Who needs the GAMS World ?

www.gamsworld.org

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GAMS Development Corporation

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Introduction

- Background
- Change in User Focus
- Viewpoints and Incentives
- Quality Assurance
- www.gamsworld.org
- Future

GAMS Overview

- Started as a Research Project at the World Bank in 1976
- GAMS went commercial in 1987
- Opened European Office in Cologne, Germany in 1996
- 10,000s of customers in over 100 countries
- Unique position between the academic and commercial world

Basic Principles

- Separation of model and solution methods
- Models is a data base operator and/or object
- Balanced mix of declarative and procedural approaches
- Computing platform independence
- Multiple model types, solvers and platforms

Solvers/Platforms

Solver/Platform availability - 20.6 May 25, 2002							
	Intel		Sun Sparc	HP 9000	DEC Alpha	IBM RS-6000	SGI
	Windows 95/98/Me/NT/2000/XP	Linux	Solaris	HP-UX 10	Digital Unix 4.0	AIX 4.3	IRIX
BDMLP	✔	✔	✔	✔	✔	✔	✔
CONOPT	✔	✔	✔	✔	✔	✔	✔
CPLEX 7.5	✔	✔	✔	✔	✔	✔	✔
DECIS	✔	✔	✔		✔		✔
DICOPT	✔	✔	✔	✔	✔	✔	✔
MILES	✔	✔	✔	✔	✔	✔	✔
MINOS	✔	✔	✔	✔	✔	✔	✔
MPSGE	✔	✔	✔	✔	✔	✔	✔
OSL V3	✔	✔	✔	✔		✔	✔
PATH	✔	✔	✔	✔	✔	✔	✔
SBB	✔	✔	✔	✔	✔	✔	✔
SNOPT	✔	✔	✔	✔	✔	✔	✔
XA	✔	✔	✔	✔	✔	✔	
XPRESS 13.02	✔	✔	✔	13.01			
Beta solvers							
BARON	✔	✔				✔	
CONVERT	✔	✔	✔	✔	✔	✔	✔
LGO	✔						
MOSEK	✔	✔	✔				
NLPEC	✔	✔	✔	✔	✔	✔	✔
OQMS	✔						
PATHNLP	✔	✔	✔	✔	✔	✔	✔
Contributed Plug&Play solvers							
AMPLwrap	✔	✔	✔	✔	✔	✔	✔
DEA	✔	✔	✔	✔	✔	✔	✔

Change in Focus

Computation
Past

- **Algorithm limits** applications
- Problem representation is low priority
- Large costly projects
- Long development times
- Centralized expert groups
- High computational cost, mainframes
- **Users left out**

Model
Present

- **Modeling skill limits** applications
- Algebraic model representation
- Smaller projects
- Rapid development
- Decentralized modeling teams
- Low computational cost, workstations
- Machine independence
- **Users involved**

