nag_ip_mps_read (h02buc)

1.   Purpose

nag_ip_mps_read (h02buc) reads data for a linear, quadratic, or integer programming problem from a file which is in standard or compatible MPSX input format.

2.   Specification

```
#include <nag.h>
#include <nagh02.h>

void nag_ip_mps_read(char *mps_file, Boolean minimize, Integer *n,
                     Integer *m, double **a, double **bl, double **bu,
                     Boolean **intvar, double **cvec, double **x,
                     Nag_H02_Opt *h02_options, NagError *fail)
```

3.   Description

nag_ip_mps_read reads linear programming (LP), linear terms of quadratic programming (QP), or integer programming (IP) problem data from a file which is prepared in standard or compatible MPSX (unattributed (1971)) input format and then initializes n (the number of variables), m (the number of general linear constraints), the m by n matrix A, and the vectors l, u and c for use with functions which are designed to solve problems of the form

$$\underset{x \in R^n}{\text{minimize}} \quad f(x) \quad \text{subject to} \quad l \le \left\{ \begin{array}{c} x \\ Ax \end{array} \right\} \le u, \tag{1}$$

where $f(x)$ is a linear function (of the form $c^T x$) or a quadratic function (of the form $c^T x + \frac{1}{2} x^T H x$). Note that for quadratic problems, nag_ip_mps_read reads only the linear part of the objective; the quadratic part must be supplied separately to the solver. See the documentation for the appropriate solver for further details. (nag_ip_mps_read is primarily designed for use with nag_ip_bb (h02bbc), but may also be used in conjunction with nag_opt_lp (e04mfc), nag_opt_lin_lsq (e04ncc) and nag_opt_qp (e04nfc)).

Since, in general, the exact size of the problem defined by an MPSX file may not be known in advance, the arrays returned by nag_ip_mps_read are all allocated internally.

MPSX Input Format

The MPSX data file may only contain two types of line:

(1)   Indicator lines (specifying the type of data which is to follow).

(2)   Data lines (specifying the actual data).

The input file must not contain any blank lines. Any characters beyond column 80 are ignored. Indicator lines must not contain leading blank characters (in other words they must begin in column 1). The following displays the order in which the indicator lines must appear in the file:

```
NAME            user-supplied name
ROWS
     data line(s)
COLUMNS
     data line(s)
RHS
     data line(s)
RANGES       (optional)
     data line(s)
BOUNDS       (optional)
     data line(s)
ENDATA
```

The 'user-supplied name' specifies a name for the problem and must occupy columns 15-22. The name can either be blank or up to a maximum of 8 characters.

A data line follows the same fixed format made up of fields defined below. The contents of the fields may have different significance depending upon the section of data in which they appear.

	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6
Columns	2-3	5-12	15-22	25-36	40-47	50-61
Contents	Code	Name	Name	Value	Name	Value

The names and codes consist of 'alphanumeric' characters (i.e., a−z, A−Z, 0−9, +, −, asterisk (*), blank ( ), colon (:), dollar sign ($) or full stop (.) only) and the names must not contain leading blank characters. Values may be entered in several equivalent forms. For example, 1.2345678, 1.2345678e+0, 123.45678e−2 and 12345678E−07 all represent the same number. It is safest to include an explicit decimal point. Note that the lower case 'e' exponential notation is not standard MPSX, and if compatibility with other MPSX readers is required then the upper case notation should be used. The lower case notation is supported by nag_ip_mps_read since this is the natural notation in a C programming language environment.

It is recommended that numeric values be *right-justified* in the 12-character field, with no trailing blanks. This is to ensure compatibility with other MPSX readers, some of which may, in certain situations, interpret trailing blanks as zeros. This can dramatically affect the interpretation of the value and is relevant if the value contains an exponent, or if it contains neither an exponent nor an explicit decimal point.

Comment lines are allowed in the data file. These must have an asterisk (*) in column 1 and any characters in columns 2-80. In any data line, a dollar sign ($) as the first character in field 3 or 5 indicates that the information from that point through column 80 consists of comments.

Columns outside the six fields must be blank, except for columns 72-80, whose contents are ignored by the routine. These columns may be used to enter a sequence number. A non-blank character outside the predefined six fields and columns 72-80 is considered to be a major error unless it is part of a comment.

ROWS Data Lines

These lines specify row (constraint) names and their inequality types (i.e., =, $\geq$ or $\leq$).

Field 1: defines the constraint type as follows (may be in column 2 or column 3):

>   N   free row, i.e., no constraint. It may be used to define the objective row.
>
>   G   greater than or equal to (i.e., $\geq$).
>
>   L   less than or equal to (i.e., $\leq$).
>
>   E   exactly equal to (i.e., =).

Field 2: defines the row name.

Row type N stands for 'Not binding', also known as 'Free'. It can be used to define the objective row. The objective row is a free row that specifies the vector c in the linear objective term $c^T x$. It is taken to be the first free row, unless some other free row name is specified by the optional parameter **obj_name** (see Section 7.2). Note that c is assumed to be zero if (for example) the line

>   %N%%DUMMYROW

(where % denotes a blank) appears in the ROWS section of the MPSX data file, and the row name DUMMYROW is omitted from the COLUMNS section.

COLUMNS Data Lines

These lines specify the names to be assigned to the variables (columns) in the general linear constraint matrix A, and define, in terms of column vectors, the actual values of the corresponding matrix elements.

Field 1: blank (ignored).

Field 2: gives the name of the column associated with the elements specified in the following fields.

Field 3: contains the name of a row.

Field 4: used in conjunction with field 3; contains the value of the matrix element.

Field 5: is optional (may be used like field 3).

Field 6: is optional (may be used like field 4).

