35e-2) +	5.2520e+00(1.33e-01)-	4.9927e+0 (7.12e-2)
WFG6	2	100	2.5580e-2 (1.89e-4) +	2.5812e-02(1.57e-03)+	2.9661e-2 (2.43e-3)
WFG6	2	200	2.2242e-2 (2.21e-2) -	1.3327e-02(1.17e-06) +	1.7915e-2 (1.39e-3)
WFG6	2	500	3.8789e-2 (8.25e-2) -	6.9084e-03(5.80e-06) +	1.2482e-2 (3.05e-3)
WFG6	2	1000	8.7328e-2 (1.39e-1) =	5.2322e-03(6.58e-06) +	1.2221e-2 (4.94e-3)
WFG6	3	100	1.6593e-1 (3.15e-3) -	1.3230e-01(8.86e-04) +	1.4004e-1 (5.11e-3)
WFG6	3	200	1.6800e-1 (2.47e-3) -	1.2930e-01(6.84e-04) +	1.3283e-1 (3.45e-3)
WFG6	3	500	2.7654e-1 (1.89e-1) =	1.2952e-01(6.50e-04) +	1.9857e-1 (5.50e-2)
WFG6	3	1000	2.0035e-1 (9.18e-2) =	1.2992e-01(9.09e-04) +	1.7362e-1 (4.00e-2)
WFG6	5	100	1.0615e+0 (1.84e-2) =	1.0300e+00(8.23e-03) +	1.0606e+0 (8.55e-3)
WFG6	5	200	1.0263e+0 (1.24e-2) +	1.0316e+00(8.83e-03)+	1.0734e+0 (2.12e-2)
WFG6	5	500	1.0013e+0 (2.48e-2) +	1.0262e+00(9.29e-03)+	1.0849e+0 (2.12e-2)
WFG6	5	1000	9.7241e-1 (1.07e-2) +	1.0314e+00(1.04e-02)+	1.3864e+0 (3.03e-2)
WFG6	8	100	3.3281e+0 (5.88e-2) -	3.4873e+00(3.08e-01)-	3.1393e+0 (8.91e-2)
WFG6	8	200	3.3033e+0 (3.70e-2) -	3.4588e+00(5.74e-01)=	3.1595e+0 (8.56e-2)
WFG6	8	500	3.4173e+0 (7.24e-2) -	3.2709e+00(1.79e-01)=	3.1892e+0 (5.75e-2)
WFG6	8	1000	3.3268e+0 (7.66e-2) +	3.2212e+00(1.26e-01) +	3.4520e+0 (6.52e-2)
WFG6	10	100	4.6295e+0 (4.10e-2) =	5.6169e+00(4.84e-01)-	4.6680e+0 (1.04e-1)
WFG6	10	200	4.6365e+0 (2.42e-2) =	5.8026e+00(5.15e-01)-	4.5751e+0 (7.01e-2)
WFG6	10	500	4.8264e+0 (2.12e-1) =	5.6689e+00(4.01e-01)-	4.6990e+0 (1.56e-1)
WFG6	10	1000	4.7804e+0 (1.09e-1) =	5.4252e+00(4.37e-01)=	4.9120e+0 (2.16e-1)
WFG7	2	100	2.1547e-2 (1.97e-3) +	1.4255e-01(1.20e-02)-	1.2382e-1 (9.87e-3)
WFG7	2	200	1.1791e-1 (1.77e-2) =	1.4227e-01(7.72e-03)-	1.2664e-1 (7.82e-3)
WFG7	2	500	2.5012e-1 (2.17e-2) -	1.5189e-01(9.70e-03)-	1.2925e-1 (5.48e-3)
WFG7	2	1000	2.7562e-1 (9.37e-3) -	1.5401e-01(7.91e-03)-	1.2301e-1 (4.64e-3)
WFG7	3	100	2.6992e-1 (9.35e-3) +	3.0407e-01(7.31e-03)=	2.9567e-1 (1.73e-2)
WFG7	3	200	3.9089e-1 (3.28e-2) -	3.0233e-01(1.21e-02) =	3.0577e-1 (9.44e-3)
WFG7	3	500	4.6539e-1 (2.90e-2) -	3.1215e-01(1.50e-02) +	3.3910e-1 (2.23e-2)
