New Mexico Science and Tech Initiatives, Computing Applications Center

Thomas Bowles
Science Advisor to Gov. Richardson

AAAS Meeting, Albuquerque NM

April 11, 2008

The State Science and Technology Plan (I)

1) Determine priorities for a State Innovation Investment Fund that will provide significant return to NM in economic and workforce development and address important issues in NM

- *NM has remarkable S&T resources at the labs and universities*
  - *Need to retain our intellectual resources in NM*
- *Leverage state investments by drawing on these strengths*
  - *Provides mechanism to support lab diversification*

The State Science and Technology Plan (II)

2) Develop model for how the investments should be made through a coordinated and sustained State investment

- *Based strongly on state needs and market pull (with some technology push)*
- *Based on partnering with institutions in NM*
- *Based on ability to partner with private businesses (through equity investments)*
- *Based on accountability, metrics, and return on investment*

S&T Plan Elements

- Assessment of issues and opportunities (SWOT analysis)
- Elements of investment plan
- Process for making sustaining investments
- Projected Return on Investment
- Metrics, oversight, and accountability processes
- Integrate and coordinate State investments taking into account Federal basic R&D, mid-stage, late-stage, and commercialization efforts
- Include workforce development and education aspects

S&T Plan Core Team

State Offices: Tom Bowles (chair), Stephan Helgesen (vice-chair), Sarah Cottrell, Fred Mondragon, Bill Hume, Lenny Martinez, Roy Soto, Kurt Steinhaus, Eric Witt

Universities: Van Romero, Vimal Chaitanya, Jack McIver

Labs: Terry Wallace, Rick Stulen

Rural NM: Jim Fries, Margaret McDaniel, Gene Simmons, Faye Vowell

R&D Organizations: Garrey Carruthers

Discipline Leaders: Scott Bryant, Casey de Raad, Bill Feiereisen, James Peery

Input from individuals, working groups, town meetings involving more than 200 participants

S&T Plan Interdisciplinary Areas

Economic Development: Stephan Helgesen (NM EDD)

Includes basic research, development, testing, evaluation, technology maturation, commercialization, marketing, investment (private, angel, venture capital, state, Federal, foundations), sustainability, metrics, tracking, business planning, return on investment, integration

Education: Kurt Steinhaus (Governor's Office)

Vice-chairs: Bill Flores (NMHED), Rick Scott (NMPED)

Includes math, technology, science, and engineering, K-12, college, post-graduate, continuing education, professional development, public STEM awareness, cyber academies, charter schools, private schools, community colleges, colleges, universities, distance teaching, R&D at colleges and universities, sustainability, metrics, tracking, business planning, return on investment, integration

Science and Technology Initiatives

- S&T Plan Core Areas:
  - Aerospace
  - Biosciences
  - Energy, Environment, and Water
  - Information Technologies
  - Nanotechnologies

- S&T Initiatives (FY08-09)
  - Energy Innovation/Clean Energy Projects ($5.5M)
  - Water Innovation ($2.5M)
  - Supercomputing ($18.6M)

Aerospace and Computing

Chair - Casey de Raad (AFRL)

Vice-chair: Jay Jordan (NMSU)

Includes aerospace and space sciences.

Includes avionics, unmanned aerial vehicles, spaceport activities, astronomy, astrophysics, remote sensing, satellite imaging, homeland defense, …

Strengths in aerospace and space sciences, remote sensing, astronomy

Grow avionics, Spaceport America, remote sensing and imaging

Blue indicates computationally intensive

Bioscience and Computing

Gary Resnick (LANL)

Vice-chair: Scott Burchiel (UNM Med School)

Includes bioscience and biotechnology.