Note that only the non-zero elements of A and c need to be specified in the COLUMNS section, as any unspecified elements of A and c are assumed to be zero. In addition, any non-zero elements in the jth column of A must be grouped together before those in the $(j + 1)$-th column, for $j = 1, 2, \ldots, \mathbf{n}-1$. Non-zero elements within a column may however appear in any order.

RHS Data Lines

This section specifies the right-hand side values of the general linear constraint matrix A (if any). The lines specify the name to be given to the right-hand side (RHS) vector along with the numerical values of the elements of the vector, which may appear in any order. The data lines have exactly the same format as the COLUMNS data lines, except that the column name is replaced by the RHS name. Only the non-zero elements need be specified. Note that this section may be empty, in which case the RHS vector is assumed to be zero.

RANGES Data Lines (optional)

Ranges are used for constraints of the form $l \leq Ax \leq u$, where both l and u are finite. The effect of specifying a range r_j for constraint j depends on the type of the constraint (i.e., G, L or E), the sign of r_j, and the bound associated with the constraint in the RHS section. (Recall that this bound is taken to be zero if the constraint has no entry in the RHS section.) The various possibilities may be summarised as follows.

Row Type	Sign of r_j	Bound from RHS	Resultant l_j	Resultant u_j
G	$+$ or $-$	l_j	l_j	$l_j + |r_j|$
L	$+$ or $-$	u_j	$u_j - |r_j|$	u_j
E	$+$	l_j	l_j	$l_j + r_j$
E	$-$	u_j	$u_j - |r_j|$	u_j

The data lines have exactly the same format as the COLUMNS data lines, except that the column name is replaced by the RANGE name.

BOUNDS Data Lines (optional)

These lines specify limits on the values of the variables (l and u in $l \leq x \leq u$). If the variable is not specified in the bound set then it is automatically assumed to lie between default lower and upper bounds (usually 0 and $+\infty$). (These default bounds may be reset to the values specified by the optional parameters **col_lo_default** and **col_up_default**; see Section 7.2.) Like an RHS column which is given a name, the set of variables in one bound set is also given a name.

Field 1: specifies the type of bound or defines the variable type as follows:

> LO   lower bound.
>
> UP   upper bound.
>
> FX   fixed variable.
>
> FR   free variable ($-\infty$ to $+\infty$).
>
> MI   lower bound is $-\infty$.
>
> PL   upper bound is $+\infty$. This is the default variable type.

Field 2: identifies a name for the bound set.

Field 3: identifies the column name of the variable belonging to this set.

Field 4: identifies the value of the bound; this has a numerical value only in association with LO, UP, FX in field 1, otherwise it is blank.

Field 5: is blank and ignored.

Field 6: is blank and ignored.

Note that if RANGES and BOUNDS sections are both present, the RANGES section must appear first.

Integer Programming Problems

In IP problems there are two common integer variable types: (a) 0–1 integer variables (or 'binary' variables) which represent 'on' or 'off' situations and (b) general integer variables which are forced to take an integer value, in a specified range, at the optimal integer solution. Integer variables can be defined in the following compatible and standard MPSX forms.

In the compatible MPSX format, the type of integer variables are defined in field 1 of the BOUNDS section, that is:

Field 1: specifies the type of the integer variable as follows:

> BV   0-1 integer variable (bound value is 1.0).
>
> UI   general integer variable (bound value is in field 4).

In the standard MPSX format, the integer variables are treated the same as 'ordinary' bounded variables, in the BOUNDS section. Integer markers are, however, introduced in the COLUMNS section to specify the integer variables. The indicator lines for these markers are:

	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6
Columns	2-3	5-12	15-22	25-36	40-47	50-61
Contents		*name*	'MARKER'		'INTORG'	

to mark the beginning of the integer variables and

	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6
Columns	2-3	5-12	15-22	25-36	40-47	50-61
Contents		*name*	'MARKER'		'INTEND'	

to mark the end. That is, any variables between these markers are treated as integer variables. The *name* in Field 2 may be any name different from the preceding and following column names, the other entries in the indicator lines must be exactly as described above (including quotation marks). Note that if the INTEND indicator line is not specified then all columns between the INTORG indicator line and the end of the COLUMNS section are assumed to be integer variables. nag_ip_mps_read accepts both standard and/or compatible MPSX format as a means of specifying integer variables.

An example of the compatible MPSX format is given in Section 6 and an example of the standard MPSX format is given in Section 12.

4.   Parameters

mps_file

Input: the name of the MPSX data file. If **mps_file** is a null pointer or null string, then the data is assumed to come from `stdin`.

minimize

Input: specifies the direction of the optimization. **minimize** must be set to **TRUE** for minimization and to **FALSE** for maximization. For a maximization problem, c, the coefficients of the linear part of the objective function, is negated with respect to its definition in the MPSX file. For maximization problems involving a quadratic objective function, the user must also modify the sign of the quadratic term as appropriate.

n

Output: n, the number of variables specified by the data file.

m

Output: m, the number of general linear constraints specified by the data file.

a

Output: A, the matrix of general linear constraints.

Sufficient memory is allocated internally by nag_ip_mps_read and may be freed by the utility function nag_ip_mps_free (h02bvc).

bl
bu

Output: **bl** and **bu** hold the lower bounds and upper bounds, respectively, for all the variables and constraints, in the following order. The first **n** elements contain the bounds on the variables x and the next **m** elements contain the bounds for the general linear constraints Ax (if any). Note that an 'infinite' lower bound is indicated by $\mathbf{bl}[j-1] = -10^{20}$, an 'infinite' upper bound by $\mathbf{bu}[j-1] = 10^{20}$, and an equality constraint by $\mathbf{bl}[j-1] = \mathbf{bu}[j-1]$.