WFG7	3	1000	3.9969e-1 (6.68e-3) -	3.1572e-01(8.95e-03) +	3.4150e-1 (1.39e-2)
WFG7	5	100	1.2924e+0 (2.24e-2) -	1.2390e+00(1.48e-02)-	1.1053e+0 (6.00e-3)
WFG7	5	200	1.2925e+0 (3.45e-2) -	1.2653e+00(2.37e-02)-	1.1238e+0 (7.95e-3)
WFG7	5	500	1.2213e+0 (2.69e-2) -	1.2571e+00(1.52e-02)-	1.1375e+0 (6.22e-3)
WFG7	5	1000	1.2276e+0 (4.05e-2) =	1.2680e+00(2.54e-02)=	1.2482e+0 (2.09e-2)
WFG7	8	100	3.5875e+0 (5.30e-2) -	4.1885e+00(5.92e-02)-	3.1192e+0 (2.66e-2)
WFG7	8	200	3.5478e+0 (3.38e-2) -	4.2056e+00(9.32e-02)-	3.1565e+0 (2.86e-2)
WFG7	8	500	3.6222e+0 (5.63e-2) -	4.1289e+00(6.25e-02)-	3.1208e+0 (1.84e-2)
WFG7	8	1000	3.6886e+0 (8.71e-2) -	4.1694e+00(9.97e-02)-	3.3300e+0 (4.05e-2)
WFG7	10	100	4.8447e+0 (3.79e-2) -	5.6428e+00(4.55e-01)-	4.4828e+0 (4.43e-2)
WFG7	10	200	4.8418e+0 (4.70e-2) -	5.5887e+00(3.02e-01)-	4.4663e+0 (5.14e-2)
WFG7	10	500	4.9394e+0 (8.56e-2) -	5.6143e+00(2.87e-01)-	4.4638e+0 (1.18e-1)
WFG7	10	1000	4.9761e+0 (6.85e-2) -	5.3640e+00(2.97e-01)-	4.6457e+0 (1.11e-1)
WFG8	2	100	1.2646e-1 (1.51e-2) +	2.5631e-01(1.05e-02)-	2.3974e-1 (9.48e-3)
WFG8	2	200	2.0154e-1 (2.08e-2) +	2.5753e-01(6.84e-03)-	2.4560e-1 (1.27e-2)
WFG8	2	500	2.7606e-1 (1.29e-2) -	2.5311e-01(1.60e-02)-	1.7036e-1 (1.43e-2)

WFG8	2	1000	2.4012e-1 (3.41e-2) -	2.3905e-01(1.52e-02)-	1.3687e-1 (4.02e-3)
WFG8	3	100	3.4036e-1 (1.34e-2) +	3.6511e-01(6.17e-03)=	3.7263e-1 (7.64e-3)
WFG8	3	200	4.6795e-1 (2.30e-2) -	3.6269e-01(6.42e-03)=	3.7016e-1 (7.34e-3)
WFG8	3	500	4.7332e-1 (1.50e-2) -	3.5857e-01(7.12e-03)+	3.7377e-1 (2.37e-3)
WFG8	3	1000	3.8075e-1 (3.70e-2) -	3.5148e-01(6.19e-03)=	3.5338e-1 (1.43e-2)
WFG8	5	100	1.3066e+0 (1.77e-2) -	1.1830e+0(2.86e-02)-	1.1426e+0 (4.87e-3)
WFG8	5	200	1.3276e+0 (4.31e-2) -	1.1815e+00(1.07e-02)=	1.1737e+0 (1.07e-2)
WFG8	5	500	1.2276e+0 (1.52e-2) -	1.1847e+00(2.19e-02)=	1.1718e+0 (1.33e-2)
WFG8	5	1000	1.0816e+0 (2.95e-2) +	1.1917e+00(1.30e-02)+	1.3015e+0 (1.09e-2)
WFG8	8	100	3.4809e+0 (6.12e-2) -	4.4365e+00(2.43e-01)-	3.2508e+0 (6.18e-2)
WFG8	8	200	3.4557e+0 (4.05e-2) -	4.6687e+00(6.27e-01)-	3.2326e+0 (2.47e-2)
WFG8	8	500	3.4097e+0 (5.26e-2) -	4.1164e+00(1.69e-01)-	3.1741e+0 (4.80e-3)
