Develop a complete strategic agenda to guide EU investments in HPC and to help drive European leadership in using and providing HPC

- Increase scientific and research competitiveness
- Increase the use of HPC for economic growth
- Bring together users and vendors to help ensure that offerings match users' requirements
- Enlarge/deepen the use of e-Infrastructure computing services to meet the growing demand from academia and industry

Contract Number: 2009/S99-142914
EU Contract Manager: Bernhard FABIANEK, Performance Computing Officer
European Commission, DG Information Society, Unit F03 — office BU25 04/087
25 Avenue Beaulieu, B-1160 Bruxelles
Overall Study Process Approach

IDC HPC Databases

Survey Input From European Users, Vendors and Stakeholders

Technical Working Group Ideas, Suggestions, etc.

Broader Inputs From The Web Site

Extensive Analysis #1: What is the current situation and European view points?

Interim Report: April 2010

EU Advice/Ideas

Additional Executive Discussions

Extensive Analysis #2: What are the options, and what should be done for leadership?

Recommendations Report With SWOTS: July 2010

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External Technical Committee

- **Richard Blake**, Acting Director - Computational Science and Engineering Department, Daresbury Science and Innovation Campus, UK

- **Prof. Dr. Arndt Bode**, Chairman of Board of Directors - Leibniz-Rechenzentrum, Germany

- **Dr. Friedel Horst Willi Hossfeld**, Professor Emeritus - Forschungszentrum Jülich, Germany

- **Hervé Mouren**, Managing Director - Teratec, France

- **Christian Saguez**, Teratec, France
One Reason Action Is Needed: A Concern: Will China Exceed The EU In Supercomputers?

From:
A June 30, 2010 interview with Jack Dongarra, by Sander Olson

Question:
How quickly will China become a major player in the HPC space?

Dongarra Answer:
China is already a major player. In 2001, China had no machines in the top500 supercomputer list.
They have more computing power than Japan, which is considered a supercomputing powerhouse, and
“I predict that within a year they will have surpassed the entire European Union with its 27 nations.”
China may soon have the fastest computer on the planet, and should soon have scores of systems in the top500.
#2 in China: Nebulae’s New Home – National Supercomputing Center in Shenzhen, China
HPC use is indispensable for advancing both science and industrial competitiveness.

Europe is under-investing in HPC, while other nations are growing their supercomputer investments dramatically:

- Even in 2009, the most difficult year of the global economic recession.

The transition to petascale and exascale computing creates opportunities:

- For Europe to return to the forefront of development for the next generation of research and HPC software/hardware/storage/networking technologies.
Europe declined from 34.4% in 2007, to 24.8% in 2009

**TABLE 6**

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>CAGR (05–09)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total WW Revenue</td>
<td>2,160,829</td>
<td>1,925,165</td>
<td>2,011,793</td>
<td>2,014,596</td>
<td>2,527,058</td>
<td>4.0%</td>
</tr>
<tr>
<td>North America Revenue</td>
<td>1,043,865</td>
<td>903,948</td>
<td>932,183</td>
<td>1,031,201</td>
<td>1,291,493</td>
<td>5.5%</td>
</tr>
<tr>
<td>Europe Revenue</td>
<td>614,307</td>
<td>582,989</td>
<td>692,038</td>
<td>592,535</td>
<td>627,732</td>
<td>0.5%</td>
</tr>
<tr>
<td>** Percent of WW</td>
<td>28.4%</td>
<td>30.3%</td>
<td>34.4%</td>
<td>29.4%</td>
<td>24.8%</td>
<td></td>
</tr>
<tr>
<td>Asia/Pac Revenue</td>
<td>249,244</td>
<td>204,639</td>
<td>228,972</td>
<td>219,970</td>
<td>226,608</td>
<td>-2.4%</td>
</tr>
<tr>
<td>Japan Revenue</td>
<td>231,745</td>
<td>206,965</td>
<td>122,733</td>
<td>137,872</td>
<td>348,448</td>
<td>10.7%</td>
</tr>
<tr>
<td>Rest of World Revenue</td>
<td>2,669</td>
<td>8,594</td>
<td>14,464</td>
<td>14,692</td>
<td>13,362</td>
<td>49.6%</td>
</tr>
</tbody>
</table>