Includes plant and animal growth and diseases, human health, computational biology, sensor development, therapeutics, natural and engineered agents, neuroscience, biofuels, modeling of biosystems, microbial remediation, genomics, pathomics, nanobio, nuclear medicine, health, social modeling, …

Strengths in genomics, computational biology, neuroscience, diagnostics

Grow personalized medicine, medical diagnostics and therapeutics, and neuroscience

Energy, Environment, Water and Computing

<u>Energy, Environment, Water</u>: Chair - Tom Bowles (Governor's Office)

Vice-chairs: Sarah Cottrell, Bill Hume (Gov Ofc)

Energy includes renewable energy sources (biofuel, wind, solar, …), hydrogen, fuel cells, conservation, clean coal, socio-economic research, …

Environment includes impact of global climate change on NM, clean water, remote sensing, modeling of biosystems, impact of forest thinning, atmospheric modeling, soil, air, and water remediation, groundwater, …

Water includes hydrology, sensors, modeling, watershed sustainability, conservation, water quality, desalination, use of brackish water, use of oil and gas field water, …

Strengths in clean coal, solar, wind, biofuels, fuel cells, sequestration, storage

Grow solar, wind, algal biodiesel, fuel cells, sequestration, energy storage, increased water supply and conservation, clean land, air, and water

Initiatives - Energy Innovation

- Support innovation in energy technologies important to NM that offer significant return on investment
- Drive NM efforts to achieve a clean and sustainable energy future in which clean energy is an important economic factor
- $2M effort was funded this year
- $3.5M effort was funded this year
  (includes clean energy projects)

Significant prospects in solar, algal biodiesel, energy efficiency

FY08 Energy Innovation Projects

Biodiesel from microalgae

10,000 gal/acre/yr *(200 x soybeans)*

Best place in US is SE NM

120 sq miles can replace all diesel used in New Mexico

Projected cost at plant is ~ $2/gal

Requires modeling and simulation for genetic engineering of microalgae as well as optimization of system design and operational parameters

Energy Demands

New Mexico Energy Demand

- Electricity demand ~ 21 M MW-hrs/yr (~2.4 GW average)
- Fuel demand 23 M barrels gasoline + 14 M barrels diesel
- Natural gas consumption ~ 220 B cu ft/yr
- Population growth 1.9%/yr (+40% in 2025)
- Energy use increase now 3.2%/yr (+76% in 2025)

Meet demand for clean energy in New Mexico:

- Energy efficiency 2025 implementation goal ~40% reduction (electricity and fuels) below 2007 levels
- RPS requirement (2025) of 25% clean energy
- CCAG goal of 40% GHG reduction below 2000 levels

Projected 2025 Needs

Meeting demand in New Mexico

- 600 MW wind + 1000 MW solar + 200 MW distributed
- 1.6 GW new transmission lines
- 100 M gallons ethanol/yr → E-10 in every car in NM
- Replace 50% (100%?) of diesel with biodiesel
- Projected cost is $10-20B
- Potential for geothermal?

25% of vehicles are electric by 2025

- Requires 400 MW wind and 800 MW solar
- Projected cost is ~$8B

Strawman Model

Meeting regional demand

- Provide up to 25% of electricity demand in AZ
  600 MW wind and 1 GW solar
  Projected cost ~$10B
  Economic impact in NM ~ $1B/yr
- Provide up to 20% of electricity demand in CA
  800 MW wind and 1.5 GW solar
  Projected cost ~$14B
  Economic impact in NM ~ $2B/yr
- Increased natural gas production during the transition period to renewable fuels
- Export of biodiesel

Energy Technology Issues

The following areas require R&D in order to fill gaps in meeting a clean energy future for NM:

- Solar energy - increased PV efficiency, storage of electrical power from solar, demonstrated concentrating solar thermal with storage, combined solar heat and power, reliability and cost, understanding of environmental impacts of large-scale solar plants
- Wind power - storage of wind power, improved predictive capability for wind energy, in-situ monitoring of blade degradation, improved blade designs, larger and more cost-effective turbines, alternative uses of wind power (e.g., desalination), understanding of environmental impacts of large-scale wind plants

Energy Technology Issues

- Transmission and distribution - modeling of performance of micro grids and smart grids, net metering technology development, DC high-voltage transmission, superconducting elements for transmission
- Coal - clean coal technologies, carbon capture and sequestration, modeling of environmental impact
- Oil and gas - enhanced recovery, produced water issues, carbon capture and sequestration
- Nuclear - environmental impact of mining, in-situ leading technologies and ground water issues