WFG8	8	1000	3.4986e+0 (5.56e-2) -	4.6518e+00(2.38e-01)-	3.4078e+0 (3.16e-2)
WFG8	10	100	4.7536e+0 (5.37e-2) -	5.9049e+00(4.21e-01)-	4.6268e+0 (9.97e-2)
WFG8	10	200	4.7148e+0 (4.64e-2) -	5.8954e+00(6.43e-01)-	4.5396e+0 (8.20e-2)
WFG8	10	500	4.9660e+0 (1.59e-1) -	5.9735e+00(4.18e-01)-	4.7277e+0 (5.74e-2)
WFG8	10	1000	4.9745e+0 (1.72e-1) -	6.0053e+00(5.22e-01)-	4.7367e+0 (1.34e-1)
WFG9	2	100	2.9850e-2 (8.62e-3) +	3.8821e-02(7.78e-03)+	7.4102e-2 (1.01e-2)
WFG9	2	200	4.7961e-2 (4.10e-2) =	3.2095e-02(8.65e-03)+	6.0157e-2 (3.15e-3)
WFG9	2	500	5.4861e-2 (7.75e-2) =	5.3070e-02(2.90e-02)=	5.1020e-2 (4.95e-3)
WFG9	2	1000	2.0243e-2 (3.27e-2) +	2.8194e-02(7.11e-03)+	4.0541e-2 (5.70e-3)
WFG9	3	100	2.1288e-1 (2.72e-2) +	1.8901e-01(1.38e-02)+	3.3069e-1 (1.89e-2)
WFG9	3	200	2.6746e-1 (1.25e-1) =	1.8456e-01(7.45e-03)=	1.8597e-1 (1.67e-2)
WFG9	3	500	3.6640e-1 (1.22e-1) -	1.8179e-01(9.23e-03)=	1.7455e-1 (1.27e-2)
WFG9	3	1000	2.6171e-1 (1.90e-2) -	1.7059e-01(4.73e-03)=	1.7183e-1 (1.09e-2)
WFG9	5	100	1.2006e+0 (3.82e-2) -	1.0469e+00(1.26e-02)-	1.0434e+0 (9.91e-3)
WFG9	5	200	1.2699e+0 (1.44e-1) -	1.0529e+00(1.97e-02)=	1.0619e+0 (9.93e-3)
WFG9	5	500	1.3413e+0 (7.13e-2) -	1.0362e+00(1.21e-02)+	1.0759e+0 (1.61e-2)
WFG9	5	1000	1.1384e+0 (8.46e-2) =	1.0334e+00(1.03e-02)+	1.1851e+0 (1.98e-2)
WFG9	8	100	3.7612e+0 (5.03e-2) -	3.9191e+00(6.01e-02)-	3.0253e+0 (2.74e-2)
WFG9	8	200	3.8530e+0 (5.88e-2) -	3.8805e+00(1.29e-01)-	3.0798e+0 (3.05e-2)
WFG9	8	500	3.7867e+0 (9.01e-2) -	3.8128e+00(1.29e-01)-	3.0605e+0 (3.92e-2)
WFG9	8	1000	3.6885e+0 (1.44e-1) -	3.7313e+00(1.08e-01)-	3.4628e+0 (6.34e-2)
WFG9	10	100	5.1466e+0 (9.37e-2) -	5.2748e+00(9.74e-02)-	4.6532e+0 (4.89e-2)
WFG9	10	200	5.2758e+0 (1.07e-1) -	5.2504e+00(1.60e-01)-	4.6372e+0 (7.13e-2)
WFG9	10	500	5.0246e+0 (1.26e-1) =	5.2600e+00(6.79e-02)-	5.0515e+0 (8.17e-2)
WFG9	10	1000	4.9593e+0 (1.03e-1) =	5.2676e+00(1.39e-01)-	4.9860e+0 (1.42e-1)

+/-/=

52/96/32

50/99/31

TABLE A. 14

THE IGD RESULTS OF ALL ALGORITHMS ON 5-OBJECTIVE LSMOP1 AND LSMOP9, 2-OBJECTIVE UF3, 3-OBJECTIVE UF9, 5-OBJECTIVE DTLZ1 AND DTLZ2, AND 5-OBJECTIVE WFG2 AND WFG8 WITH 5000 AND 10000 DECISION VARIABLES.