Source: IDC, 2010
FIGURE 2

EU Total Over $3M/€2.25M + High-End Supercomputer Revenue Mix by Country, 2009

- Germany (31.5%)
- France (19.8%)
- U.K. (16.3%)
- Italy (15.2%)
- Spain (5.0%)
- Sweden (2.9%)
- All Others (9.2%)
In 2009, EU spending was greatest for systems in the following application sectors, in order of the amount spent:

- University/academic ($370 million)
- Bio-sciences ($354 million)
- CAE ($337 million)
- Government labs ($302 million)
- Defense ($208 million)
### TABLE 28

**EU Countries HPC Revenue (€000) by Application, 2005–2009**

<table>
<thead>
<tr>
<th>Application</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>CAGR (05–09)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-Sciences</td>
<td>302,182</td>
<td>331,635</td>
<td>348,304</td>
<td>322,705</td>
<td>265,509</td>
<td>-3.2%</td>
</tr>
<tr>
<td>CAE</td>
<td>261,610</td>
<td>294,130</td>
<td>316,270</td>
<td>299,927</td>
<td>252,487</td>
<td>-0.9%</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>43,681</td>
<td>51,332</td>
<td>57,368</td>
<td>56,064</td>
<td>48,493</td>
<td>2.6%</td>
</tr>
<tr>
<td>DCC &amp; Distribution</td>
<td>97,497</td>
<td>102,734</td>
<td>102,900</td>
<td>89,934</td>
<td>69,348</td>
<td>-8.2%</td>
</tr>
<tr>
<td>Economics/Financial</td>
<td>42,898</td>
<td>50,917</td>
<td>56,969</td>
<td>55,636</td>
<td>48,018</td>
<td>2.9%</td>
</tr>
<tr>
<td>EDA</td>
<td>126,954</td>
<td>141,789</td>
<td>150,907</td>
<td>140,428</td>
<td>115,781</td>
<td>-2.3%</td>
</tr>
<tr>
<td>Geosciences and Geo-engineering</td>
<td>107,260</td>
<td>119,138</td>
<td>126,176</td>
<td>117,248</td>
<td>96,894</td>
<td>-2.5%</td>
</tr>
<tr>
<td>Mechanical Design and Drafting</td>
<td>38,718</td>
<td>41,583</td>
<td>42,306</td>
<td>37,792</td>
<td>29,774</td>
<td>-6.4%</td>
</tr>
<tr>
<td>Defense</td>
<td>131,623</td>
<td>155,652</td>
<td>175,132</td>
<td>174,738</td>
<td>155,639</td>
<td>4.3%</td>
</tr>
<tr>
<td>Government Lab</td>
<td>309,590</td>
<td>325,110</td>
<td>324,815</td>
<td>286,797</td>
<td>226,579</td>
<td>-7.5%</td>
</tr>
<tr>
<td>Software Engineering</td>
<td>4,472</td>
<td>4,474</td>
<td>4,240</td>
<td>3,520</td>
<td>2,563</td>
<td>-13.0%</td>
</tr>
<tr>
<td>Technical Management</td>
<td>22,192</td>
<td>22,058</td>
<td>20,479</td>
<td>16,417</td>
<td>11,285</td>
<td>-15.6%</td>
</tr>
<tr>
<td>University/Academic</td>
<td>339,481</td>
<td>365,139</td>
<td>375,398</td>
<td>341,381</td>
<td>278,036</td>
<td>-4.9%</td>
</tr>
<tr>
<td>Weather</td>
<td>87,922</td>
<td>93,970</td>
<td>96,225</td>
<td>87,239</td>
<td>70,561</td>
<td>-5.4%</td>
</tr>
<tr>
<td>Other</td>
<td>648</td>
<td>2,484</td>
<td>4,422</td>
<td>5,768</td>
<td>6,138</td>
<td>75.4%</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td><strong>1,916,730</strong></td>
<td><strong>2,102,146</strong></td>
<td><strong>2,201,912</strong></td>
<td><strong>2,035,594</strong></td>
<td><strong>1,677,105</strong></td>
<td><strong>-3.3%</strong></td>
</tr>
</tbody>
</table>

Source: IDC, 2010
Study Highlights: Successful HPC Programs (As Seen By HPC Experts)

Most successful international HPC programs:
2. U.S. Department of Energy — INCITE (9)
3. U.S. National Science Foundation – NSF (8)
4. Japan's RIKEN /Keisoku Project (7)
5. U.S. Department of Defense — DARPA (5)
6. U.S. Department of Defense — HPC Modernization Program (3)
7. PRACE (2)
8. IESP (2)