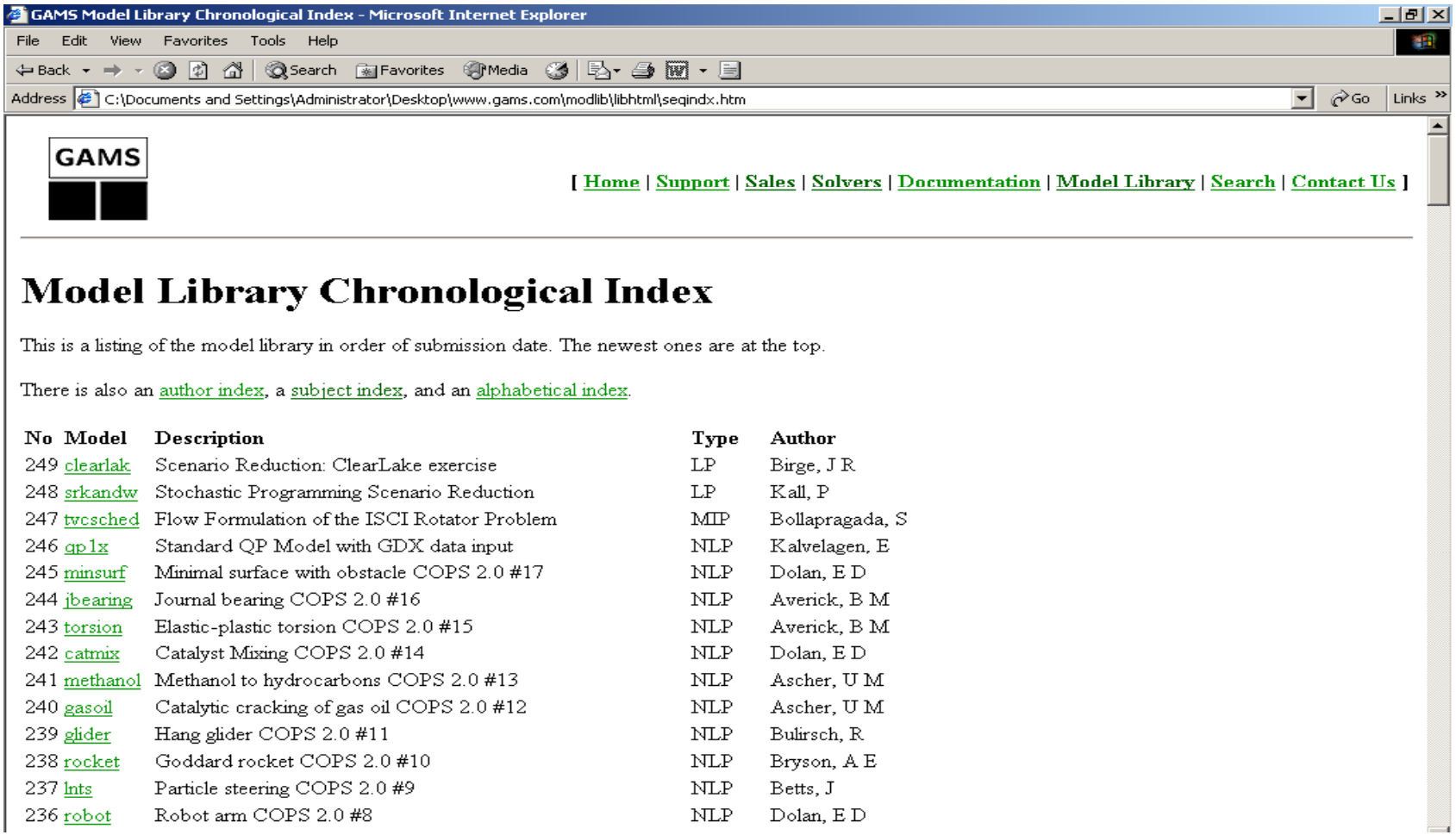
Application
Future

- **Domain expertise limits** application
- Off-the-shelf graphical user interfaces
- Links to other types of models
- Models embedded in business applications
- New computing environments
- Internet/web
- **Users hardly aware of model**