Problem	M	D	LSMOF	DGEA	LMEA	LSMOEA/D	MOEADVA	MOEA/PSL	AMOEAD/D	NN-CSO
LSMOP1	5	5000	9.3139e-1 (6.16e-3) -	9.5070e-1 (6.51e-2) =	1.0530e+1 (2.31e-1) -	1.0874e+1 (3.91e-1) -	1.0774e+1 (4.18e-1) -	1.9955e+0 (1.68e+0) -	6.9876e-1 (1.24e-2) +	8.6393e-1 (9.68e-2)
LSMOP1	5	1000	9.3310e-1 0 (2.37e-3) -	1.4113e+0 (5.01e-4) -	1.0490e+1 (1.08e-1) -	1.0782e+1 (4.51e-1) -	1.0613e+1 (2.41e-1) -	8.7397e+0 (1.10e+1) -	7.1396e-1 (2.56e-2) +	8.7742e-1 (6.24e-2)
LSMOP9	5	5000	2.4795e+0 (4.38e-1) -	1.3574e+2 (1.22e+1) -	3.7108e+2 (5.25e+0) -	3.7007e+2 (6.25e+0) -	3.7255e+2 (3.07e+0) -	2.7608e+0 (1.30e-1) -	2.5695e+0 (9.34e-3) -	1.4232e+0 (7.27e-1)
LSMOP9	5	1000	2.3317e+0 0 (7.32e-2) -	1.5923e+2 (1.59e+1) -	3.7760e+2 (8.49e-1) -	3.7614e+2 (2.79e+0) -	3.7420e+2 (9.39e-1) -	2.9184e+0 (1.61e-1) -	2.9885e+0 (4.26e-3) -	2.1580e+0 (3.34e-1)
UF3	2	5000	1.2222e-1 (1.06e-3) -	1.2100e-1 (2.62e-3) -	1.1391e+0 (7.94e-3) -	1.1356e+0 (5.06e-3) -	1.1371e+0 (7.42e-3) -	4.6559e-1 (1.74e-1) -	2.2282e-1 (4.16e-3) -	1.1851e-1 (5.97e-4)
UF3	2	1000	1.2114e-1 0 (5.11e-4) -	1.2134e-1 (5.06e-3) -	1.1453e+0 (5.50e-3) -	1.1479 e+0 (4.07e-3) -	1.1457e+0 (3.68e-3) -	3.4326e-1 (1.13e-1) -	2.2277e-1 (2.74e-3) -	1.1773e-1 (3.65e-4)
UF9	3	5000	6.2887e-1 (1.65e-2) +	1.5021e+0 (1.75e-1) -	4.6081e+0 (2.97e-2) -	4.6021e+0 (1.62e-2) -	4.6231e+0 (3.16e-2) -	8.8941e-1 (1.24e-4) -	7.5768e-1 (2.55e-2) =	7.9618e-1 (5.44e-2)
UF9	3	1000	6.5166e-1 0 (2.86e-3) =	1.4377e+0 (2.56e-2) -	4.6291e+0 (2.42e-2) -	4.6433e+0 (1.61e-2) -	4.6118e+0 (1.00e-2) -	8.8339e-1 (8.49e-6) -	7.2767e-1 (4.25e-2) -	6.4750e-1 (1.91e-3)
DTLZ1	5	5000	1.1039e+3 (2.92e+3) +	1.2072e+4 (4.50e+3) =	1.2711e+5 (4.92e+3) -	1.2574e+5 (3.33e+3) -	1.2370e+5 (9.77e+2) -	3.3982e+4 (6.30e+3) -	2.6421e+4 (3.24e+3) -	1.5009e+4 (2.30e+3)
DTLZ1	5	1000	1.1824e+4 (1.61e+4) +	2.3069e+4 (2.01e+3) +	2.5275e+5 (1.27e+4) -	2.5051e+5 (3.91e+3) -	2.4828e+5 (1.23e+3) -	7.0949e+4 (2.82e+3) -	4.9604e+4 (4.25e+3) -	3.0143e+4 (1.00e+3)
DTLZ2	5	5000	3.2036e+2 (7.09e+1) -	2.8295e+1 (2.68e+0) -	4.0236e+2 (2.30e+0) -	4.0204e+2 (1.99e+0) -	4.0238e+2 (2.18e+0) -	1.3661e+2 (1.43e+2) -	1.4428e+1 (1.23e+0) -	1.3658e+1 (1.04e+0)
DTLZ2	5	1000	7.3561e+2 (6.95e+1) -	6.0237e+1 (9.39e+0) -	8.1184e+2 (2.33e+0) -	8.0897e+2 (2.02e+0) -	8.1300e+2 (2.64e+0) -	3.5682e+2 (3.48e+2) -	2.8494e+1 (1.28e+0) -	2.7554e+1 (3.14e+0)