Energy Technology Issues

- Energy efficiency - improved materials for use in buildings, zero waste technologies, combined use (e.g., combined solar heat and electricity), natural lighting and ventilation design, increased efficiency for chilled air and heating
- Biofuels - improved energy and water efficiency in cellulose to ethanol, cellulose to butanol production, biodiesel (especially algal biodiesel), environmental impact of biofuels, mapping and modeling of surface water, fresh aquifers, and deep saline aquifers
- Geothermal - improved seismic identification of deep geothermal reservoirs, modeling of underground thermal reservoirs, improved drilling and heat extraction technologies

Energy Technology Issues

- Biomass - improved efficiencies for converting biomass to electricity, environmental impact of biomass removal, efficient use of waste products as heat source
- Hydrogen - improved high-density hydrogen storage, non-precious metal fuel cells, improved durability of fuel cells, new technologies for producing hydrogen
- Transportation - improved engine efficiencies, novel materials to make vehicles lighter and stronger, reduced emissions, improved batteries, improved energy recovery, improved fuel cell technologies

Initiatives - Water Innovation

- Support innovation in water technologies that provide more clean water
- Providing novel means of conserving, producing, and cleaning water is critical if NM is going to grow.

Significant prospects in conservation technologies, produced water, desalination, weather modification, and clean-up.

Potential Water Initiatives

Conservation: Development of novel techniques and demonstration projects to conserve water in urban, rural, and agricultural uses.

Understanding surface/aquifer interactions. Data / simulations.

New sources of water:

Clean-up and use of produced water

Desalination of water from saline aquifers

Tularosa Basin Desalination Research Center

Weather modification - demonstration winter cloud seeding pgm

Understanding surface/aquifer interactions. Data / simulations.

Clean water:

New technologies to clean water (e.g. nanofiltration) and in-situ remediation of ground waters (bioremediation)

Potential Water Issues

Surface / aquifer interactions:

Decrease in feeding of aquifers with increased conservation in agriculture

In-situ uranium leaching - strong push with renewed interest in nuclear energy to exploit U reserves in NM.

Ground water contamination - arsenic, hexavalent chromium, …

Use of saline water for large-scale algal biodiesel production

May be technically possible and economically viable for NM to produce significant fraction of nation's biodiesel.

Requires production in Permian Basin of ~ 1 M acres of ponds

~1 M acre-feet to initially fill ponds to produce

6 B gallons/yr biodiesel $\Rightarrow$ 20,00 acre-feet of water

Information Technology and Computing

Co-Chairs: Bill Feieresien (LANL), James Peery (SNL)

Vice-chairs: Van Romero (LANL), Ed Angel (UNM), John Miner (Intel)

Includes broad range of computer and computational science, remote sensing, distance learning, telehealth, …

High performance computing includes innovation in algorithm development, information use and data mining, molecular dynamics, designer materials, networks (including sensor networks), intelligent and reconfigurable sensors, adaptable architectures, data imaging, visualization, cyber security, …

Homeland security includes remote sensing, satellite mapping, geospatial information, future combat systems, secure border initiative, …

Strengths in high performance computing, digital film, homeland security

Grow supercomputing, digital film, homeland security

Nanotechnology and Computing

Scott Bryant (MANCEF)

Vice-chairs: Julia Phillips (Sandia), Toni Taylor (Los Alamos)

Includes micro, nano, and quantum systems.

Includes MEMS, nanobio, photovoltaics, water purification, efficient lighting, modeling and simulation, quantum cryptography, quantum computing, ion traps, solid state physics, materials science, …

Strengths in micro electrical-mechanical systems (MEMS) and nano systems

Grow MEMS, nano-bio, sensors, nano-materials

New Mexico Computing Applications Center

Thomas Bowles
Science Advisor to Gov. Richardson

Stephan Helgesen
S&T Director, NM EDD

Bill Feiereisen
Interim Science Dir.

Lorie Liebrock
Interim Education Dir.