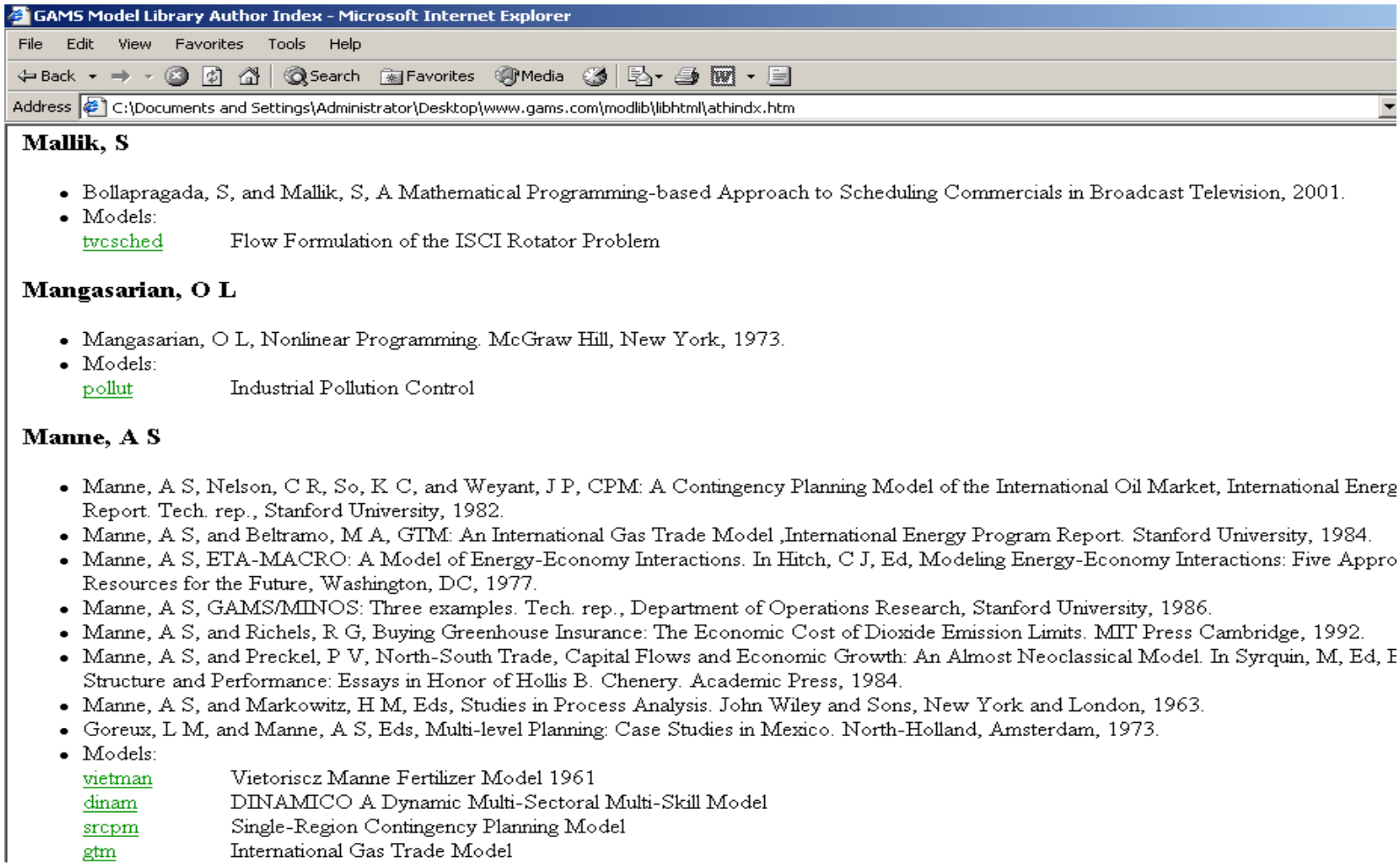
Conflicting View Points

- Research Priorities and Incentives
- Numeric and Symbolic Software
- User Risk
- User Focus
- Quality Assurance

GAMS Model Library



Author Index



Mallik, S

- Bollapragada, S, and Mallik, S, A Mathematical Programming-based Approach to Scheduling Commercials in Broadcast Television, 2001.
- Models:
  twcsched Flow Formulation of the ISCI Rotator Problem

Mangasarian, O L

- Mangasarian, O L, Nonlinear Programming. McGraw Hill, New York, 1973.
- Models:
  pollut Industrial Pollution Control

Manne, A S

- Manne, A S, Nelson, C R, So, K C, and Weyant, J P, CPM: A Contingency Planning Model of the International Oil Market, International Energ Report. Tech. rep., Stanford University, 1982.
- Manne, A S, and Beltramo, M A, GTM: An International Gas Trade Model ,International Energy Program Report. Stanford University, 1984.
- Manne, A S, ETA-MACRO: A Model of Energy-Economy Interactions. In Hitch, C J, Ed, Modeling Energy-Economy Interactions: Five Appro Resources for the Future, Washington, DC, 1977.
- Manne, A S, GAMS/MINOS: Three examples. Tech. rep., Department of Operations Research, Stanford University, 1986.
- Manne, A S, and Richels, R G, Buying Greenhouse Insurance: The Economic Cost of Dioxide Emission Limits. MIT Press Cambridge, 1992.
- Manne, A S, and Preckel, P V, North-South Trade, Capital Flows and Economic Growth: An Almost Neoclassical Model. In Syrquin, M, Ed, E Structure and Performance: Essays in Honor of Hollis B. Chenery. Academic Press, 1984.
- Manne, A S, and Markowitz, H M, Eds, Studies in Process Analysis. John Wiley and Sons, New York and London, 1963.
- Goreux, L M, and Manne, A S, Eds, Multi-level Planning: Case Studies in Mexico. North-Holland, Amsterdam, 1973.
- Models:
  vietman Vietoriscz Manne Fertilizer Model 1961
  dinam DINAMICO A Dynamic Multi-Sectoral Multi-Skill Model
  srcpm Single-Region Contingency Planning Model
  gtm International Gas Trade Model

GAMS World Home Page

GAMS World

The Worlds
- GLOBAL
- MINLP
- MPEC
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- Performance
- Translation

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Contact

Welcome to the GAMS World

This is the home page of the GAMS World, a web site aiming to bridge the gap between academia and industry by providing highly focused forums and dissemination services in specialized areas of mathematical programming.

Substantial progress was made in the 1980s and 1990s with the development of algebra based modeling systems, algorithms, and computer codes to solve large and complex mathematical programs. The application of these tools, however, was less than expected. The abstraction, expression, and translation of real world problems into reliable and effective operational systems requires highly specialized and domains specific knowledge. The process of acquisition and dissemination of this knowledge is complex and poorly understood and the number of "good modelers" is much less than we all hoped for. Similarly, the process of transforming a new algorithm into a reliable and effective solution system is a slow and expensive process and there are few "good implementers". This web site hopes to address some of these problems by helping with the collection and dissemination of domain specific information and knowledge that is outside the established channels because of its content or form.

For example, model structures and results get published in commercial and academic papers but it is virtually impossible to reproduce any of those results or lift model components and data from one study to be used in some other study. Algorithm implementers face a similar dilemma when trying to get their hands on real world data models and data to test and refine their systems. This web site offers a few, well focused and maintained services to help with the dissemination of problems and solutions.

GAMS World is featured by GAMS Development Corp. and GAMS Software GmbH

Purpose of GAMS World

…a web site aiming to bridge the gap between academia and industry by providing highly focused forums and dissemination services in specialized areas of mathematical programming.