WFG2	5	5000	7.1205e-1 (3.64e-2) =	7.7819e-1 (6.10e-2) -	1.7830e+0 (2.69e-1) -	1.7690e+0 (2.86e-1) -	1.8467e+0 (2.06e-3) -	8.8720e-1 (6.86e-2) -	1.9647e+0 (5.28e-2) -	7.1638e-1 (3.99e-2)
WFG2	5	1000	7.0344e-1 (4.04e-2) =	7.6681e-1 (2.55e-2) =	1.6756e+0 (2.94e-1) -	1.7078e+0 (2.25e-1) -	1.8461e+0 (1.51e-3) -	8.4204e-1 (2.10e-2) -	1.9722e+0 (8.28e-2) -	7.1856e-1 (2.47e-2)
WFG8	5	5000	1.4042e+0 (9.26e-2) -	1.3032e+0 (3.87e-2) -	1.8368e+0 (5.67e-2) -	1.8484e+0 (5.89e-2) -	1.7849e+0 (2.00e-3) -	1.1402e+0 (1.75e-2) +	1.2365e+0 (3.28e-2) -	1.2074e+0 (9.96e-3)
WFG8	5	1000	1.2713e+0 (3.58e-2) =	1.3052e+0 (2.84e-2) =	1.7765e+0 (3.74e-2) -	1.8077e+0 (7.55e-2) -	1.7754e+0 (2.78e-4) -	1.2222e+0 (5.16e-2) -	1.2211e+0 (4.89e-2) =	1.1977e+0 (2.64e-2)
+/-=			3/9/4	1/11/4	0/16/0	0/16/0	0/16/0	1/15/0	2/12/2	

TABLE A. 15

THE IGD COMPARISON RESULTS OF ALL COMPARED ALGORITHMS ON 20-OBJECTIVE, 50-OBJECTIVE AND 100-OBJECTIVE LSMOP1, LSMOP9, DTLZ1, DTLZ2, WFG2 AND WFG8 WITH 1000 DECISION VARIABLES.

Problem	M	D	LSMOF	DGEA	LMEA	LSMOEA/D	MOEADVA	MOEA/PSL	AMOEAD	NN-CSO
LSMOP1	20	1000	2.6584e+0 (1.62e+0) =	1.1334e+0 (2.62e-2) =	1.0470e+1 (1.21e+0) -	9.7027e+0 (7.43e-1) -	1.1189e+1 (7.27e-1) -	6.5171e+0 (3.59e+0) -	8.6094e-1 (1.24e-1) +	1.5015e+0 (3.00e-1)
LSMOP1	50	1000	2.5576e+0 (9.42e-1) =	1.1847e+0 (1.07e-1) =	1.0257e+1 (2.33e+0) -	1.1006e+1 (1.07e+0) -	1.0994e+1 (9.05e-1) -	2.1923e+0 (2.11e+0) =	9.415e-1 (1.25e-1) +	1.6321e+0 (8.78e-1)
LSMOP1	100	1000	1.2155e+0 (4.93e-4) =	1.2988e+0 (2.24e-1) =	9.1316e+0 (1.03e+0) -	8.3145e+0 (1.70e+0)-	8.3725e+0 (6.49e-1) -	1.1187e+0 (1.22e-1) =	9.2754e-1 (2.35e-1) +	1.4161e+0 (3.44e-1)
LSMOP9	20	1000	1.6507e+1 (1.63e-1) +	2.0413e+3 (3.28e+2) -	4.9409e+3 (1.54e+2) -	4.9715e+3 (1.46e+2) -	4.9791e+3 (1.55e+2) -	1.5949e+1 (4.71e-1) +	5.6433e+1 (1.89e+1) -	3.8832e+1 (1.85e+1)
LSMOP9	50	1000	4.8217e+3 (1.27e+4) -	1.5924e+4 (1.76e+3) -	3.5695e+4 (4.55e+2) -	3.5572e+4 (6.41e+2) -	3.6153e+4 (4.60e+2) -	8.5469e-1 (2.11e-1) +	8.4583e+2 (3.68e+1) -	5.5973e+2 (2.68e+1)
LSMOP9	100	1000	4.0583e+1 (4.34e+1)+	7.7574e+4 (7.28e+3)-	1.5999e+5 (2.17e+3)-	1.5774e+5 (2.83e+3)-	1.5888e+5 (1.61e+3)-	7.9767e-1 (1.74e-1) +	5.2751e+3 (1.26e+2) -	4.1730e+3 (2.85e+2)