Lenny Martinez
Interim Business Dir

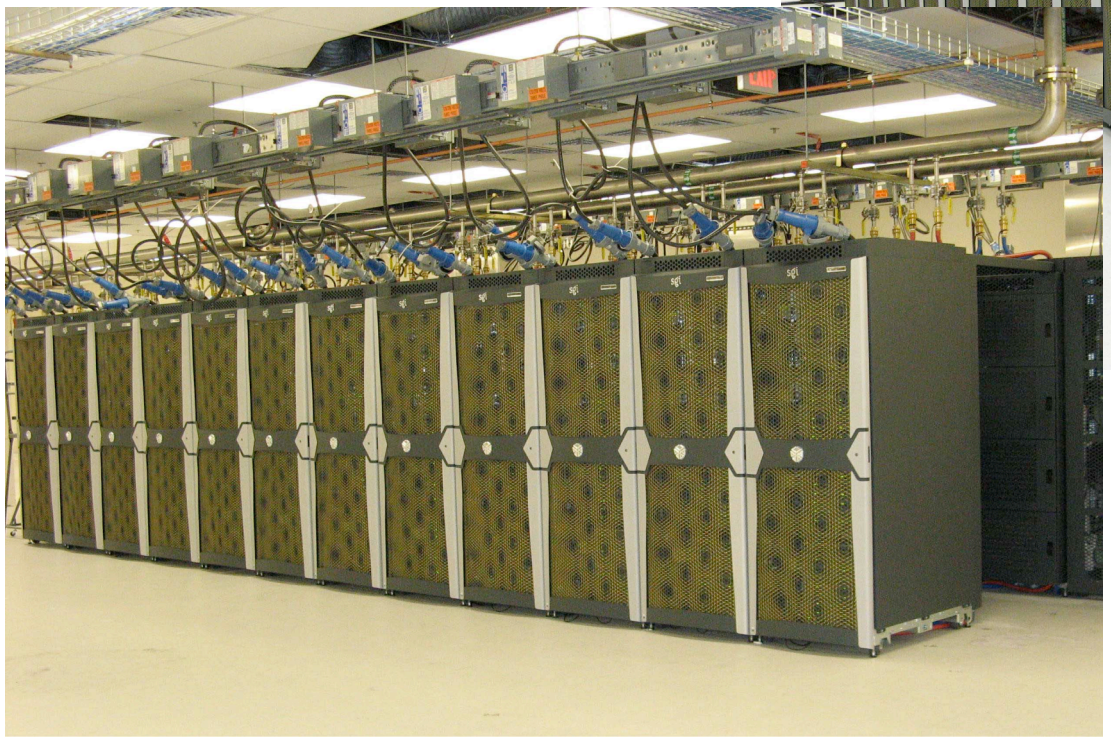
March, 2008

Supercomputing Initiative

- The New Mexico Computing Applications Center founding members: *State of NM, NMT, NMSU, UNM, LANL, Sandia, Intel*
- Draw out world-class talent from the Labs and universities to increase economic development:
  - *Benefit business development in urban and rural NM*
  - *Bring major new businesses into NM*
- Get kids excited about supercomputing to attract them into science and engineering careers.
  - *3-D visualization is a great way to interest kids*
  - *Will support distance education (IDEAL) through gateways*
  - *Support professional development for teachers*
  - *Support college students in STEM careers*
- Address issues of importance to New Mexico
  - Provide assistance to NM communities in solving problems:
    - *Health, water issues, environment, clean energy, traffic, …*