Substantial progress in the 1980s and 1990s …. application of these tools less than expected …. abstraction, expression, and translation of real world requires highly specialized and domains specific knowledge … process of acquisition and dissemination of this knowledge is complex and poorly understood…process of transforming a new algorithm into a reliable and effective solution system is a slow and expensive…helping with the collection and dissemination of domain specific information and knowledge that is outside the established channels because of its content or form.

Global Home Page

GLOBAL World

- Editorial Board
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Welcome to GLOBAL World!

The Global World is a forum for discussion and dissemination of all aspects of computational methods to find global optimal solutions to nonconvex nonlinear optimization problems.

Recently, general purpose global solution algorithms have been implemented and have matured into reliable solution systems that can be connected to modeling systems. These new developments make the application of nonlinear global optimization methods available to users outside the narrow global research community.

General purpose global nonlinear optimization is a new field and much work needs to be done to test the capabilities and robustness on real world models. We are interested in practical software (see GLOBAL Solvers) and an ever growing, well maintained library of academic and practical client test problems in the GLOBAL Library. Communication is supported by maintaining the GLOBAL list server and related links.

For other specialized topics in the are of mathematical programming consult the GAMS World.

GLOBAL World is featured by GAMS World

MINLP Home Page

MINLP World

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Welcome to the MINLP World!

MINLP World is a forum for discussion and dissemination of information about all aspects of Mixed Integer Nonlinear Programming (MINLP).

MINLP models are models that combine combinatorial aspects with nonlinearities. MINLP models are much more difficult than both Mixed Integer Linear Programming (MIP) and Nonlinear Programming (NLP) models.

MINLP is still a new field, and we cannot yet solve all the problems that naturally fall within this area. It is the purpose of this site to bring people that work with MINLP together. We are interested in practical software (MINLP Solvers), testing, comparison, and quality of solvers (MINLPLib), research in both solution methods and in good model formulations, and in improving the communication between people interested in these topics (Related Links and MINLP list).

MINLP World is featured by GAMS World

MPEC World Home Page

MPEC World

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Welcome to the MPEC World!

MPEC World is a forum for discussion and dissemination of information about all aspects of Mathematical Programs with Equilibrium Constraints (MPEC).

MPEC is a relatively new field (not nearly so mature as LP or NLP), and we cannot yet solve many of the problems that naturally fall within this area. It is the purpose of this site to bring people that work with MPEC together. We are interested in practical software (MPEC Solvers), testing, comparison, and quality of solvers (MPECLib), research in both solution methods and in good model formulations, and in improving the communication between people interested in these topics (Related Links and MPEC list).

MINLP World is featured by GAMS World

MPSGE Home Page

MPSGE World

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- MPSGE Tools
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- Contact

Welcome to the MPSGE World!

MPSGE WORLD is a forum for discussion and dissemination of information about economic equilibrium modeling with the Mathematical Programming System for General Equilibrium (MPSGE).

MPSGE is a small language for representing computable general equilibrium models in a non-algebraic format. It is the purpose of this site to bring people that work with MPSGE together. We are interested in providing introductory material for new users (Tutorial), prototype models (MPSGELib), suggestions for solving large scale models (MPSGE tips). The intent of the site is to provide a common point of reference for effective modeling with MPSGE. We also seek to improve communication between people interested in using computable equilibrium models for policy analyis (Related Links and MPSGE List).

Performance Home Page

Performance World

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- Contact

Welcome to the Performance World!

Performance World is a forum for discussion and dissemination of information and tools about all aspects of performance testing of mathematical programming problems. This world has been established in response to user demands for independent and reproducible performance results.

Overall performance highly depends on problem formulation, solver, and tuning parameters. Our performance tools are designed to serve the different needs of our user community. One user may be interested in finding the most reliable way to solve a proprietary or classified model. On the other hand, an academic researcher may be interested in testing a new algorithm against a set of existing test problems and competing approaches. The main features are:

- Uniform access to a comprehensive set of established and new test problems
- Automation tools for collecting performance measurements
- Tools for analyzing and visualizing test results

What's New:

- Try our online PAVER Server for automated performance analysis and batch file creation
- New tools for analyzing non-convex or discrete models
- MINLP type models from the MINLP World have been added to the PerformanceLib A tutorial (August, 2002)

Translation Services

Instructions

In order to use the GMS2XX translation service which is based on the "solver" GAMS/CONVERT you have to attach your model to an email and send it to our translation server at gms2xx@gamsworld.org. You specify the language in the subject line, for example

```
Subject: GAMS
```

At the moment we support the following *languages*:

- AMPL
- BARON
- CplexLP
- CplexMPS
- GAMS
- LGO
- LINGO
- MINOPT
- ALL (this creates scalar versions of all supported languages, listed above)

Global Editorial Board

GLOBALLib

GLOBALLib is a collection of Nonlinear Programming models. The purpose of the collection is to provide algorithm developer of global optimization codes with a large and varied set of both theoretical and practical test models.