Most successful EU HPC Programs:
1. PRACE (14)
2. DEISA (10)
3. CEA-DAM (4)
4. CERN (4)
5. HPC Europa (4)
6. Blue Brain –EPFL (2)
7. EGEE (2)
8. ESA (2)
9. Forschungszentrum Juelich (2)
10. GEANT (2)
The survey respondents see the areas of expertise most needed from HPC user organizations as:

- Expertise in parallel programming for highly parallel HPC systems
- Expertise in creating advanced software algorithms
- The ability to port and optimize applications for new hardware architectures, including heterogeneous architectures that include newer processor types
### TABLE 58

**What is Your Company/Organization's Current Funding Approach for HPC?**

<table>
<thead>
<tr>
<th>Approach</th>
<th>Respondents</th>
<th>Percentage of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our internal funding is helped by government funding from within our country</td>
<td>34</td>
<td>65.4%</td>
</tr>
<tr>
<td>Our HPC is primarily funded by our own organization</td>
<td>26</td>
<td>50.0%</td>
</tr>
<tr>
<td>We receive multi-country funding, but it is less than 20% of our HPC costs</td>
<td>5</td>
<td>9.6%</td>
</tr>
<tr>
<td>We have public-private partnership(s) that help to fund our HPC</td>
<td>5</td>
<td>9.6%</td>
</tr>
<tr>
<td>We receive multi-country funding, and it is more than 20% of our HPC costs</td>
<td>3</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

Note: Multiple responses were allowed. 52 sites responded to this question.

Source: IDC, 2010
The survey respondents' ideas for the best funding models to pursue HPC goals in Europe included:

- Provide an EU-wide framework (such as PRACE) to drive toward HPC goals
- Create sustained, multi-year funding
- Focus funding most heavily on a limited number of well-defined scientific and industrial problems, and use a cost-benefit analysis to identify these problem domains
- Focus more on software than hardware
- Base access heavily on grants awarded through peer-reviewed proposals
Funding Models That Have Failed in HPC:

- Models based on short-term goals
- Funding heavily focused on many small projects rather than a few large ones
- Funding procurements that include protectionist measures
- Models that impose overly burdensome bureaucratic requirements to gain access to HPC resources.
- Models that require organizations to pay to use HPC resources
- Models that require countries to "buy their way in"
- Models aimed at developing new HPC system architectures
From The Interim Report: Top Areas That Stakeholders Said The EU Should Focus On

What are the most important approaches for EU HPC leadership?

<table>
<thead>
<tr>
<th>Approach</th>
<th>Number of Responses</th>
<th>Percentage Of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Making world-class HPC resources more widely available to the EU scientific and engineering communities</td>
<td>57</td>
<td>93.4%</td>
</tr>
<tr>
<td>Advancing scientific leadership by using HPC to solve some of the world's most challenging problems</td>
<td>50</td>
<td>82.0%</td>
</tr>
<tr>
<td>Making HPC more readily available for the first time to small and medium-size businesses (including industrial supply chains, small educational sites, etc.)</td>
<td>33</td>
<td>54.1%</td>
</tr>
<tr>
<td>Having many very large supercomputers, e.g., being at or near the top of the Top500 list of the world’s most powerful supercomputers (<a href="http://www.top500.org">www.top500.org</a>)</td>
<td>25</td>
<td>41.0%</td>
</tr>
<tr>
<td>Building an EU-based HPC vendor community with world-class capabilities in important areas (hardware, software, storage, networking, etc.)</td>
<td>24</td>
<td>39.3%</td>
</tr>
</tbody>
</table>
Part 2: Final Report: Strategic Agenda

Recommendations
Proposed Vision
For EU
HPC Leadership

Note: Over 200 HPC experts across the EU have provided ideas, insights and suggestions in the creation of this report and proposal.
Provide World-Class HPC Expertise and Resources

To Make EU Scientists, Engineers And Analysts The Most Productive and Innovative In The World

In Applying HPC To Advance Their Research

In The Pursuit Of Scientific Advancement And Economic Growth
Potential Results From The Vision

By the year 2020, the EU HPC strategy has enabled the following progress to occur:

1. Europe is recognized as a hotbed for new science and engineering research.

2. Europe's leadership in the targeted areas has created many new jobs in science and industry, and has caused the national economies to grow faster.
   • Europe's move to the forefront of progress in other areas has preserved many existing jobs in both science and industry.

