

This document lists all new routines that are part of the xGELSZ package. The document also lists the existing LAPACK routines that were modified to support the xGELSZ package. The files that were modified were all part of the Lapack's testing and timing suites. The core Lapack routines (those described in the LAPACK User's Guide, Third Edition, SIAM Press, 1999) have not been changed.

1 New files in the SRC directory

1.1 The new driver routines sgelsz.f, cgelsz.f, dgelsz.f and zgelsz.f

These are the new, efficient driver routines for computing minimum-norm solutions to real and complex linear least squares problems. The signatures of these driver routines (for the real and double precision case) look like

```
SUBROUTINE xGELSZ(M, N, NRHS, A,LDA ,B,LDB , JPVT, RCOND, RANK,
WORK, LWORK, INFO)
```

This is identical to the signature of the xGELSY routines. Documentation describing the parameters is contained in the routines. The parameters and their use are identical to the xGELSY parameters described in the LAPACK User's Guide except that the workspace size, LWORK, should be slightly larger.

1.2 The new auxiliary routines slaqp3.f, claqp3.f, dlaqp3.f and zlaqp3.f

The new auxiliary routines compute partial QR factorization of A using column pivoting. The signatures of these driver routines are (for the real and double precision case)

```
SUBROUTINE xLAQP3(M, N, A, LDA, JPVT, RCOND, RANK, TAU, WORK,
LWORK, INFO)
```

The parameters are described in documentation in the routines. A user of the driver xGELSY does not need understand the details of xLAQP3.

1.3 The new auxiliary routines slaqpp.f, claqpp.f, dlaqpp.f and zlaqpp.f

The new auxiliary routines use Level 3 BLAS to calculate a portion of the partial QR factorization of A using column pivoting. The signatures of these routines are (for the real and double precision case)

```
SUBROUTINE xLAQPP(M, N, OFFSET, NB, KB, A, LDA, JPVT, RCOND, RANK,
TAU, SMIN, XMIN, SMAX, XMAX, VN1, VN2, AUXV, F, LDF)
```

The parameters are described in documentation in the routines. A user of the driver xGELSY does not need understand the details of xLAQPP.

1.4 The new auxiliary routines slaqpq.f, claqpq.f, dlaqpq.f and zlaqpq.f

The new LAPACK auxiliary routines use Level 2 BLAS to calculate a portion of the partial QR factorization of A using column pivoting. The signatures of these routines (for the real and double precision case) are

```
SUBROUTINE xLAQPQ(M, N, OFFSET, A, LDA, JPVT, RCOND, RANK, TAU,  
SMIN, XMIN, SMAX, XMAX, VN1, VN2, WORK)
```

The parameters are described in documentation in the routines. A user of the driver xGELSY does not need understand the details of xLAQPQ.

2 Modified files in the TESTING/LIN directory

2.1 sdrvls.f, cdrvls.f, ddrvls.f and zdrvls.f

These are the driver routines for testing the least squares code. The following changes have been made to Lapack's xDRVLS test routines.

1. NTESTS has changed from 18 to 22, since 4 additional tests for testing the xGELSZ routines have been added.
2. Additional code for testing the xGELSZ routines has been added.

2.2 serrls.f, cerrls.f, derrls.f and zerrls.f

These routines test for error exits in the least squares driver routines. Additional code for testing the error exits for the xGELSZ least squares routines has been added.

2.3 sqrt15.f, cqrt15.f, dqrt15.f and zqrt15.f

This code generates test matrices for testing and timing the least square routines. In the original version of the xQRT15 routines, RKSEL = 1 generated a full rank matrix and RKSEL = 2 generated a rank deficient matrix, with rank = $3 \min(m,n) / 4$ where the matrix being generated is m by n. In the modified versions of the xQRT15 routines, RKSEL = 2 generates a matrix whose rank is the ceiling of, or first integer greater than or equal to, $\min(m,n)/10$. The change was made to include testing for low-rank matrices.

3 Modified files in the TIMING/LIN directory

3.1 stimaa.f, ctimaa.f, dtimaa.f and ztimaa.f

These programs are main programs that allow testing of the linear equation and least squares routines in LAPACK and the xGELSZ routines. The following changes have been made to LAPACK's xTIMAA timing routines.

1. Parameter `NMAXB` has changed from 5000 to $13 \times \text{NMAX}$ (with `NMAX = 512`). This change was made to allow adequate space for the `IWORK` (next to the last) parameter in `xGELSD`.
2. Parameter `MXNLDA` has changed from 4 to 2. This change was made since on some platforms when `MXNLDA` was set to 4 the image sizes of `xlntimd` and `xlntimz`, the executable versions of the compiled `dtimaa` and `ztimaa` programs, exceeded the maximum allowed image size.
3. The dimensions for the `FLPTBL`, `OPCTBL` and `TIMTBL` have changed from $6 \times 6 \times \text{MAXSZS} \times \text{MAXPRM} \times 5$ to $6 \times 6 \times \text{MAXSZS} \times \text{MAXPRM} \times 6$. This change was made since we now test 6 least-square routines, instead of 5.

3.2 `stimls.f`, `ctimls.f`, `dtimls.f` and `ztimls.f`

These are the driver routines for timing the least squares code. The following changes have been made to Lapack's `xTIMLS` timing routines.

1. The value for parameter `NSUBS` has changed from 5 to 6, since there is an additional subroutine, `xGELSZ`, that needs to be timed.
2. Additional code for timing `xGELSZ` has been added.
3. An additional format statement, has been added for reporting the `xGELSZ` timing results.
4. A workspace corresponding to the `JPVT` or eighth parameter of `xGELSX`, `xGELSY` and `xGELSZ` has been set to zero prior to each call to these routines. This has been done to insure that these routines use pivoting in the QR factorizations that are computed.

3.3 `sqrt15.f`, `cqrt15.f`, `dqrt15.f` and `zqrt15.f`

This code generates test matrices for testing and timing the least square routines. In the original version of the `xQRT15` routines, `RKSEL = 1` generated a full rank matrix and `RKSEL = 2` generated a rank deficient matrix, with rank = $3 \min(m,n) / 4$ where the matrix being generated is m by n . In the modified versions of the `xQRT15` routines, `RKSEL = 2` generates a matrix whose rank is the ceiling of, or first integer greater than or equal to, $\min(m,n)/10$. The change was made to include testing for low-rank matrices.

3.4 `sprtls.f` and `dprrtls.f`

These routines print tables of timing data for the least squares routines. The format statement labelled 9997 has been modified from

```
9997 FORMAT( I5, 2X, 1P, 6G11.2 )
```

to

```
9997 FORMAT( I5, 2X, 1P, 6G11.3 )
```

to include an additional digit of precision in the printed output.

4 New files in the TIMING/LIN/LINSRC directory

4.1 The new instrumented routines sgelsz.f, cgelsz.f, dgelsz.f and zgelsz.f

These new files are instrumented versions of the new driver routines. The instrumented versions of the routines allow the collection of timing information for different sections of the algorithms. The signatures of the instrumented versions of these routines are identical to the signatures of the uninstrumented versions located in the SRC directory.