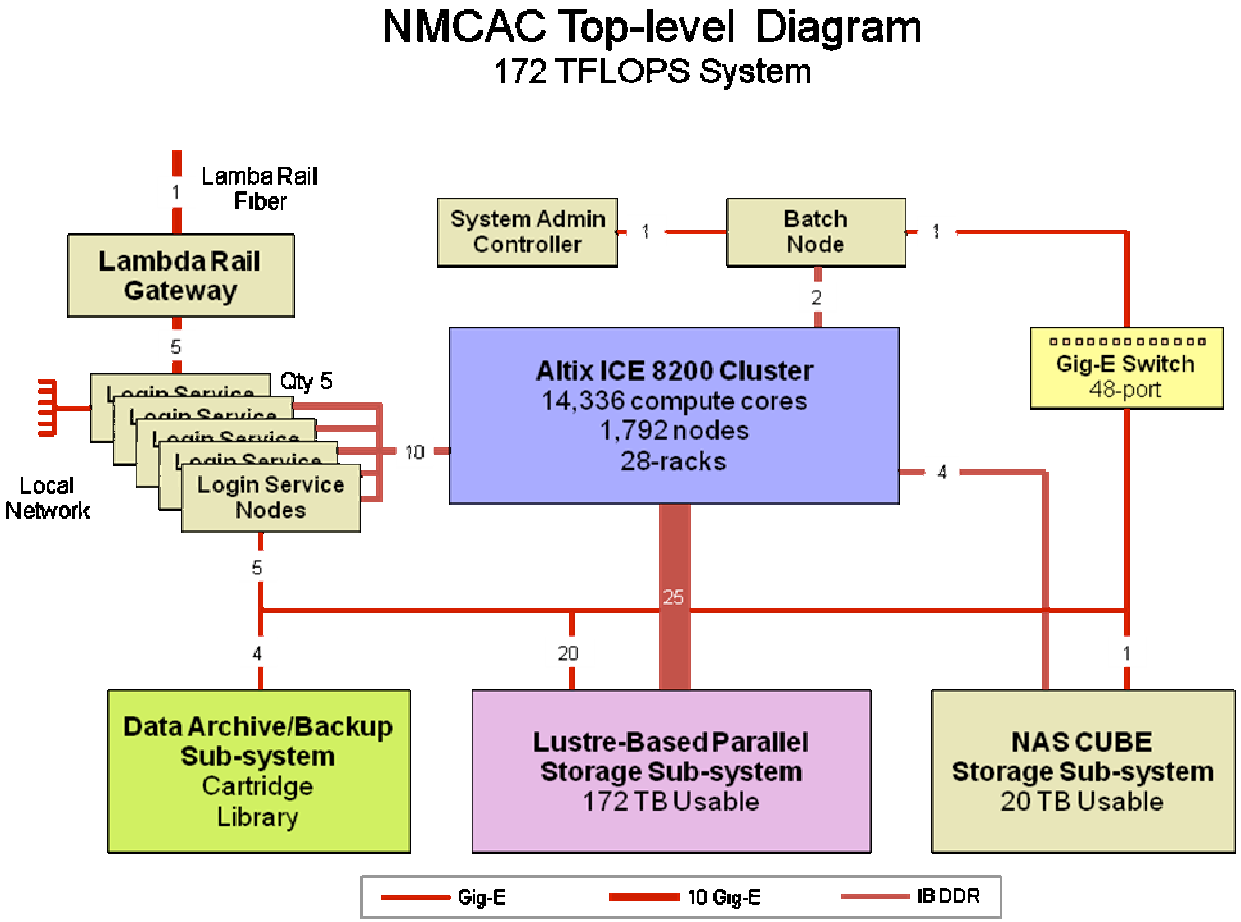
Computing System

Delivered, Installed
and Running at
Intel in Rio Rancho



SGI Altix ICE 8200
Cluster with
14,336 Cores

Computing System



- 14,336 cores of 3.0 GHz quad-core Xeon processors
- 32 TB memory (2 GB/core)
- File storage “Ice Cube” of 20 TB NFS storage
- 172 TB Lustre parallel filesystem