3. Europe is the world leader in important high-end HPC technologies.
   • Europe leads the world in scalable algorithms and software applications, and in tools to make HPC systems easy-to-use and to make researchers highly innovative and productive.
Vision → Results

Vision

- Provide world-class HPC resources
  - To make EU scientists, engineers and analysts
    - The most productive and innovative in the world
  - In applying HPC to advance their research
  - In pursuit of scientific advancement and economic growth

Results

- Adds billions of euros a year to European economies by 2020
- Make the EU a hotbed for scientific and engineering research
- Invigorate EU institutions by making EU researchers the most productive in the world
- Expand the HPC ecosystem across the EU creating a vibrant HPC supplier economy
Actions Required
Europe Needs To Invest In/Support A Robust HPC Industry With Hardware, Software, Etc.

Hardware:

• Develop unique capabilities for use in standards-based systems, e.g. interconnects, system design, packaging, power and cooling, alternative processors, SSDs, etc.

• IDC recommends that the EU avoids making any excessively large R&D or NRE investments (in the €1+ billion range) in exotic custom areas

Software:

• Exploit world-class strengths in Europe

• Algorithms, compliers, system software, file systems, applications, libraries, etc.

Storage:

• Advanced storage systems and file systems

Networking:

• Internal and external to the exascale system, high-bandwidth, low latency communications, grids and perhaps clouds
1. First is the need for expanding the number and size of HPC resources across the EU (including broader access to the tools by all EU researchers).
   • An expanded PRACE can address this requirement.

2. Second is to provide broader access to industrial HPC users.

3. Third is to make HPC users more productive by creating the world's best tools, training and development environment.
   • Requires a new initiative (HPC development labs/test-beds).

4. Fourth is to attract more students into scientific, engineering and HPC fields and to attract more experts around the world to join in EU projects.
   • Requires additional funding and a "Magnet" program.

5. Fifth is the need to increase funding in developing next generation Exascale software.

6. Sixth is to target a few strategic application areas for global leadership.
Recommended Enhancements to PRACE:

1. First is increasing funding to provide for more very-large systems and for more systems across the EU.

2. Second is increasing access to researchers in science and industry.
   - And to include more countries.

3. Third is the enhanced charter and perhaps a new name:
   - Expand the mission, stature and funding of the PRACE program to make it the central EU organization responsible for pursuing the mainstream system acquisition and operating EU HPC strategy on behalf of, and in collaboration with, the member states.
   - The creation of an EU HPC system strategy elevates HPC to an appropriate, larger role within Europe.
   - An expanded central organization is needed to pursue the strategy and to signal the EU's increased commitment to HPC leadership.
These new HPC development labs/test bed centers are needed to address these weaknesses in HPC today:

- **Most large HPC systems are very hard to use by all but the most talented experts.**

- **The productivity in using highly parallel systems is very low, no matter which metric ones uses:**
  - Time to get an application up and running vs. the usefulness of the results.
  - Time to optimize codes vs. the speed-up obtained.
  - Percentage of the system that can be effectively used by a user's job.

- **There are a limited number of scientists, engineers and analysts in the EU.**
  - While other countries like China and India have strong growth in graduates, making the productivity of these experts a critical deciding factor in the advancement of science and research.
What the new HPC development labs/test-bed centers could look like:

- These would be dedicated HPC centers with the goals of helping users, researchers and companies make their codes and products highly scalable and highly productive.

- These HPC systems would only be used in a test and development mode.
  - They may crash hourly as new algorithms, new codes or even new hardware is being tested, optimized and made resilient.

- The systems need to be large, but not extremely large.

- The HPC development test-beds should have major training and teaching responsibilities. They should offer classes in advance HPC, again with a focus on making users and products more productive.
  - This requires a strong technical staff, along with teachers and HPC experts across multiple domains.
What the new HPC development labs/test-bed centers could look like:

- To support individual users and researchers across the EU.
  - For example, if a scientist has an idea on how to make their codes run at a larger scale, they could make use of the test-bed systems and staff to figure out new algorithms, test them at scale, make improvements and then take the results back to their home organization.