- Browse GLOBALLib by model name
- Browse GLOBALLib by author/contributor
- Download GLOBALLib
- Read more about the organization of models and points in GLOBALLib
- GLOBALLib Changelog

Reference

- GLOBALLib Bibliography

Scalar Models

The collection has initially been created by combining small-scale models from the literature with large industrial models. We invite everybody to make contributions to the collection. See the contact page for additional information.

Since many industrial models are based on proprietary information, the models have been translated into a scalar format in which documentation and comments have been removed, sets and set operators have been unrolled, and the original data and structure of the model have disappeared. Most industrial users will accept that translated confidential models can be made publicly available. The scalar models are not intended to serve as guidelines for good modeling practice.

GLOBALLib Model Statistics

Name	Type	#Eqns	#Vars	#NZ	#NNZ	Bestknown	at Point
abel	NLP	15	31	101	30		
alkyl	NLP	8	15	32	19	-1.7650	p1
bearing	NLP	13	14	41	28	1.9517	p1
camcge	NLP	243	280	1356	850		
camcns	NLP	243	280	1356	850		
camshape100	NLP	201	200	697	299		
camshape200	NLP	401	400	1397	599		
camshape400	NLP	801	800	2797	1199		
camshape800	NLP	1601	1600	5597	2399		
catmix100	NLP	201	304	1203	1200		
catmix200	NLP	401	604	2403	2400		
catmix400	NLP	801	1204	4803	4800		
catmix800	NLP	1601	2404	9603	9600		
chain100	NLP	102	203	704	303		
chain200	NLP	202	403	1404	603		
chain400	NLP	402	803	2804	1203		
chain50	NLP	0	0	0	0		
chakra	NLP	42	63	143	41		
chance	NLP	4	5	17	4	29.8944	p1
chem	NLP	5	12	37	11		
chenery	NLP	39	44	133	56		
circle	NLP	10	3	30	30	4.5742	p1

Model Credits

Tendulkar, S	Tesi, A	Tjoa, I B	Tronconi, E	Tuy, H
Vanderbei, R	Varbrand, P	Vicino, A	Visweswaran, V	von Stryk, O
Wall, T W	Westerberg, A W	Weyant, J P	Wilkinson, J H	Williams, A C
Wingo, D	Wollenberg, B F	Wood, A J	Woolsey, R E D	Wright, M H
Xue, G L	Yezza, A	Zenios, S A	Zhou, S	

Credit List:

Abate, M:

- Abate, M, Barmish, B R, Murillo-Sanchez, C, and Tempo, R, Application of Some New Tools to Robust Stability Analysis of Spark Ignition Engines : A Case Study. IEEE Trans. Contr. Syst. Tech. 2 (1994), 22.
- Model:
  - ex7_3_6

Ackermann, J:

- Ackermann, J, Kaesbauer, D, and Muench, R, Robust Gama-Stability Analysis in a Plant Parameter Space. Automatica 27 (1991), 75.
- Models:
  - ex7_3_3
  - ex7_3_5

Client Models

- waterz

GAMS Software Client Models:

- GAMS Development, GAMS Software Client Models.
- Models:
  - 4stufen
  - beuster
  - deb10
  - deb6
  - deb7
  - deb8
  - deb9
  - detf1
  - johnall
  - saa_2
  - var_con10

Sample ‘scalar’ model (1)

alkyl.gms:

Reference:

- Berna, T, Locke, M, and Westerberg, A W, A New Approach to Optimization of Chemical Processes. American Institute of Chemical Engineers Journal 26, 1 (1980), 37-43.
- Original source: GAMS Model of alkyl.gms from GAMS Model Library

Point: p1
Best known point: p1 with value -1.7650

```
*  NLP written by GAMS Convert at 07/26/01 10:00:56
*
*  Equation counts
*     Total       E       G       L       N       X
*         8       8       0       0       0       0
*
*  Variable counts
*                 x       b       i     s1s     s2s      sc      si
*     Total     cont  binary integer    sos1    sos2   scont    sint
*        15       15       0       0       0       0       0       0
*  FX     0        0       0       0       0       0       0       0
*
*  Nonzero counts
*     Total   const      NL     DLL
*        32      13      19       0
*
```

Sample 'scalar' model (2)

```
e2..  - 0.819672131147541*x2 + x5 - 0.819672131147541*x6 =E= 0;

e3.. 0.98*x4 - x7*(0.01*x5*x10 + x4) =E= 0;

e4..  - x2*x9 + 10*x3 + x6 =E= 0;

e5.. x5*x12 - x2*(1.12 + 0.13167*x9 - 0.0067*x9*x9) =E= 0;

e6.. x8*x13 - 0.01*(1.098*x9 - 0.038*x9*x9) - 0.325*x7 =E= 0.57425;

e7.. x10*x14 + 22.2*x11 =E= 35.82;

e8.. x11*x15 - 3*x8 =E= -1.33;

* set non default bounds

x2.up = 2;
x3.up = 1.6;
x4.up = 1.2;
x5.up = 5;
x6.up = 2;
x7.lo = 0.85; x7.up = 0.93;
x8.lo = 0.9; x8.up = 0.95;
x9.lo = 3; x9.up = 12;
x10.lo = 1.2; x10.up = 4;
```

