The Corrector

Iteration 2 Substep 2 **January 1996**

A NEWSLETTER FOR THE NPARC USERS ASSOCIATION

From the Support Team

Our third major release of NPARC will be available soon with some major changes that the user community has been asking for. See the articles on Version 3.0 and the parallel processing development effort for more information. Also take a look at the article on the results of the last user survey. The next user survey will be out shortly and your input is important to us.

To let us know what you think or for support questions, the NPARC support team can be contacted at:

e-mail:
nparc-support@info.arnold.af.mil

phone:
(615) 454-7455

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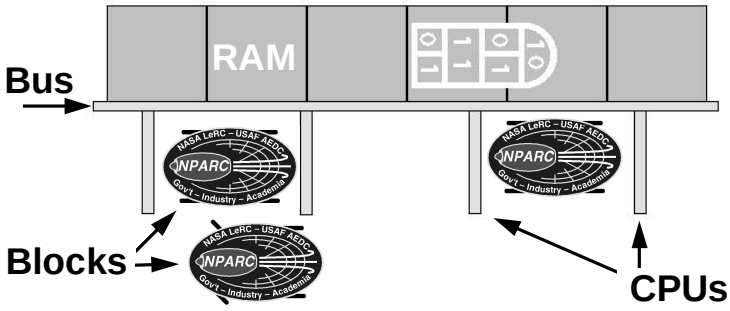
Version 3.0 Nearing Completion

Version 3.0 of NPARC is nearing completion, with Beta testing slated to begin in January. The current release date is expected to be mid-March. We think it will be worth the wait. A few items in the original Version 3.0 wish list have been delayed, but we have added a few based on user input. Here is a list of new or improved features. See related articles on some of these items for further details.



Version 3.0 makes parallel NPARCing possible on workstation clusters and coarse grain parallel platforms.

- Parallel Implementation - The code has been extensively modified to take advantage of parallel computer platforms and distributed workstation networks.
- Spalart-Almarass Turbulence Model - This one equation turbulence model performs quite

What's Inside

well for wall bounded and free-shear layers.

- Updated CMOTT Turbulence Module
  Wall functions have been added.

- Dynamic Memory Allocation
  You asked for it. Now, no more modifying NPARC.INC for every case and re-compiling. The code now looks at your input file to determine how much memory is required and allocates this memory at run time.

- Improved Block Interface Input
  A new block interface BC is now available which allows the user greater flexibility and reduces the input information required. The user simply specifies that the boundary is a block interface and the code determines the connectivity automatically. As an option, the user can provide a list of blocks from which interpolations could be made, otherwise all blocks are searched.

- Improved Contiguous Block BC
  You've asked for this one too. You no longer have to specify a one cell overlap if two block boundaries match point-to-point or if periodic boundaries match point-to-point. This will significantly reduce the grid generation requirements and errors associated with generating overlaps.

- No Need to Specify Normal Direction
  As an added benefit to the implementation of the improved block interface input, the user is no longer required to specify the normal direction for each boundary. The code will do it for you based on you BC input and the grid topology.

As a consequence of some of these changes, e.g. parallel and dynamic memory, subroutines written in the C programming language are required. For now, a FORTRAN only version will be made available, but without full functionality. Operation of the code will also be completely backward compatible with previous versions of NPARC.

As always, we encourage comments from users concerning our current and future plans. We also encourage your contributions to the development effort. Several modifications supplied by developers outside of the NPARC Alliance have been incorporated. If you would like to have your favorite features incorporated and maintained by the NPARC Alliance, give us a call or send an email message.

WWW Update

We are continuing to update our World Wide Web information service. A major new feature is the validation archive which is described in the related article on the validation effort. We have added a "What's New" hotlink and have modified the Pre- and Post-Processing page. The NPARC Alliance does not endorse any particular pre- or post-processing package. Therefore, if you have a favorite package that is not listed, let us know and we'll provide a link to their home page. Also, please let us know of any other information exchange ideas for the NPARC WWW service. The URL is: *http://info.arnold.af.mil/nparc*.

Parallel NPARC Effort

One of the enhancements available in Version 3.0 of NPARC is support for block level parallelism using PVM (Parallel Virtual Machine) from the Oak Ridge National Laboratory. This allows a collection of workstations to pool their computational resources by assigning one or more blocks to each machine and performing the block calculations in parallel. In implementing this enhancement various aspects of the NPARC code have been affected, including the procedure used to build the code, how the code is run, and result files.

To begin with, there are now three distribution files: (1) the "full" distribution which supports parallelism but requires 'make', 'm4', a C compiler, a FORTRAN compiler, and a UNIX-like operating system, (2) a 2D FORTRAN-only distribution, and (3) a 3D FORTRAN-only distribution. The latter two distribution files are supplied for those users who do not need the parallel features and would prefer a pure FORTRAN 77 version of the code to work with. The rest of this article describes the "full" distribution.