Sufficient memory is allocated internally by nag_ip_mps_read and may be freed by the utility function nag_ip_mps_free (h02bvc).

intvar

Output: indicates which are the integer variables in the problem. More precisely, $\mathbf{intvar}[j-1]$ = **TRUE** if x_j is an integer variable, and **FALSE** otherwise, for $j = 1, 2, \ldots, n$.

Sufficient memory is allocated internally by nag_ip_mps_read and may be freed by the utility function nag_ip_mps_free (h02bvc).

cvec

Output: c, the coefficients of the linear term of the objective function. The signs of these coefficients are determined by the problem and the direction of the optimization (see **minimize** above).

Sufficient memory is allocated internally by nag_ip_mps_read and may be freed by the utility function nag_ip_mps_free (h02bvc).

x

Output: an initial estimate of the solution to the problem. More precisely, $\mathbf{x}[j] = \min(\max(0.0, \mathbf{bl}[j]), \mathbf{bu}[j])$, for $j = 0, 1, \ldots, n - 1$.

Sufficient memory is allocated internally by nag_ip_mps_read and may be freed by the utility function nag_ip_mps_free (h02bvc).

options

Input/Output: a pointer to a structure of type Nag_H02_Opt whose members are optional parameters for nag_ip_mps_read. These structure members offer the means of adjusting the parameter values used when reading in the MPSX file and on output will supply further details of the results. A description of the members of **options** is given below in Section 7.2.

If any of these optional parameters are required then the structure **options** should be declared and initialised by a call to nag_ip_init (h02xxc) and supplied as an argument to nag_ip_mps_read. However, if the optional parameters are not required the NAG defined null pointer, H02_DEFAULT, can be used in the function call.

fail

The NAG error parameter, see the Essential Introduction to the NAG C Library.
Users are recommended to declare and initialise **fail** and set **fail.print** = **TRUE** for this function.

4.1. Description of Printed Output

Results are printed out by default. The level of printed output can be controlled by the user with the structure members **options.list** and **options.output_level** (see Section 7.2). If **list** = **TRUE** then the parameter values to nag_ip_mps_read are listed, whereas the printout of results is governed by the value of **output_level**. The default print level of **Nag_MPS_Summary** gives the following information if the MPSX file has been read successfully:

(a)   the number of lines read.

(b)   the number of columns specified by the data. If any of these are specified as integer variables, the number of such variables is also reported.

(c)   the number of rows specified by the data. The objective row is counted amongst these.

In addition, the names of the problem, the objective row, the RHS set, the RANGES set, and the BOUNDS set read are listed. Unless specified otherwise by the optional parameters **prob_name**, **obj_name**, **rhs_name**, **range_name** and/or **bnd_name** (see Section 7), these names will correspond to the first problem, objective row, etc., encountered in the MPSX file. Where no set was encountered (RANGES and BOUNDS are optional), a 'blank' is output.

Additionally, when **output_level = Nag_MPS_List**, each line of the MPSX file is echoed as it is read. This may be useful as a debugging aid.

If **outout_level = Nag_NoOutput** then printout will be suppressed; the user can print the information contained in (b) and (c) when nag_ip_mps_read returns to the calling program.

5.   Comments

A list of possible error exits and warnings from nag_ip_mps_read is given in Section 8.

6.   Example 1

This example reads a compatible format MPSX file (see Section 3 for a description of standard and compatible MPSX formats) which specifies an instance of the so-called diet problem, and solves it as an LP problem. Given the nutritional content of a selection of foods, the cost of each food, the amount available of each food and the consumer's minimum daily energy requirements, the problem is to find the cheapest combination. This gives rise to the following problem:

minimize

$$c^T x \text{ subject to } Ax \geq b, \ 0 \leq x \leq u,$$

where

$$c = (\begin{matrix} 3 & 24 & 13 & 9 & 20 & 19 \end{matrix})^T, \quad x = (x_1, x_2, x_3, x_4, x_5, x_6)^T \quad \text{is real}$$

$$A = \begin{pmatrix} 110 & 205 & 160 & 160 & 420 & 260 \\ 4 & 32 & 13 & 8 & 4 & 14 \\ 2 & 12 & 54 & 285 & 22 & 80 \end{pmatrix}, \quad b = \begin{pmatrix} 2000 \\ 55 \\ 800 \end{pmatrix} \quad \text{and}$$

$$u = (\begin{matrix} 4 & 3 & 2 & 8 & 2 & 2 \end{matrix})^T.$$

The rows of A correspond to energy, protein and calcium and the columns of A correspond to oatmeal, chicken, eggs, milk, pie and bacon respectively.

The following program calls nag_ip_mps_read to read the MPSX file containing the data for this problem and solves it as an LP problem by calling nag_opt_lp (e04mfc). Finally, nag_ip_mps_free (h02bvc) is called to free the memory allocated by nag_ip_mps_read.

This example shows the simple use of nag_ip_mps_read where default values are used for all optional parameters. An example showing the use of optional parameters is given in Section 12. There is one example program file, the main program of which calls both examples. The main program and Example 1 are given below.