Sample ‘scalar’ model (3)

```
x3.l = 1.2;
x4.l = 1.1;
x5.l = 3.048;
x6.l = 1.974;
x7.l = 0.893;
x8.l = 0.928;
x9.l = 8;
x10.l = 3.6;
x12.l = 1;
x13.l = 1;
x14.l = 1;
x15.l = 1;

* set non default marginals


Model m / all /;

m.limrow=0; m.limcol=0;

$if NOT '%gams.u1%' == '' $include '%gams.u1%'

Solve m using NLP minimizing objvar;
```

Point Information

Point p1 for model bearing.gms (Best known point)

```
Solution found by BARON
Solution value: 1.95173322000
```

Point: p1

```
$ontext
Solution found by BARON
Solution value: 1.95173322000
$offtext
 e1.m =    0.100000000000E-03;
 e2.m =    0.100000000000E-03;
 e3.m =    0.678797965783E-01;
 e4.m =   -0.100471493287E-04;
 e5.m =    -66740.1820898    ;
 e6.m =   -0.192279198322E-03;
$offlisting
 e7.m =     2.28831817941    ;
 e8.m =   -0.228657564414E-01;
```

Mailing List

We set up a mailling list for exchanging all sorts of materials, problems, and questions concerning GLOBAL optimization problems.

To **subscribe** to the list send a message to global-l-request@gamsworld.org containing the word *subscribe* only in the subject line.

To **post** to the list after you subscribed send your mail to global-l@gamsworld.org.

You can **unsubscribe** anytime in a similar way: send a message to global-l-request@gamsworld.org containing the word *unsubscribe* only in the subject line.

To obtain more information about your options concerning the list, send a message to the list server account listar@gamsworld.org containing the word *help* only in the subject line.

Translation Service

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```
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- LGO
- LINGO
- MINOPT
- ALL (this creates scalar versions of all supported languages, listed above)

The attached model has to follow some conventions:

- The extension of the attached model is .gms
- The model is self contained, i.e. no $include or $batinclude
- No execution of external programs is allowed, i.e. no $call or execute
- No file creation, i.e. no put files or $echo

LGO Example

```
~
C  Nonzero counts
C      Total    const       NL      DLL
C         19       19        0        0
C
C  **** 8 bounds have been reset in file lgo.in


      Subroutine USER_FCT(x,obj,objname,ctype,g,gname)

      implicit real*8 (a-h,o-z)
      DLL_EXPORT USER_FCT

      dimension x(7),ctype(6),g(6),gname(6)
      character*20 gname,objname
      integer*2 ctype

      objname=' '
      do i=1,6
      gname(i)=' '
      end do

      g(1) =  - 0.225*x(1) - 0.153*x(2) - 0.162*x(3) - 0.225*x(4)
     . - 0.162*x(5) - 0.126*x(6) + x(7)
      ctype(1) = 0

      g(2) =    x(1) + x(2) + x(3) - 350
      ctype(2) = -1

      g(3) =    x(4) + x(5) + x(6) - 600
      ctype(3) = -1
```

Lingo Example

```
!         7        7        0        0        0        0        0        0
!  FX     0        0        0        0        0        0        0        0
!
!  Nonzero counts
!     Total    const       NL      DLL
!        19       19        0        0
!
;

MODEL:

[Obj] MIN = x7;

[e1]  - 0.225*x1 - 0.153*x2 - 0.162*x3 - 0.225*x4 - 0.162*x5 - 0.126*x6 + x7
      = 0;

[e2]    x1 + x2 + x3 <= 350;

[e3]    X4 + x5 + x6 <= 600;

[e4]    x1 + x4 >= 325;

[e5]    x2 + x5 >= 300;

[e6]    x3 + x6 >= 275;

@Free(x7);

End

Init:

End
```

Research v.Commercial Codes

- Run in “expert mode” tuned by the developer for a particular problem
- User wants to solve his business problem and wants to treat the solver as a black box
- Solver has to work decently in *all* cases
- Even if the algorithm fails, the solver has to be “*fail-safe*”