After unpacking the full distribution you'll notice new directories and a significantly different 'Makefile' from previous releases. The 'Readme' file in the 'doc' subdirectory gives a fair description of how the files are laid out in the directory tree. There is now more commonality between the 2D and 3D versions of NPARC, and you don't have to edit any makefiles to build the code for any of the supported machines (including Convex, Cray YMP, Cray T3D, HP, IBM, IBM SP2, SGI, and Sun). Users familiar with how PVM is built

will recognize similarities with how the new NPARC code is built.

The parallel code uses a master/worker paradigm. A master process is responsible for coordination and file access while worker processes do the block calculations. A shell script, ' runnparc' handles system startup, fault recovery, and system shutdown issues. The same script is used for all machines and isolates you from the differences of the different parallel machines.

The performance of the parallel code is highly dependent upon the load balance between worker processes. While the master process does perform static load balancing at initialization time, large differences in block sizes limit how much parallel speedup is even theoretically possible. Another major affect on performance is file I/O. The new code supports a variety of methods to tune the application to the available hardware, either through compile-time parameters in the NPARC.INC file or via environment variables.

With block calculations split among worker processes running in parallel, both where result data is stored and the result data itself are slightly changed. First, since blocks are being calculated in parallel, the interface data available at the time a block iteration is calculated will differ from the serial case, slightly affecting the convergence history. The effect is analogous to running a serial calculation with different IBORD arrays specified. Second, due to the way results are output you get multiple result files (one per worker process) rather than a single file. The ' runnparc' script will retrieve these files if they are written on a remote disk, but at this time there is no tool which automatically merges the various files into one. Of course, when run serially the new code will still write a single file which matches the output from the previous release.

The parallel processing capability of NPARC Version 3.0 will increase performance for many users, however some time is required to get used to how the new code is built and run. Some aspects, such as greater commonality between 2D and 3D versions and file I/O optimizations, should be beneficial to serial NPARC users as well.

User Association Meetings

The NPARC User's Association meeting at the AIAA JPC meeting on July 11, 1995 was attended by about 25 users and developers. Most of the discussions focused on plans for Version 3.0 (see related article).

A summary of some recent applications of NPARC at AEDC and NASA LeRC was distributed. If you would like a copy, let us know. We plan to make this an annual publication and would like to have representation from all users. Send us a color plot and a brief (1/2 page) description of your favorite application and we'll see that it is included in the next publication. Please send us a note stating that the information is cleared for public release.

User survey results were discussed at the user's meeting. These results are summarized in a related article. The next survey should be going out soon. (We hope to have an electronic version available on the WWW.) Please fill it out. This is how we know what you, the user, think is important.

There were also two NPARC sessions at the JPC. featuring NPARC developments and applications from a wide range of users. The paper numbers are 95-2609 to 95-2616, 95-2627, and 95-2755 to 95-2757. Abstracts of each of these papers can be found in the NPARC reference database accessible from the NPARC WWW server.

The following is a list of upcoming NPARC User's Association meetings:

January 15, 1996 7-9pm
AIAA Aerospace Sciences Meeting
Reno, NV

Two NPARC Technical Sessions on January 16

July 1-3, 1996
AIAA Joint Propulsion Conference
Lake Buena Vista, FL

One NPARC Technical Session

January 1997
AIAA Aerospace Sciences Meeting
Reno, NV

Technical Sessions planned

June 1997
AIAA Applied Aerodynamics Conference

Technical Sessions planned

Please plan to attend the User's meeting to let your views be known. You are also encouraged to contribute to the NPARC technical sessions to communicate your experiences to other users.

CMOTT Turbulence Model Update

The wall functions for the CMOTT two equation eddy viscosity turbulence models have been added to CMOTT' s turbulence module for the NPARC code. CMOTT (the Center for Modeling of Turbulence and Transition), a focus group within the Institute for Computational Mechanics in Propulsion (ICOMP) at NASA Lewis Research Center, has been developing a turbulence module for the NPARC code since it joined the NPARC Team in the Fall of 1994. The first version of the CMOTT turbulence module, which contains a number of low Reynolds number k-ε eddy viscosity models, was made available to NPARC users community in NPARC Version 2.2. The current version with the added wall functions feature will be available in NPARC Version 3.0.

In using the low-Reynolds number two equation eddy viscosity models for wall bounded flows, very fine grid spacing is needed to resolve the flow field near the wall. Such a grid resolution requirement leads to a considerable computational burden, especially for complex, three-dimensional flows of engineering interest. Furthermore, the highly stretched nature of mesh distribution used for low Reynolds number two equation turbulence models often has an adverse impact on numerical stability. In contrast, the use of the wall functions obviates the above mentioned numerical difficulties because the governing equations are integrated only down to the lower end of the log-layer and wall functions are used to bridge the region between the log-layer and the wall. In CMOTT' sturbulence module for the NPARC code, an implicit procedure was used to implement the wall functions so that the resulting program is numerically very robust. The wall functions were also reformulated so that computations can be carried out for flows with separation and reattachment.

Code Validation Update

The Validation Team has been continuing in its efforts to develop a database of validation cases covering a range of flow parameters and geometric configurations. Model validation studies currently underway are:

- Subsonic diffuser flow
- Flat plate boundary layer with heat transfer
- 3-D glancing sidewall shock/boundary layer interaction

The 3-D glancing shock problem has been documented as an example case, and includes results using the Baldwin-Lomax and the Chien turbulence models. The relevant files and documentation are available through the NPARC WWW server and via anonymous ftp.