133 Tflop Linpack speed

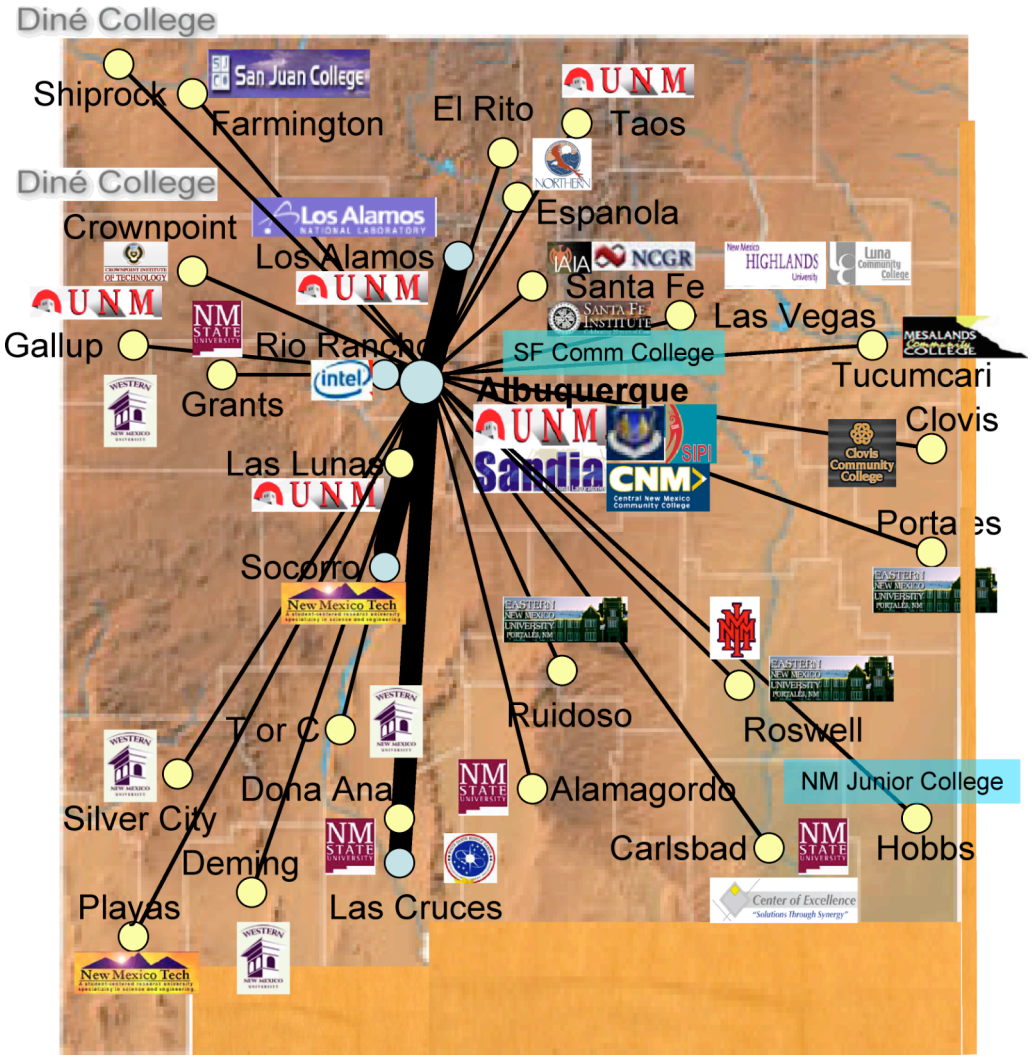
12 GB/s interconnect

Gateways for New Mexico

- Gateways at every public college campus in NM:
  - Bring small R&D businesses onto campus
  - Bring large R&D businesses into NM
- Support education throughout NM
- Support needs of municipalities in NM

The Center is about connecting the people, science, education and jobs -

It's not about the computer



Gateways

- All colleges and universities (including branches) in NM will be equipped as gateways:
  - *Stand-alone, simple to use Polycom system*
  - *High-definition (720p or better) high-speed Access Grid*
  - *High-definition (720p or better) 3-D Powerwall*
  - *Desktop computers (15-30 ea) with 3-D visualization screens and software*
  - *High-speed connectivity to NMCAC center in Albuquerque*
- Universities can connect not only to their own branches, but to every college and university in NM
  - *Enables a new mode for distance learning and collaboration*
  - *Provides ability to tailor courses for specific workforce development that can be taught across NM*
- Gateways will be connected to Lambda Rail and I2
  - *Other campuses connected thru Wire New Mexico to NLR and I2*
  - *Provides new capabilities for national/international collaborations*