DTLZ1	20	1000	9.9925e+3 (2.80e+3) -	7.5612e+3 (2.34e+3) =	2.2108e+4 (1.57e+3) -	2.1926e+4 (6.57e+2) -	2.1874e+4 (9.51e+2) -	8.9582e+3 (3.87e+2) -	7.0721e+3 (6.85e+2) -	5.7768e+3 (1.39e+3)
DTLZ1	50	1000	7.2494e+3 (1.16e+3) -	3.9538e+3 (1.48e+3) =	2.2207e+4 (1.46e+3) -	2.0959e+4 (1.18e+3) -	2.1771e+4 (1.29e+3) -	8.0003e+3 (1.20e+3) -	6.6498e+3 (1.43e+3) -	2.7294e+3 (1.25e+3)
DTLZ1	100	1000	5.8106e+3 (5.89e+2) -	3.8815e+3 (8.70e+2) -	1.9828e+4 (1.07e+3) -	2.0085e+4 (1.04e+3)-	2.0040e+4 (1.52e+3) -	7.5242e+3 (6.37e+2) -	5.9803e+3 (5.98e+2) -	3.0483e+3 (4.92e+2)
DTLZ2	20	1000	8.7289e+1 (1.33e+1) -	8.9914e+0 (1.26e+0) -	7.6580e+1 (5.49e-1) -	7.6034e+1 (8.36e-1) -	7.6225e+1 (6.30e-1) -	1.0944e+2 (4.67e+1) -	8.6925e+0 (1.26e+0) -	5.8713e+0 (1.09e+0)
DTLZ2	50	1000	9.8361e+1 (1.09e+1) -	1.1454e+1 (6.61e+0) =	7.4264e+1 (9.89e-1) -	7.4621e+1 (1.14e+0) -	7.4687e+1 (1.06e+0) -	9.7953e+1 (3.65e+1) -	1.4032e+1 (4.28e+0) =	1.1886e+1 (3.23e+0)
DTLZ2	100	1000	1.0102e+2 (1.52e+1) -	1.2899e+1 (1.94e+0) =	7.0399e+1 (8.11e-1) -	7.0776e+1 (5.66e-1)-	6.9946e+1 (1.30e+0) -	1.4031e+2 (7.47e+0) -	1.5313e+1 (3.98e+0) -	1.1233e+1 (3.00e+0)
WFG2	20	1001	4.5369e+0 (9.62e-2) +	4.7435e+0 (1.71e-1) +	8.5177e+0 (1.55e+0) -	8.6584e+0 (1.02e+0) -	9.2429e+0 (1.43e+0) -	4.6432e+0 (2.73e-1) +	6.7004e+0 (2.23e+0) =	5.2299e+0 (2.61e-1)
WFG2	50	1001	9.4127e+0 (2.27e-1) +	1.3403e+1 (3.00e-1) +	2.6197e+1 (5.23e+0) =	2.9524e+1 (5.06e+0) -	3.0385e+1 (3.51e+0) -	1.5674e+1 (1.55e+0) =	3.1583e+1 (4.23e+0) -	1.8739e+1 (6.98e+0)
WFG2	100	1001	2.7071e+1 (8.95e-1) +	4.0397e+1 (1.20e+0) +	6.6794e+1 (4.70e+0) -	6.2398e+1 (8.33e+0)-	6.2105e+1 (6.97e+0) -	3.9927e+1 (1.92e+0) +	6.5723e+1 (7.25e+0) -	4.9086e+1 (9.12e+0)
WFG8	20	1000	1.3900e+1 (8.32e-2) +	1.6449e+1 (5.46e-1) =	2.5534e+1 (9.31e-1) -	2.5843e+1 (1.08e+0) -	2.5978e+1 (7.49e-1) -	1.6563e+1 (1.10e+0) =	2.2782e+1 (1.03e+0) -	1.5704e+1 (1.40e+0)
WFG8	50	1000	3.6024e+1 (6.91e-1) +	4.2696e+1 (1.58e+0) =	9.1577e+1 (1.61e+0) -	9.2501e+1 (1.52e+0) -	9.1607e+1 (1.70e+0) -	7.1229e+1 (4.70e+0) -	9.1324e+1 (3.06e+0) -	4.4519e+1 (6.01e+0)
WFG8	100	1000	7.9616e+1 (1.76e+0) +	9.1456e+1 (2.70e+0) =	2.0368e+2 (2.13e+0) -	2.0457e+2 (2.12e+0)-	2.0445e+2 (9.35e-1) -	1.8062e+2 (2.12e+0) -	2.0463e+2 (4.29e+1) -	1.0117e+2 (2.01e+1)
+/-=			8/7/3	3/5/10	0/17/1	0/18/0	0/18/0	5/9/4	3/13/2	