6.1. Program Text

```
/* nag_ip_mps_read (h02buc) Example Program.
 *
 * Copyright 1998 Numerical Algorithms Group.
 *
 * Mark 5, 1998.
 *
 * Mark 6 revised, 2000.
 */
#include <nag.h>
#include <stdio.h>
```

```
      #include <nag_stdlib.h>
      #include <nage04.h>
      #include <nagh02.h>

      static void ex1(void);
      static void ex2(void);

      main()
      {
        Vprintf("h02buc Example Program Results.\n");
        ex1();
        ex2();
        exit(EXIT_SUCCESS);
      }

      static void ex1(void)
      {
        Integer n, m;
        double *a, *c, *bl, *bu, *x, objf;
        Boolean *intvar;
        static NagError fail;

        Vprintf("\nExample 1: default options used.\n");

        fail.print = TRUE;

        /* Read MPSX data */
        h02buc(0, TRUE, &n, &m, &a, &bl, &bu, &intvar, &c, &x,
      H02_DEFAULT, &fail);

        /* Solve IP problem defined by data as an LP problem */
        e04mfc(n, m, a, n, bl, bu, c, x, &objf, E04_DEFAULT, NAGCOMM_NULL, &fail);

        /* Free memory allocated by h02buc */
        h02bvc(&a, &bl, &bu, &intvar, &c, &x);
      }
```

6.2. Program Data

```
      * h02buc Example Program Data
      *
      * Example 1 data.
      *
      * This is an example of 'compatible format' MPSX data.
      *
      *
      NAME           DIET
      ROWS
       G  ENERGY
       G  PROTEIN
       G  CALCIUM
       N  COST
      COLUMNS
          OATMEAL    ENERGY     110.0
          OATMEAL    PROTEIN    4.0
          OATMEAL    CALCIUM    2.0
          OATMEAL    COST       3.0
          CHICKEN    ENERGY     205.0
          CHICKEN    PROTEIN    32.0
          CHICKEN    CALCIUM    12.0
          CHICKEN    COST       24.0
          EGGS       ENERGY     160.0
          EGGS       PROTEIN    13.0
          EGGS       CALCIUM    54.0
          EGGS       COST       13.0
          MILK       ENERGY     160.0
          MILK       PROTEIN    8.0
          MILK       CALCIUM    285.0
          MILK       COST       9.0
          PIE        ENERGY     420.0
          PIE        PROTEIN    4.0
```

```
        PIE       CALCIUM      22.0
        PIE       COST         20.0
        BACON     ENERGY      260.0
        BACON     PROTEIN      14.0
        BACON     CALCIUM      80.0
        BACON     COST         19.0
RHS
        DEMANDS   ENERGY     2000.0
        DEMANDS   PROTEIN      55.0
        DEMANDS   CALCIUM     800.0
BOUNDS
 UI SERVINGS  OATMEAL       4.0
 UI SERVINGS  CHICKEN       3.0
 UP SERVINGS  EGGS          2.0
 UP SERVINGS  MILK          8.0
 UP SERVINGS  PIE           2.0
 UI SERVINGS  BACON         2.0
ENDATA
```

6.3. Program Results

```
h02buc Example Program Results.

Example 1: default options used.

Parameters to h02buc
--------------------


prob_name............... (first)
obj_name................ (first)    rhs_name................ (first)
range_name.............. (first)    bnd_name................ (first)
col_lo_default.......... 0.00e+00   col_up_default.......... 1.00e+20
ncol_approx.............      100    nrow_approx.............      100
output_level......Nag_MPS_Summary
outfile................    stdout



The MPS file has successfully been read.
Number of lines read:      50
Number of columns:          6  (of which 3 are integers)
Number of rows:             4  (including objective row)

MPS Names Selected:
Problem    DIET
Objective COST      RHS        DEMANDS
RANGES              BOUNDS     SERVINGS

MPS data successfully assigned to problem data.

Parameters to e04mfc
--------------------


Linear constraints...........    3    Number of variables...........    6

prob....................    Nag_LP   start...................  Nag_Cold
ftol....................  1.05e-08   reset_ftol..............         5
fcheck..................        50   crash_tol...............  1.00e-02
inf_bound...............  1.00e+20   inf_step................  1.00e+20
max_iter................        50   machine precision.......  1.11e-16
optim_tol...............  1.72e-13   min_infeas..............     FALSE
print_level........ Nag_Soln_Iter
outfile................    stdout


Memory allocation:
state...................       Nag
ax......................       Nag   lambda..................       Nag
```

```
Results from e04mfc:
-------------------

  Itn Jdel  Jadd   Step    Ninf  Sinf/Obj   Bnd  Lin  Nart  Nrz  Norm Gz

    0   0     0   0.0e+00   3   2.8550e+03   6    0    0     0   0.00e+00
    1   4 L   4 U  1.8e-02   1   7.2000e+02   6    0    0     0   0.00e+00
    2   5 L   7 L  4.1e-03   0   1.0629e+02   5    1    0     0   0.00e+00
    3   1 L   1 U  1.9e+00   0   9.7333e+01   5    1    0     0   0.00e+00
    4   4 U   5 U  2.9e+00   0   9.2500e+01   5    1    0     0   0.00e+00

Final solution:

  Varbl State    Value     Lower Bound  Upper Bound    Lagr Mult     Residual

V   1    UL   4.00000e+00  0.0000e+00   4.0000e+00    -3.187e+00    0.000e+00
V   2    LL   0.00000e+00  0.0000e+00   3.0000e+00     1.247e+01    0.000e+00
V   3    LL   0.00000e+00  0.0000e+00   2.0000e+00     4.000e+00    0.000e+00
V   4    FR   4.50000e+00  0.0000e+00   8.0000e+00     0.000e+00    3.500e+00
V   5    UL   2.00000e+00  0.0000e+00   2.0000e+00    -3.625e+00    0.000e+00
V   6    LL   0.00000e+00  0.0000e+00   2.0000e+00     4.375e+00    0.000e+00

  LCon  State    Value     Lower Bound  Upper Bound   Lagr Mult     Residual

L   1    LL   2.00000e+03  2.0000e+03    None        5.625e-02   -2.274e-13
L   2    FR   6.00000e+01  5.5000e+01    None        0.000e+00    5.000e+00
L   3    FR   1.33450e+03  8.0000e+02    None        0.000e+00    5.345e+02

Exit after 4 iterations.

Optimal LP solution found.

Final LP objective value =   9.2500000e+01
```

7. Optional Parameters

A number of optional input and output parameters to nag_ip_mps_read are available through the structure argument **options**, type Nag_H02_Opt. A parameter may be selected by assigning an appropriate value to the relevant structure member; those parameters not selected will be assigned default values. If no use is to be made of any of the optional parameters the user should use the NAG defined null pointer, H02_DEFAULT, in place of **options** when calling nag_ip_mps_read; the default settings will then be used for all parameters.