Education / Workforce Development

- The NMCAC will provide:
  - Professional teacher development
  - Student engagement in research at the center and gateways
  - Student scholarships
  - Excite K-12 students using supercomputing and 3-D visualization about real-life issues

- The NMCAC will support:
  - Distance education
  - Coordinating courses across NM to improve college education for students at diverse institutions
  - Specialized courses required for growth areas
  - Hi-definition videoconferencing between colleges and universities
  - Supercomputing Challenge

Benefits to the Universities and Colleges

- *Economic Development benefits:*
  - *Serves as a bridge between computation and local R&D businesses*
  - *Provides the universities with access to new business opportunities with companies within and outside of NM*

- *Educational benefits:*
  - *Provides increased interactions with prospective students*
  - *Strength in computing is a significant draw for students*
  - *Center will provide student fellowships and intern positions*
  - *Develops challenging and high-paying jobs to keep our students in New Mexico after graduating*

- *Community benefits:*
  - *Provides means for universities to partner with the State and communities in solving significant problems in water, energy, health, …*
  - *Makes the universities more relevant to a larger base of New Mexicans*

University/College Responsibilities

- Provide physical *(multi-purpose)* space for the gateways
- Provide liaisons (POC) for:
  - *Educational outreach to local K-12 schools*
  - *Local economic development groups*
- Cooperate with NMCAC in developing educational materials
- Sponsor joint appointments with NMCAC
  - *Participate with NMCAC in commercial and state-funded projects*

If large (few $100K+) R&D projects are developed that draw heavily on NMCAC resources, we expect the Center will be part of the proposal with appropriate cost sharing.

University/College - NMCAC Agreements

- All participating institutions must join NMCAC
- Agree to common rules on establishing priorities, directions, new members, and other operational issues
- Agree to working to achieve synergies based on NMCAC support of common graphics packages, analysis routines, …
- Agree to share use of materials developed at the Center for education, economic development, and community issues
- Agree to sharing of IP and other revenues based on relative contributions

Likely to base model for agreements on those developed for the New Mexico Consortium

Meeting Community Needs

Can simulate and optimize solutions in many areas:

- *Telehealth - streaming of 3-D training videos*
  - remote computer-assisted diagnosis
  - support videoconferencing
  - emergency response planning for pandemics
- *Water - can project future water resources and demand*
  - *can determine optimal response to contamination of of surface and groundwater*
  - can help develop new clean water technologies
- *Environment - can determine best response to air, water, and soil pollution problems*
  - can project climate change issues for NM
  - can characterize climate change risk for NM business
- *Clean energy - can help develop new clean energy technologies*
  - can model optimal (and least cost) transmission lines
  - can provide better wind predictions (increased value)
- *Traffic - can model observed traffic flow and optimize timing of lights*
  - estimate savings of $1.5M/yr in gasoline in ABQ