- They would also support the broader EU vendor community and ecosystem.
  - For example if a vendor like Bull decides to research a new interconnect for exascale systems, they could use these HPC development test-beds for testing out the new interconnects by physically installing the new hardware, and the running tests, de-bugging and making their product more resilient.

- The EU should help support the broader HPC ecosystem by making these resources free to all, for development and testing work only.
To accomplish the major objective on making Europe the hotbed for scientific research, the EU needs to fund a number of "Magnet" programs to attract top scientists, recent graduates, and other researchers to European institutions.

The magnet program should include:

- Funding of highly prestigious positions/seats at top EU educational institutions. These need to include sizeable research grants to attract the top talent.
- Create a new degree-like position between a Ph.D. and a professor. And invite selected top researchers and top new graduates to attend these degree programs at no cost.
- Broad incentives should be used including prestigious positions and titles, open access to leading scientific projects, etc.
- These positions need an exciting title and full press coverage.

The goal should be to start ASAP with 10's of these new positions, growing quickly to 100's per year.
• IDC recommends that the EU buys the 4th or 5th exascale system, and does not invest in developing the first 1, 2 or 3 exascale systems in the world.
  
  • This strategy could save a billion plus euros
  • → that can be used in buying more systems and making EU researchers more productive.

• Europe could save even more by instead aiming to purchase a near-exascale system in this timeframe, but 1 year later.
  
  • We estimate that this would substantially reduce the technical challenges (e.g., hardware/software scaling) and associated costs.
  • Such that an investment on the order of €150 to €200 million per system would likely suffice.
  • The resultant near-exascale supercomputer would still sustain unrivaled performance in the targeted application domain, and still attract the best researchers and collaborations.
Investments
Required
It is recommended that the EU and the nations make HPC a higher priority and step up to either the “Full leadership level” or at least the “Funding to reach major goals level” scenario level.

- This would require a net new investment reaching 600 million euros a year within five years.
## Alternative HPC Funding Scenarios: Yearly Funding ADDITIONS By Year Five

(Millions of euros added per year)

<table>
<thead>
<tr>
<th></th>
<th>Full Leadership Funding Level</th>
<th>Funding To Reach Major Goals Level</th>
<th>Partial Funding Level</th>
<th>Minimal Increase Funding Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPC System Funding Increases</td>
<td>250</td>
<td>210</td>
<td>120</td>
<td>50</td>
</tr>
<tr>
<td>HPC Development Test-beds (H/W)</td>
<td>50</td>
<td>40</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>HPC Development Test-beds (People)</td>
<td>75</td>
<td>60</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Exascale Software Development</td>
<td>150</td>
<td>125</td>
<td>55</td>
<td>25</td>
</tr>
<tr>
<td>Scientific Talent Magnet Program</td>
<td>75</td>
<td>60</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Yearly Funding Increase</strong></td>
<td><strong>600</strong></td>
<td><strong>495</strong></td>
<td><strong>260</strong></td>
<td><strong>75</strong></td>
</tr>
</tbody>
</table>

Note: These figures include HPC funding paid by the EU, by member nations and contributions by vendors.

Source: IDC, 2010
In Summary: Actions ➔ Vision ➔ Results

**Actions**
- Expand the number, size and access to HPC resources across the EU
- Add a focus on industrial users
- Create a set of HPC development labs/test-bed centers
- Attract more students and experts from around the world to join in EU projects
- Fund development of next generation Exascale S/W
- Target strategic application areas for global leadership

**Vision**
- Provide world-class HPC resources
  - To make EU scientists, engineers and analysts the most productive and innovative in the world
  - In applying HPC to advance their research
  - In pursuit of scientific advancement and economic growth

**Results**
- Add billions of euros a year to European economies by 2020
- Make the EU a hotbed for scientific and engineering research
- Invigorate EU institutions by making EU researchers the most productive in the world
- Expand the HPC ecosystem across the EU creating a vibrant HPC supplier economy
This now has the interim report and will soon have the final report — and will ask for feedback.
We greatly thank the following for all of the great ideas, feedback, suggestions and advice:

- EC (Kostas Glinos, Bernhard Fabianek, et al.)
- The Technical and Strategy Committee
- All of the members of broader EU HPC Community that contributed to this study

Questions?
Questions?

Please email: hpc@idc.com

Or check out: www.hpcuserforum.com www.idc.com