Before assigning values to **options** directly the structure **must** be initialised by a call to the function nag_ip_init (h02xxc). Values may then be assigned to the structure members in the normal C manner.

Option settings may also be read from a text file using the function nag_ip_read (h02xyc) in which case initialisation of the **options** structure will be performed automatically if not already done. Any subsequent direct assignment to the **options** structure must **not** be preceded by initialisation.

7.1. Optional Parameter Checklist and Default Values

For easy reference, the following list shows the members of **options** which are valid for nag_ip_mps_read together with their default values where relevant.

```
Boolean list                         TRUE
Nag_OutputType output_level     Nag_MPS_Summary
char outfile[80]                    stdout
char prob_name[9]                   '\0'
char obj_name[9]                    '\0'
char rhs_name[9]                    '\0'
char range_name[9]                  '\0'
char bnd_name[9]                    '\0'
double col_lo_default                0.0
double col_up_default               10^20
Integer ncol_approx                  100
```

```
Integer nrow_approx                           100
char **crnames                           size n+m
Integer n_ivar
```

7.2. Description of Optional Parameters

list – Boolean   Default = **TRUE**

>   Input: if **options.list = TRUE** the parameter settings in the call to nag_ip_mps_read will be
>   printed.

output_level – Nag_OutputType   Default = **Nag_MPS_Summary**

>   Input: the level of printout produced by nag_ip_mps_read. The following values are available.

> | | |
> |---|---|
> | **Nag_NoOutput** | No output. |
> | **Nag_MPS_Summary** | A summary of the dimensions of the problem read and a list of the 'MPSX names' (problem name, objective row name, etc.). |
> | **Nag_MPS_List** | As **Nag_MPS_Summary** but each line of the MPSX file is echoed as it is read. This can be useful for debugging the file. |

>   Constraint: **options.output_level = Nag_NoOutput**, **Nag_MPS_Summary** or **Nag_MPS_List**.

outfile – char[80]   Default = **stdout**

>   Input: the name of the file to which results should be printed. If **options.outfile**[0] = '\0' then
>   the **stdout** stream is used.

prob_name – char[9]   Default: **prob_name**[0] = '\0'
obj_name – char[9]   Default: **obj_name**[0] = '\0'
rhs_name – char[9]   Default: **rhs_name**[0] = '\0'
range_name – char[9]   Default: **range_name**[0] = '\0'
bnd_name – char[9]   Default: **bnd_name**[0] = '\0'

>   Input: these options contain the names associated with the MPSX form of the problem.
>   These names must be specified as follows:

>   **prob_name**   must contain the name of the problem to be read or be blank. The problem
>   name is specified in the NAME indicator line (see Section 3) and if **prob_name**
>   is not blank, then nag_ip_mps_read will search the MPSX file for the specified
>   problem. If **prob_name** is blank, then the first problem encountered will be read.

>   **obj_name**   must contain the name of the objective row or be blank (in which case the first
>   objective free row is used).

>   **rhs_name**   must contain the name of the RHS set to be used or be blank (in which case the
>   first RHS set is used).

>   **range_name**   must contain the name of the RANGES set to be used or be blank (in which
>   case the first RANGES set, if any, is used).

>   **bnd_name**   must contain the name of the BOUNDS set to be used or be blank (in which
>   case the first BOUNDS set, if any, is used).

>   Constraints: the names must be valid MPSX names, i.e., they must consist only of the
>   'alphanumeric' characters as specified in Section 3 and must not contain leading blank
>   characters.

>   Output: the members contain the appropriate names as read from the MPSX file. Any names
>   specified on input which are not found in the MPSX file are unchanged on exit but will give
>   rise to an error exit from nag_ip_mps_read (see Section 8).

col_lo_default – double   Default = 0.0

>   Input: the default lower bound to be used for the variables in the problem when none is
>   specified in the BOUNDS section of the MPSX data file.

col_up_default – double   Default $= 10^{20}$

Input: the default upper bound to be used for the variables in the problem when none is specified in the BOUNDS section of the MPSX data file.
Constraint: **options.col_up_default $\geq$ options.col_lo_default**.

ncol_approx – Integer   Default $= 100$
nrow_approx – Integer   Default $= 100$

Input: an estimate of the number of columns and rows in the problem. nag_ip_mps_read is designed so that the problem size does not have to be known in advance, and allocates memory according to the data contained in the MPSX file. However, for very large problems, an advance estimate of the problem size might allow slightly more efficient memory usage to be achieved.
Constraints:

$$\textbf{options.ncol\_approx} > 0,$$

$$\textbf{options.nrow\_approx} > 0.$$

crnames – char $**$ Default memory **n+m** array of char $*$

Output: the MPSX names of all the variables and constraints in the problem in the following order. **crnames**$[j-1]$ contains the name of the jth column, for $j = 1, 2, \ldots,$**n**. **crnames**$[\textbf{n}+i-1]$ contains the name of the ith row, for $i = 1, 2, \ldots,$**m**. Each name is 8 characters long, and includes any trailing blank characters which appear in the appropriate name field of the MPSX file.

Sufficient memory to hold the names is allocated internally by nag_ip_mps_read. The memory freeing function nag_ip_free (h02xzc) should be used to free this memory. Users should **not** use the standard C function `free()` for this purpose.

