NAG C Library Function Document

nag_dtrsv (f16pjc)

1 Purpose

nag_dtrsv (f16pjc) solves a system of equations given as a real triangular matrix.

2 Specification

```
#include <nag.h>
#include <nagf16.h>
void nag_dtrsv (Nag_OrderType order, Nag_UploType uplo, Nag_TransType trans,
     Nag_DiagType diag, Integer n, double alpha, const double a[], Integer pda,
     double x[], Integer incx, NagError *fail)
```

3 Description

nag_dtrsv (f16pjc) performs one of the matrix-vector operations

$$x \leftarrow \alpha A^{-1}x \quad \text{or} \quad x \leftarrow \alpha A^{-\mathrm{T}}x,$$

where A is an n by n real triangular matrix, x is an n element real vector and α is a real scalar. $A^{-\mathrm{T}}$ denotes $\left(A^{\mathrm{T}}\right)^{-1}$ or equivalently $\left(A^{-1}\right)^{\mathrm{T}}$.

4 References

The BLAS Technical Forum Standard (2001) *www.netlib.org/blas/blast-forum*

5 Arguments

1: **order** – Nag_OrderType *Input*

On entry: the **order** argument specifies the two-dimensional storage scheme being used, i.e., row-major ordering or column-major ordering. C language defined storage is specified by **order** = **Nag_RowMajor**. See Section 2.2.1.4 of the Essential Introduction for a more detailed explanation of the use of this argument.

Constraint: **order** = **Nag_RowMajor** or **Nag_ColMajor**.

2: **uplo** – Nag_UploType *Input*

On entry: specifies whether A is upper or lower triangular.

uplo = **Nag_Upper**

A is upper triangular.

uplo = **Nag_Lower**

A is lower triangular.

Constraint: **uplo** = **Nag_Upper** or **Nag_Lower**.

3: **trans** – Nag_TransType *Input*

On entry: specifies the operation to be performed.

trans = **Nag_NoTrans**

$x \leftarrow \alpha A^{-1}x$.

trans = **Nag_Trans** or **Nag_ConjTrans**

$x \leftarrow \alpha A^{-\mathrm{T}} x$.

Constraint: **trans** = **Nag_NoTrans**, **Nag_Trans** or **Nag_ConjTrans**.

4: **diag** – Nag_DiagType *Input*

On entry: specifies whether A has non-unit or unit diagonal elements.

diag = **Nag_NonUnitDiag**

The diagonal elements are stored explicitly.

diag = **Nag_UnitDiag**

The diagonal elements are assumed to be 1 and are not referenced.

Constraint: **diag** = **Nag_NonUnitDiag** or **Nag_UnitDiag**.

5: **n** – Integer *Input*

On entry: n, the order of the matrix A.

Constraint: $\mathbf{n} \geq 0$.

6: **alpha** – double *Input*

On entry: the scalar α.

7: **a**[dim] – const double *Input*

Note: the dimension, *dim*, of the array **a** must be at least $\max(1, \mathbf{pda} \times \mathbf{n})$.

If **order** = **Nag_ColMajor**, the (i,j)th element of the matrix A is stored in $\mathbf{a}[(j-1) \times \mathbf{pda} + i - 1]$.

If **order** = **Nag_RowMajor**, the (i,j)th element of the matrix A is stored in $\mathbf{a}[(i-1) \times \mathbf{pda} + j - 1]$.

On entry: the n by n triangular matrix A.

If **uplo** = **Nag_Upper**, A is upper triangular and the elements of the array below the diagonal are not referenced.

If **uplo** = **Nag_Lower**, A is lower triangular and the elements of the array above the diagonal are not referenced.

If **diag** = **Nag_UnitDiag**, the diagonal elements of A are not referenced, but are assumed to be 1.

8: **pda** – Integer *Input*

On entry: the stride separating matrix row or column elements (depending on the value of **order**) in the array **a**.

Constraint: $\mathbf{pda} \geq \max(1, \mathbf{n})$.

9: **x**[dim] – double *Input/Output*

Note: the dimension, *dim*, of the array **x** must be at least $\max(1, 1 + (\mathbf{n} - 1)|\mathbf{incx}|)$.

On entry: the right-hand side vector b.

On exit: the solution vector x.

10: **incx** – Integer *Input*

On entry: the increment in the subscripts of **x** between successive elements of x.

Constraint: $\mathbf{incx} \neq 0$.

11: **fail** – NagError * *Input/Output*

The NAG error argument (see Section 2.6 of the Essential Introduction).

6 Error Indicators and Warnings

NE_BAD_PARAM

On entry, argument ⟨*value*⟩ had an illegal value.

NE_INT

On entry, **incx** = ⟨*value*⟩.
Constraint: **incx** $\neq 0$.

On entry, **n** = ⟨*value*⟩.
Constraint: **n** ≥ 0.

NE_INT_2

On entry, **pda** = ⟨*value*⟩, **n** = ⟨*value*⟩.
Constraint: **pda** $\geq \max(1, \mathbf{n})$.

7 Accuracy

The BLAS standard requires accurate implementations which avoid unnecessary over/underflow (see Section 2.7 of The BLAS Technical Forum Standard (2001)).

8 Further Comments

No test for singularity or near-singularity of A is included in nag_dtrsv (f16pjc). Such tests must be performed before calling this function.