Status to Date

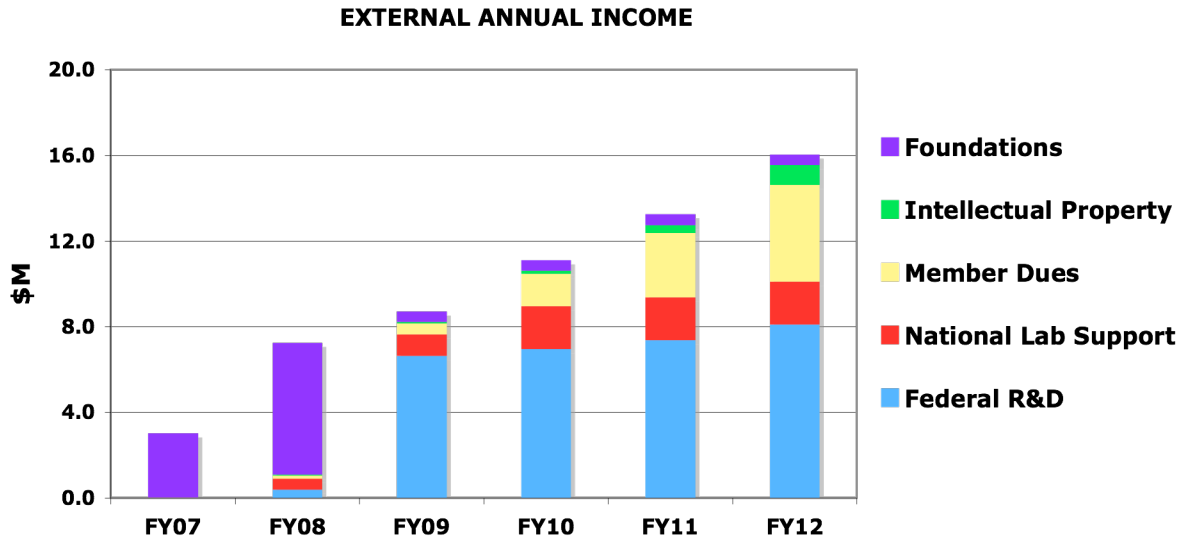
- $14M in capital funding provided in last year's session
  + $4.6M (capital + operating) in this year's session
- Completed initial business plan/market analysis 10/07
- Interim staffing to 7/1/08 by member institutions
  - *$1.2M cost savings to State*
- $11M supercomputer contract awarded 10/07
  - World's third fastest computer (172 Teraflops)
  - Includes 2.1 Teraflop exemplars at UNM, NMT, NMSU
  - Includes all operational costs thru 6/30/08

  Extremely cost-effective contract
- $4.8M RFP for gateway equipment being prepared
  - Expect to stand up 20+ gateways in next 6 months
  - Expect to stand up all gateways within 2 years

Plans

- Working with universities to create Center as 501(c)(3)
  - *Work through New Mexico Consortium*
- Targeting R&D companies, foundations, Federal grants, directed state projects
- Will start providing cycles to Center members in April
- Initiate formation of Center
  - *Looking to have joint appointments with labs and universities*
  - *Looking to build strategic relationships with business*

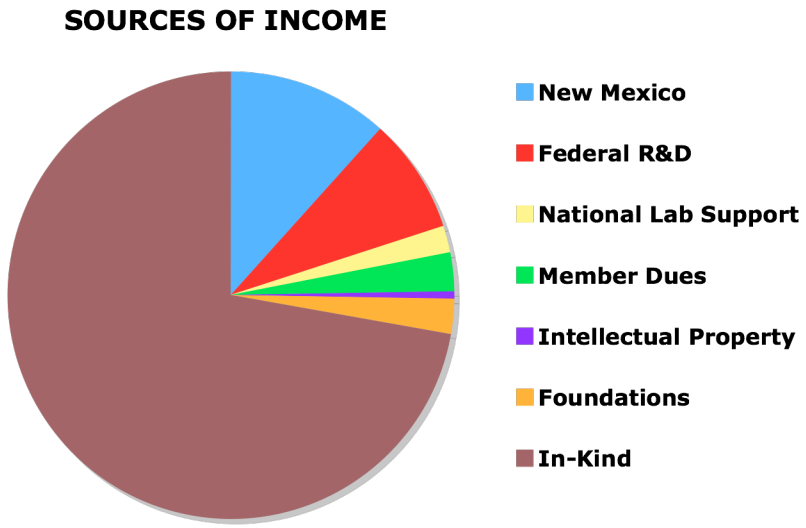
Total Budget Overview



Total Support is $300M over 5 years

Founding Partners

State of New Mexico
New Mexico State University
New Mexico Tech
University of New Mexico
Los Alamos National Laboratory
Sandia National Laboratories
Intel



Summary

The New Mexico Computing Applications Center will move New Mexico to the forefront nationally in innovation

The NMCAC will leverage our remarkable strengths and new computational power in simulation and modeling:

- Attract new business and grow existing business
- Support virtually all aspects of TBED in NM
- Support R&D at universities and labs that is important to NM
- Train the next generation workforce in HPC
- Attract students into STEM careers
- Support communities in addressing issues

The Center is just now being stood up - this is the perfect time for you to get involved!

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