If, on return from nag_ip_mps_read, nag_ip_bb (h02bbc) is called with **options** as an argument, and the memory pointed to by **crnames** has not been freed, nag_ip_bb (h02bbc) will use the row and column names stored in **crnames** in its solution output.

n_ivar – Integer

Output: the number of integer variables specified by the data file.

8.   Error Indications and Warnings

NE_NULL_ARGUMENT

Argument **n** is a null pointer. It should contain the address of a variable of type Integer.
Argument **m** is a null pointer. It should contain the address of a variable of type Integer.
Argument **a** is a null pointer. It should contain the address of a variable of type double $*$.
Argument **bl** is a null pointer. It should contain the address of a variable of type double $*$.
Argument **bu** is a null pointer. It should contain the address of a variable of type double $*$.
Argument **intvar** is a null pointer. It should contain the address of a variable of type Boolean $*$.
Argument **cvec** is a null pointer. It should contain the address of a variable of type double $*$.
Argument **x** is a null pointer. It should contain the address of a variable of type double $*$.

NE_OPT_NOT_INIT

Options structure not initialized.

NE_BAD_PARAM

On entry, parameter **options.prob_name** had an illegal value.
On entry, parameter **options.obj_name** had an illegal value.
On entry, parameter **options.rhs_name** had an illegal value.
On entry, parameter **options.range_name** had an illegal value.
On entry, parameter **options.bnd_name** had an illegal value.
On entry, parameter **options.output_level** had an illegal value.

NE_2_REAL_EE_OPT_ARG_CONS

On entry, **options.col_lo_default** $= \langle value \rangle$ while **options.col_up_default** $= \langle value \rangle$.
Constraint: **options.col_lo_default $\leq$ options.col_up_default**.

NE_INT_OPT_ARG_LT
　　On entry, **options.nrow_approx** = ⟨*value*⟩. Constraint: **nrow_approx** ≥ 1
　　On entry, **options.ncol_approx** = ⟨*value*⟩. Constraint: **ncol_approx** ≥ 1

NE_NAMES_NOT_NAG_MEM
　　options.crnames is not null but does not point to memory allocated by an earlier call to this function. This function does not accept user-allocated memory assigned to **crnames**.

NE_MPS_PROB_NOT_FOUND
　　The specified problem has not been found in the MPSX file.

NE_MPS_ILLEGAL_DATA_LINE
　　An illegal data line has been read from the MPSX file. This is neither a comment nor a legal data line.
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_ILLEGAL_NAME
　　An illegal row or column name has been detected. Names must contain only alphanumeric characters with no leading blanks.
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_ILLEGAL_NUMBER
　　Number expected but value could not be read. Check numerical fields.
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_ILLEGAL_SETNAME
　　An illegal name has been detected in field 2 of the RHS, RANGES or BOUNDS section. Names must contain only alphanumeric characters with no leading blanks.
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_INVALID_BND_TYPE
　　An invalid bound type appears in the BOUNDS section. Expect: LO, UP, FX, FR, MI, PL, BV or UI.
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_INVALID_BND_VAL
　　Invalid numeric field in bound data. Value expected for types: LO, UP, FX, UI. Blank field expected for types: FR, MI, PL, BV.
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_INVALID_INDICATOR
　　Unknown, unexpected or invalid indicator line read. Expect: NAME, ROWS, COLUMNS, RHS, RANGES, BOUNDS or ENDATA, starting in column 1 of file, and in that order. RANGES and/or BOUNDS may be omitted.
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_INVALID_INTORG_INTEND
　　An INTORG or INTEND marker is not correctly specified or is unexpected (e.g., INTEND has no matching INTORG).
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_INVALID_ROW_TYPE
　　An invalid row type appears in the ROWS section. Expect: N, G, L or E.
　　Error at MPSX line ⟨*value*⟩: ⟨*string*⟩.

NE_MPS_NO_COLS
　　There were no columns specified in the COLUMNS section.
　　Last MPSX line read (⟨*value*⟩): ⟨*string*⟩.

NE_MPS_NO_NEWLINE
　　New line expected but not found.
　　Last MPSX line read (⟨*value*⟩): ⟨*string*⟩.

NE_MPS_NO_OBJ
　　The objective row was not found. There must be at least one row of type N in the ROWS section and, if an objective name was specified, there must be a type N row with this name.
　　Last MPSX line read (⟨*value*⟩): ⟨*string*⟩.

NE_MPS_NO_ROWS
> There were no rows specified in the ROWS section.
> Last MPSX line read ($\langle value \rangle$): $\langle string \rangle$.

NE_MPS_REPEAT_ROW
> A row has been specified more than once.
> Error at MPSX line $\langle value \rangle$: $\langle string \rangle$.

NE_MPS_RHS_RANGE_BND_NOT_FOUND
> The name of the RHS, RANGES or BOUNDS set to be used was not found in the file.

NE_MPS_ENDATA_NOT_FOUND
> The file does not contain an ENDATA indicator.

NE_MPS_SPLIT_COL
> Column data is not contiguous. All entries for a given column must appear together in the COLUMNS section.
> Error at MPSX line $\langle value \rangle$: $\langle string \rangle$.

NE_MPS_UNKNOWN_COLNAME
> An unknown column name appears in the BOUNDS section. All the column names must be specified in the COLUMNS section.
> Error at MPSX line $\langle value \rangle$: $\langle string \rangle$.

NE_MPS_UNKNOWN_ROWNAME
> An unknown row name appears in the $\langle string \rangle$ section. All the row names must be specified in the ROWS section.
> Error at MPSX line $\langle value \rangle$: $\langle string \rangle$.