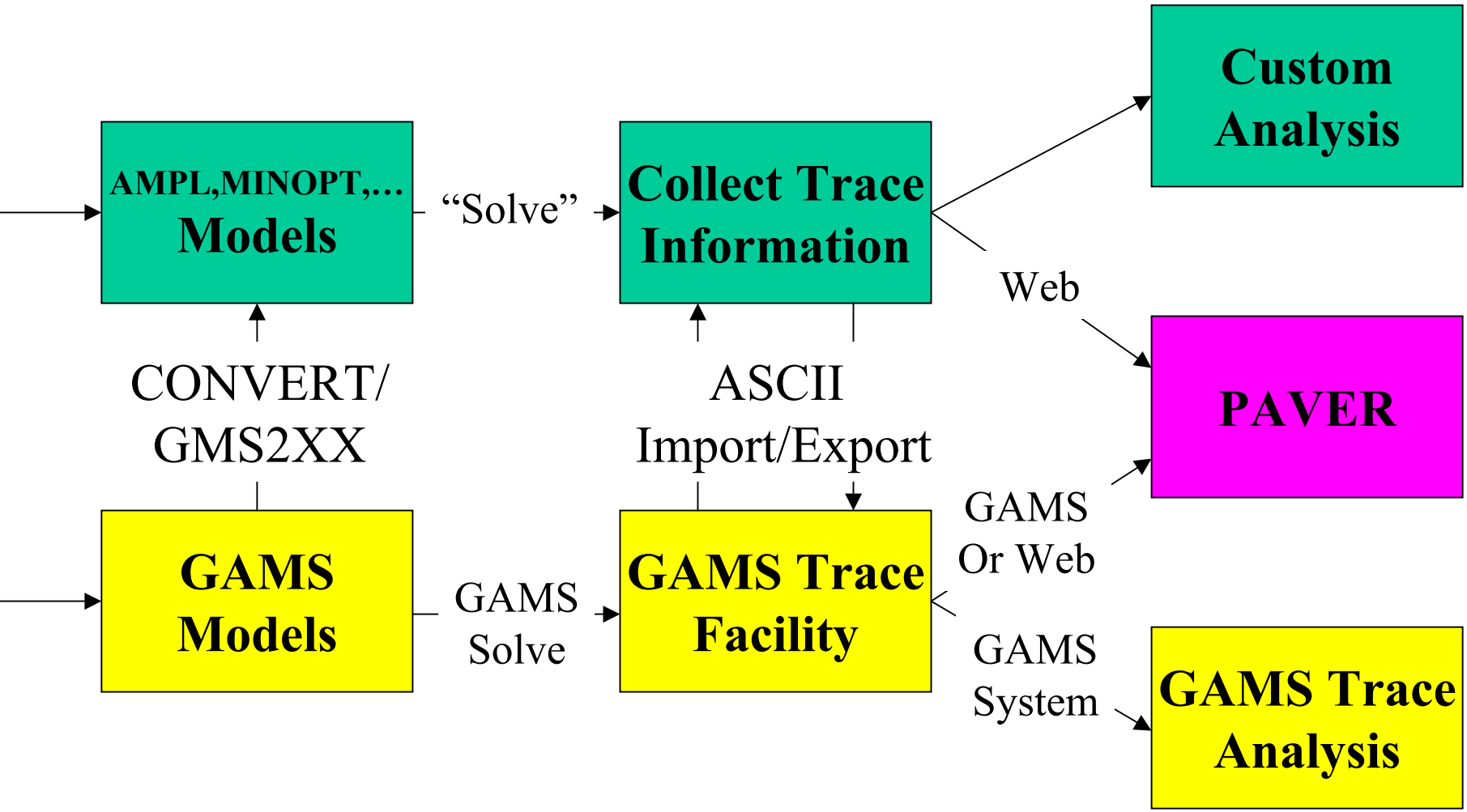
QA Tests for Reducing Risk

- Replication of quality assurance results critical factor for establishing a new solver technology in the commercial world
- Non-reproducible tests damage the reputation of a solver
- Requirement: low cost replication of such results by an independent auditor

Effective Testing

- Test cases
  - Widely available collection of standardized test instances
- Data collection tools
  - Automatic collection of solution and statistics
  - Capture test environment setting (hardware, software)
- Data analysis tools
  - Standard quality and performance measurements

Open Testing Architecture



Performance Tools

Download Performance tools:

Download the Performance Tools and sample data.

- Ptools.zip

Includes the following tools:

- pprocess.gms - performs all performance tools on a given set of trace files and combines output in a summary HTML page.
- pprofile.gms - performance profile routine for solver comparisons
- plotprof.gms - performance profile plotting routine using Gnuplotxy (Windows only)
- restime.gms - Resource time comparison utility
- schulz.gms - termination routine to ensure solvers terminate at resource time limit
- square.gms - solver outcome comparison utility

Also includes the following sample data files, where solvers have been renamed to generic A, B, C to hide proprietary data:

PAVER Web Submission

[Performance World Home | Board | Tools | PerformanceLib | Links | Performance-List | Search | Contact]