To access the cases currently available in the NPARC Validation Database connect to the NPARC WWW Homepage and follow the validation database link. To access this same information via ftp connect to *info.arnold.af.mil* and log in as "anonymous". Change directories to *pub/nparc* and look at the file *readme*. A "readme" file is present in each directory to explain the contents.

Additional model studies or example cases scheduled to begin in the next several months are:

- Rearward facing step
- MADIC axisymmetric nozzle afterbody
- Unsteady normal shock
- S-duct

Two experiments being run at NASA Lewis, one with an unsteady normal shock in a circular pipe, and one with crossed oblique shocks, will supply experimental data useful for NPARC validation.

Two papers from the validation effort will be presented during the NPARC sessions at the 1996 AIAA Aerospace Sciences Meeting in Reno, NV. One, on Tuesday morning in Session 56-GT-3, will describe the current status of the overall validation effort and present selected results. The other, on Tuesday afternoon in Session 76-GT-4, will present detailed results from the subsonic diffuser flow study.

Frequently Asked Questions

The user support team receives many calls and email messages requesting information on code operation. The following are some of the more frequently asked questions.

Can I run NPARC on a PC?

Yes, the code has been successfully run on several PC platforms using several different compilers. FORTRAN77 standards have been adhered to as much as possible, but there may be a few problem areas. Standard NAMELIST is no longer used in the code, so follow the correct

NPARC syntax. You may need to specifically open units 5 and 6 instead of allowing the default behavior, particular for unit 5, standard input. Also, be sure to set NBYTE = 4 to ensure that the correct record length is allocated to the direct access files.

User Survey Results

For the most part, the results of the FY95 NPARC User Survey are very consistent with those from the FY94 survey. In both years approximately 120 surveys were distributed to current NPARC users and about 25% were returned. The majority of questions common to both surveys received comparable ratings each year. It is clear from the surveys that current NPARC users are satisfied with their experiences with this flow simulation tool (compared to the competition), but that they need several items to be addressed if they are to produce the results required of them.

Users were asked a series of questions in four categories: Fit to User's Needs, Support, Development, and Validation. Each question could be rated on a scale from one to seven. The responses for each question were weighted according to their rating and then totaled to produce a net score. These scores were used to evaluate the worth of NPARC Alliance activities or NPARC computer program features.

Fit to User's Needs

Users were asked to:

> *Evaluate the capability of the NPARC flow simulator to meet your organization's needs.*

Users generally felt that the NPARC Alliance should concentrate on turn-around-time and accuracy issues. The users were satisfied with areas in which the user organizations have considerable control over the result (computer systems, staffing, and support software).

Support, Development and Validation

In these three sections of the survey, users were requested to:

> *Evaluate each of the proposed NPARC Alliance user support activities according to your perceptions as to how a successful result would impact your organization.*

Support

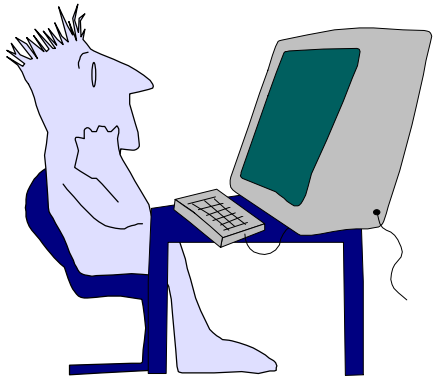
It is clear that the NPARC Alliance **must** produce an excellent User's Guide and be very responsive to bug reports. While not as critical, it is apparent that the NPARC user base considers a good Programmer's Manual and timely responses to their problems in applying the NPARC flow simulator to their applications to be of high value. Reinforcing the results from the last survey, current NPARC users see very little value in training or consultation services. While information sharing, i.e. newsletters, meetings, etc., fairs better, some aspects of this service were considered to be of marginal utility. Since the ratings for user meetings and newsletters have been consistently low, the Alliance needs to make sure that the primary purpose of these activities is to meet internal Alliance requirements.

Development

Although rather general features, the top two items requested by users for development correlate well with the top two responses in the Fit to User's Needs part of the survey, i.e. turn-around-time and accuracy. The user survey places high importance on the ability of the NPARC flow simulator to efficiently treat flow with regions of low subsonic flow and on improved two-equation turbulence modeling. Very little interest was expressed in extensions in the physical scope of the NPARC program, with the sole exception of time accuracy. In particular, all forms of chemically reacting and multi-phase flows are considered unnecessary. Several items which bear on maintainability of the NPARC computer program (combined 2D/3D solver and finite volume scheme) were rated just above the physical scope extensions and should be further considered only if of worth to the Alliance itself.

Validation

Users generally considered the investment in validation of the NPARC flow simulator and in the development of example cases representative of typical applications to be nearly essential. However, they rated the conduction of validation experiments by the NPARC Alliance to be of marginal utility. The results of last year's survey showed that there is no general agreement on particulars.



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