NE_ALLOC_FAIL
> Memory allocation failed.

NE_NOT_APPEND_FILE
> Cannot open file $\langle string \rangle$ for appending.

NE_WRITE_ERROR
> Error occurred when writing to file $\langle string \rangle$.

NE_NOT_CLOSE_FILE
> Cannot close file $\langle string \rangle$.

NE_NOT_READ_FILE
> Cannot open file $\langle string \rangle$ for reading.

NE_INTERNAL_ERROR
> An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please consult NAG for assistance.

9. Further Comments

Although nag_ip_mps_read is designed primarily for use with nag_ip_bb (h02bbc), it can also be used in conjunction with nag_opt_lp (e04mfc) (as illustrated by example 1), nag_opt_lin_lsq (e04ncc) and nag_opt_qp (e04nfc). However, these last three functions do not provide a direct means of using the row and column names which can be read by nag_ip_mps_read and stored in the optional parameter **crnames**. By making use of the user-defined printing facilities of the functions, the user can customize the solution printing to print the row and column names (see Section 8.3.1 of the documentation for the appropriate function). Alternatively, the user may call nag_ip_bb (h02bbc) to solve the LP or QP problem by specifying all variables to be non-integer via the **intvar** parameter (see Section 4 of the documentation for nag_ip_bb (h02bbc)).

10. References

(1971) Program Number 5734 XM4 *MPSX - Mathematical programming system* IBM Trade Corporation, New York.

11.   See Also

nag_opt_lp (e04mfc)
nag_opt_lin_lsq (e04ncc)
nag_opt_qp (e04nfc)
nag_ip_mps_free (h02bvc)
nag_ip_bb (h02bbc)
nag_ip_init (h02xxc)
nag_ip_read (h02xyc)
nag_ip_free (h02xzc)

12.   Example 2

This example reads in an MPSX file specifying the same IP problem as in example 1. Here the problem is specified in the standard MPSX format (in example 1 it was presented in the compatible MPSX format; see Section 3 for details of the standard and compatible MPSX formats). It is then solved as an IP problem.

The following program calls nag_ip_read (h02xyc), which initialises the **options** structure and reads optional parameter settings from the data file. The parameter settings supress all output from nag_ip_mps_read. The program then calls nag_ip_mps_read to read the MPSX data and sets the optional parameter **list** to **TRUE** before calling nag_ip_bb (h02bbc) to solve the IP problem. As the **options** structure is passed as an argument, the row and column names read from the file are stored in **options.crnames** and used in the solution output (see Section 12.3).

Finally, nag_ip_mps_free (h02bvc) is called to free the problem arrays, and nag_ip_free (h02xzc) is called to free the memory in **options**.

12.1. Program Text

```
static void ex2(void)
{
  Integer n, m;
  double *a, *c, *bl, *bu, *x, objf;
  Boolean *intvar;
  static NagError fail;
  Nag_H02_Opt options;

  Vprintf("\nExample 2: use of options structure.\n");

  /* Initialise options structure and read option settings. */
  h02xxc(&options);
  h02xyc("h02buc", "stdin", &options, (Boolean)TRUE, "stdout", NAGERR_DEFAULT);

  /* Read MPSX data */
  fail.print = TRUE;
  h02buc(0, TRUE, &n, &m, &a, &bl, &bu, &intvar, &c, &x,
 &options, &fail);

  /* Solve IP problem defined by data */
  options.list = TRUE;
  h02bbc(n, m, a, n, bl, bu, intvar, c, (double*)0, 0, NULLFN,
 x, &objf, &options, NAGCOMM_NULL, &fail);

  /* Free memory allocated by h02buc */
  h02bvc(&a, &bl, &bu, &intvar, &c, &x);

  /* Free options memory */
  h02xzc(&options, "all", NAGERR_DEFAULT);
}
```

12.2. Program Data

```
* Example 2 data.
*
* This defines the same problem as Example 1 but
* is in the 'standard' MPSX format.
*
* Options setting first:

  BEGIN nag_ip_mps_read

    list = FALSE
    output_level = Nag_NoOutput
    prob_name = DIET2

  END

NAME          DIET2
ROWS
 G  ENERGY
 G  PROTEIN
 G  CALCIUM
 N  COST
COLUMNS
    OATMEAL   ENERGY     110.0
    OATMEAL   PROTEIN    4.0
    OATMEAL   CALCIUM    2.0
    OATMEAL   COST       3.0
    CHICKEN   ENERGY     205.0
    CHICKEN   PROTEIN    32.0
    CHICKEN   CALCIUM    12.0
    CHICKEN   COST       24.0
    INTEGER   'MARKER'                 'INTORG'
    EGGS      ENERGY     160.0
    EGGS      PROTEIN    13.0
    EGGS      CALCIUM    54.0
    EGGS      COST       13.0
    MILK      ENERGY     160.0
    MILK      PROTEIN    8.0
    MILK      CALCIUM    285.0
    MILK      COST       9.0
    PIE       ENERGY     420.0
    PIE       PROTEIN    4.0
    PIE       CALCIUM    22.0
    PIE       COST       20.0
    INTEGER   'MARKER'                 'INTEND'
    BACON     ENERGY     260.0
    BACON     PROTEIN    14.0
    BACON     CALCIUM    80.0
    BACON     COST       19.0
 RHS
    DEMANDS   ENERGY     2000.0
    DEMANDS   PROTEIN    55.0
    DEMANDS   CALCIUM    800.0
 BOUNDS
 UI SERVINGS  OATMEAL    4.0
 UI SERVINGS  CHICKEN    3.0
 UP SERVINGS  EGGS       2.0
 UP SERVINGS  MILK       8.0
 UP SERVINGS  PIE        2.0
 UI SERVINGS  BACON      2.0
```