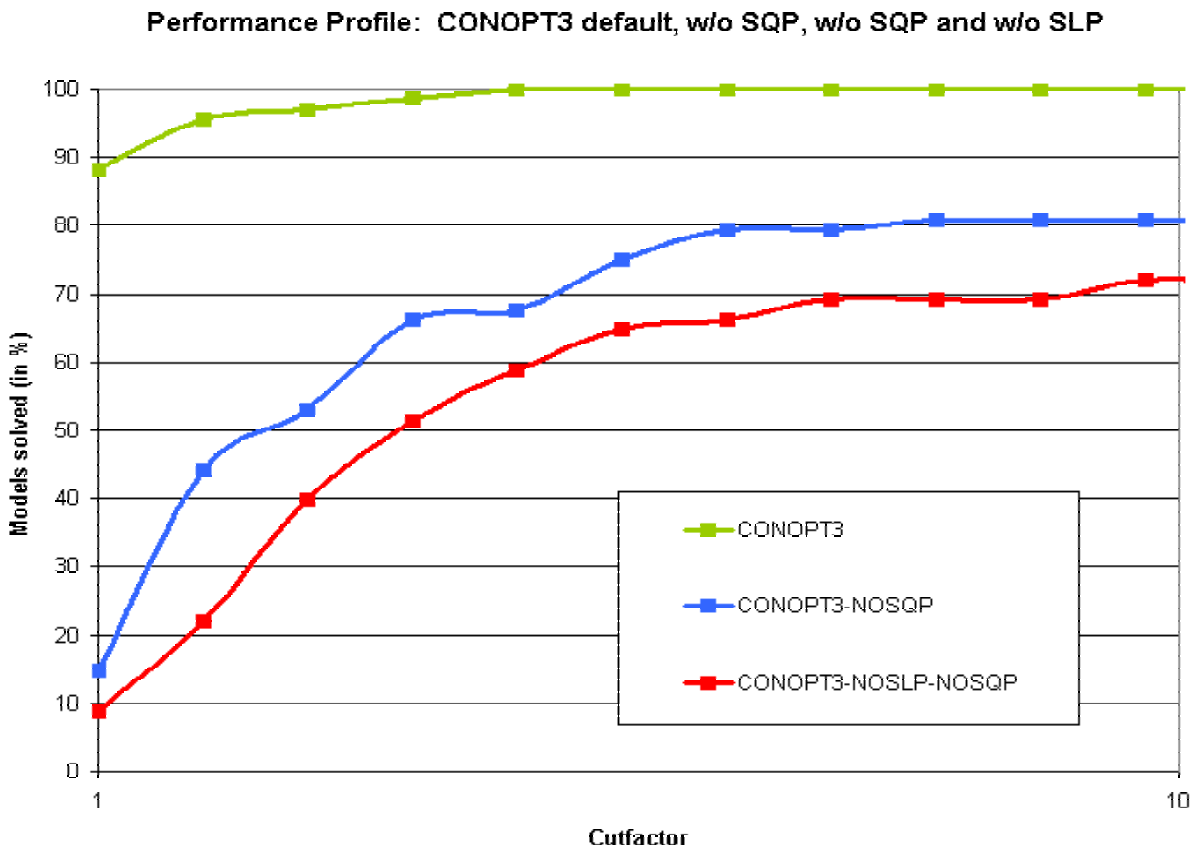
PAVER - Performance Analysis Web Submission Tool

Email Address (required): SDirkse@gams.com

	Submit trace file:		Rename solver:
Trace 1 (required)	CONOPT.TXT	Browse...	
Trace 2 (required)	MINOS.TXT	Browse...	
Trace 3	SNOPT.TXT	Browse...	
Trace 4	OQNLPCONOPT.TXT	Browse...	OQNLP/CONOPT
Trace 5	OQNLPMINOS.TXT	Browse...	OQNLP/MINOS
Trace 6	OQNLPSNOPT.TXT	Browse...	OQNLP/SNOPT
Trace 7		Browse...	
Trace 8		Browse...	

Submit Trace Files | Clear Form

CONOPT3 Performance



Trace Facility ASCII Interface

Trace file parameters

The column headers for `traceopt=3` are as follows:

```
 1. filename:     GAMS model filename
 2. modeltype:    LP, MIP, NLP, etc.
 3. solvername:
 4. NLP def:      default NLP solver
 5. MIP def:      default MIP solver
 6. juliantoday:  start day/time of job
 7. direction:    0=min, 1=max
 8. equnum:       total number of equations
 9. varnum:        total number of variables
10. dvarnum:      number of discrete variables
11. nz:           number of nonzeros
12. nlnz:         number of nonlinear nonzeros
13. optfile:      1= optfile included
14. modelstatus:
15. solvestatus:
16. obj:          value of objecive function
17. objest:       objective function estimate
18. res used:     resource time used (sec)
19. iter used:    number of solver iterations
20. dom used:
21. nodes used:
22. user1:        user comment - preceded by a #
```

Conclusions

- Commitment to quality assurance in the optimization world (critical for success in the commercial environment).
- Helped GAMS to transform an expensive and unpopular activity into an asset.
- Presentation with all examples (will be) available at `http://www.gams.com/presentations`