9 Example

This example solves the real triangular system of linear equations $Ax = y$, where A is the 4 by 4 triangular matrix given by

$$A = \begin{pmatrix} 4.30 & & & \\ -3.96 & -4.87 & & \\ 0.40 & 0.31 & -8.02 & \\ -0.27 & 0.07 & -5.95 & 0.12 \end{pmatrix}$$

and where

$$y = (-12.90, 16.75, -17.55, -11.04)^{\mathrm{T}}.$$

The vector y is stored in array **x** and nag_dtrsv (f16pjc) returns the solution in **x**.

9.1 Program Text

```
/* nag_dtrsv (f16pjc) Example Program.
 *
 * Copyright 2005 Numerical Algorithms Group.
 *
 * Mark 8, 2005.
 */

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagf16.h>
#include <nagx04.h>

int main(void)
{

  /* Scalars */
```

```
  double alpha;
  Integer exit_status, i, incx, j, n, pda, xlen;

  /* Arrays */
  double *a=0, *x=0;
  char nag_enum_arg[40];

  /* Nag Types */
  NagError fail;
  Nag_OrderType order;
  Nag_TransType trans;
  Nag_UploType uplo;
  Nag_DiagType diag;

#ifdef NAG_COLUMN_MAJOR
#define A(I,J) a[(J-1)*pda + I - 1]
  order = Nag_ColMajor;
#else
#define A(I,J) a[(I-1)*pda + J - 1]
  order = Nag_RowMajor;
#endif

  exit_status = 0;
  INIT_FAIL(fail);

  Vprintf( "nag_dtrsv (f16pjc) Example Program Results\n\n");

  /* Skip heading in data file */
  Vscanf("%*[^\n] ");

  /* Read the problem dimensions */
  Vscanf("%ld%*[^\n] ", &n);

  /* Read the uplo storage parameter */
  Vscanf("%s%*[^\n] ", nag_enum_arg);
  /* nag_enum_name_to_value(x04nac).
   * Converts NAG enum member name to value
   */
  uplo = nag_enum_name_to_value(nag_enum_arg);
  /* Read the transpose parameter */
  Vscanf("%s%*[^\n] ", nag_enum_arg);
  /* nag_enum_name_to_value(x04nac), see above. */
  trans = nag_enum_name_to_value(nag_enum_arg);
  /* Read the unit-diagonal parameter */
  Vscanf("%s%*[^\n] ", nag_enum_arg);
  /* nag_enum_name_to_value(x04nac), see above. */
  diag = nag_enum_name_to_value(nag_enum_arg);

  /* Read scalar parameters */
  Vscanf("%lf%*[^\n] ", &alpha);
  /* Read increment parameter */
  Vscanf("%ld%*[^\n] ", &incx);

  pda = n;
  xlen = MAX(1, 1 + (n - 1)*ABS(incx));

  if (n > 0)
    {
      /* Allocate memory */
      if ( !(a = NAG_ALLOC(pda*n, double)) ||
           !(x = NAG_ALLOC(xlen, double)))
        {
          Vprintf("Allocation failure\n");
          exit_status = -1;
          goto END;
        }
    }
  else
    {
      Vprintf("Invalid n\n");
      exit_status = 1;
```

```
      return exit_status;
    }

  /* Input matrix A and vector x*/

  if (uplo == Nag_Upper)
    {
      for (i = 1; i <= n; ++i)
        {
          if (diag == Nag_NonUnitDiag)
            Vscanf("%lf", &A(i,i));
          for (j = i+1; j <= n; ++j)
            Vscanf("%lf", &A(i,j));
        }
      Vscanf("%*[^\n] ");
    }
  else
    {
      for (i = 1; i <= n; ++i)
        {
          for (j = 1; j < i; ++j)
            Vscanf("%lf", &A(i,j));
          if (diag == Nag_NonUnitDiag)
            Vscanf("%lf", &A(i,i));
        }
      Vscanf("%*[^\n] ");
    }
  for (i = 0; i < xlen; ++i)
    Vscanf("%lf%*[^\n] ", &x[i]);

  /* nag_dtrsv(f16pjc).
   * Solution of real triangular system of linear equations.
   *
   */
  nag_dtrsv(order, uplo, trans, diag, n, alpha, a, pda, x, incx,
            &fail);
  if (fail.code != NE_NOERROR)
    {
      Vprintf("Error from nag_dtrsv.\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }

  /* Print output vector x */
  Vprintf("%s\n", " Solution x:");
  for (i = 0; i < xlen; i = ++i)
    {
      Vprintf("%11f\n", x[i]);
    }

 END:
  if (a) NAG_FREE(a);
  if (x) NAG_FREE(x);

  return exit_status;
}
```

9.2 Program Data

```
nag_dtrvs (f16pjc) Example Program Data
  4                           :Value of n
  Nag_Lower                   :Storage of A
  Nag_NoTrans                 :Transpose A?
  Nag_NonUnitDiag             :Unit diagonal elements?
  1.0                         :Value of alpha
  1                           :Value of incx
  4.30
 -3.96  -4.87
  0.40   0.31  -8.02
 -0.27   0.07  -5.95   0.12   :End of matrix A
```

```
-12.90
 16.75
-17.55
-11.04                          :End of vector x
```

9.3 Program Results

```
nag_dtrsv (f16pjc) Example Program Results

 Solution x:
  -3.000000
  -1.000000
   2.000000
   1.000000
```