12.3. Program Results

```
Example 2: use of options structure.

Optional parameter setting for h02buc.
--------------------------------------

Option file: stdin

list set to FALSE
output_level set to Nag_NoOutput
prob_name set to DIET2

Parameters to h02bbc
--------------------

Linear constraints........... 3     Number of variables........... 6
Number of integer variables... 6

prob.................... Nag_MILP
feas_tol............... 1.05e-08     machine precision....... 1.11e-16
inf_bound.............. 1.00e+20     max_iter...............      50
first_soln.............    FALSE     max_depth..............      10
max_nodes..............ALL_NODES     int_tol................ 1.00e-05
int_obj_bound.......... 1.00e+20     soln_tol............... 1.05e-08
nodsel.........Nag_MinObj_Search     varsel.............Nag_First_Int
branch_dir........Nag_Branch_Left    crnames.................supplied
print_level........Nag_Soln_Iter
outfile...............    stdout

Memory allocation:
lower..................     Nag
upper..................     Nag
state..................     Nag
lambda.................     Nag
```

Node No	Parent Node	Obj Value	Varbl Chosen	Value Before	Lower Bound	Upper Bound	Value After	Depth
1		9.250e+01						
2	1	9.385e+01	4	4.50e+00	0.00e+00	4.00e+00	4.00e+00	1
3	1	9.319e+01	4	4.50e+00	5.00e+00	8.00e+00	5.00e+00	1
4	3	9.612e+01	5	1.81e+00	0.00e+00	1.00e+00	1.00e+00	2
5	3	9.482e+01	5	1.81e+00	2.00e+00	2.00e+00	2.00e+00	2
6	2	9.450e+01	6	3.08e-01	0.00e+00	0.00e+00	0.00e+00	2
7	2	9.688e+01	6	3.08e-01	1.00e+00	2.00e+00	1.00e+00	2
8	6	9.737e+01	3	5.00e-01	0.00e+00	0.00e+00	0.00e+00	3
9	6	9.650e+01	3	5.00e-01	1.00e+00	2.00e+00	1.00e+00	3
10	5	9.569e+01	1	3.27e+00	0.00e+00	3.00e+00	3.00e+00	3
11	5	9.700e+01	1	3.27e+00	4.00e+00	4.00e+00	4.00e+00	3

```
*** Integer Solution ***
```

Node No	Parent Node	Obj Value	Varbl Chosen	Value Before	Lower Bound	Upper Bound	Value After	Depth
12	10	9.619e+01	4	5.19e+00	5.00e+00	5.00e+00	5.00e+00	4
13	10	9.945e+01 CO	4	5.19e+00	6.00e+00	8.00e+00	6.00e+00	4
14	4	9.646e+01	4	7.12e+00	5.00e+00	7.00e+00	7.00e+00	3
15	4	9.733e+01 CO	4	7.12e+00	8.00e+00	8.00e+00	8.00e+00	3
16	12	9.644e+01	6	1.15e-01	0.00e+00	0.00e+00	0.00e+00	5
17	12	1.067e+02 CO	6	1.15e-01	1.00e+00	2.00e+00	1.00e+00	5
18	16	9.751e+01 CO	3	1.88e-01	0.00e+00	0.00e+00	0.00e+00	6
19	16	1.035e+02 CO	3	1.88e-01	1.00e+00	2.00e+00	1.00e+00	6
20	14	9.662e+01	6	7.69e-02	0.00e+00	0.00e+00	0.00e+00	4
21	14	1.005e+02 CO	6	7.69e-02	1.00e+00	2.00e+00	1.00e+00	4
22	9	9.850e+01 CO	4	3.50e+00	0.00e+00	3.00e+00	3.00e+00	4
23	9	9.719e+01 CO	4	3.50e+00	4.00e+00	4.00e+00	4.00e+00	4
24	20	9.734e+01 CO	3	1.25e-01	0.00e+00	0.00e+00	0.00e+00	5

Node No	Parent Node	Obj Value	Varbl Chosen	Value Before	Lower Bound	Upper Bound	Value After	Depth
25	20	1.001e+02 CO	3	1.25e-01	1.00e+00	2.00e+00	1.00e+00	5
26	7	1.052e+02 CO	4	2.88e+00	0.00e+00	2.00e+00	2.00e+00	3
27	7	9.705e+01 CO	4	2.88e+00	3.00e+00	4.00e+00	3.00e+00	3

```
Final solution:

Varbl    State    Value       Lower Bound  Upper Bound  Lagr Mult    Residual

OATMEAL   EQ    4.00000e+00    4.0000e+00   4.0000e+00   3.000e+00   0.000e+00
CHICKEN   LL    0.00000e+00    0.0000e+00   3.0000e+00   2.400e+01   0.000e+00
EGGS      LL    0.00000e+00    0.0000e+00   2.0000e+00   1.300e+01   0.000e+00
MILK      LL    5.00000e+00    5.0000e+00   8.0000e+00   9.000e+00   0.000e+00
PIE       EQ    2.00000e+00    2.0000e+00   2.0000e+00   2.000e+01   0.000e+00
BACON     LL    0.00000e+00    0.0000e+00   2.0000e+00   1.900e+01   0.000e+00


Constr   State    Value       Lower Bound  Upper Bound  Lagr Mult    Residual

ENERGY    FR    2.08000e+03    2.0000e+03     None       0.000e+00   8.000e+01
PROTEIN   FR    6.40000e+01    5.5000e+01     None       0.000e+00   9.000e+00
CALCIUM   FR    1.47700e+03    8.0000e+02     None       0.000e+00   6.770e+02

Exit from branch and bound tree search after 27 nodes.

Optimal IP solution found.

Final IP objective value =   9.7000000e+01
```