Technology in North Carolina: Three Phases of Development

Submitted to the Institute for Emerging Issues, NC State University

March 2010

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Since its first settlement, the history of North Carolina has been largely shaped by the interplay of three major variables: technology, environment, and culture. This paper discusses dominant technological trends, but it is important to note that these technologies were applied by people with particular skills and values in particular environments that prescribed what was possible. The cultures of the different Native Americans, the huge variety of primarily European immigrants and American transplants, and the large African-American population all contributed to decisions about which technologies would be applied in what locations and to what ends. The story of North Carolina is, therefore, a story of changing technologies and their applications. And, as we move through the 21st century, North Carolinians face major policy questions regarding the future support for development and application of various technologies to promote quality of life in the state.

There is an inextricable link in North Carolina, as in all human settlements, between the economy and the application of technology. Advances in technology have long been understood as the basis for creating economic surplus which has allowed population increases and development of such important human activities as art, music, formal education, and literature, as well as the invention of the practical sciences (see, for instance, the classic work by V. Gordon Childe, 1950). In the instance of North Carolina, there are three broad eras in which one area of the economy—and its attendant technologies—dominated development. These three eras can be defined as: 1) agriculture, 2) mill production, and 3) advanced technology (based on Hardin, 2009). As the dominant economic activity transitions from one era to another, the previous dominating activity does not disappear. Simply, its relative importance to the state diminishes. So, as the state moves to the future, we can anticipate that agriculture and mill production, and their attendant technologies, will remain significant contributors to the future prosperity of the state.

What is Technology?

There are many definitions of technology and people often equate "high technology" such as biotechnology, nanotechnology, or information technology as "technology." These are, in fact, all forms of technology, but they represent a very limited range. Technology, generally, can be seen as a human creation that is designed to do something or solve a problem that, itself, is defined by humans. All of human settlements and cultures are shaped by technologies, but the technologies are themselves part of culture. That is, technology does not occur naturally in the environment; it is a human creation and, therefore, cultural. Which technologies evolve are themselves dependent on the culture of the people who will use them. For example, technologies associated with hog production which are very important in North Carolina would be much less important in a predominantly Muslim population where pork is not consumed. There is always a key linkage between technology applications and the goals and cultures of the people who are applying them.

Technologies commonly are seen as having certain characteristics:

1. Technology generally results in an artifact or object. That is, technology has a tangible outcome in the form of a machine, tool, or other material object.
2. Technology is a part of human knowledge. It is the "know how" behind the object.
3. Technology generally involves a set of activities, skills, procedures, and routines in its application. People *do things* with technology to solve problems.
4. Technology normally involves a process that begins with a need or problem and ends with a solution.
5. Technology is a "socio-technical" system involving people, objects, and processes aimed at solving a problem or answering a need.[1]

When we talk about technology, then, we are dealing with human creations that are designed to solve problems. These creations most often involve some physical object, the knowledge required to use that object, and the sharing of that knowledge among groups of people.

The Agricultural Era

Agricultural dominance of the economy can be traced to the original Native American settlement of the land that became North Carolina. What Native Americans knew, and taught to the early European settlers, was that European methods of farming were not suitable to the new environment. English traditional farming was based on broadcasting seeds on plowed fields. When that process was used in eastern North Carolina, most seed was eaten by birds or it did not germinate well. Native Americans had learned to plant in rows, burying the seed, and tending the weeds—techniques used today for most crops. They taught these techniques to early European settlers and changed the productivity of farms as a result.[2] Likewise, the early success with crops was primarily with those adopted from the Native Americans: corn, beans, peas, and squash.[3]

Most of the farms that were built in early North Carolina served the farmer and local populations. During the Colonial and Post-colonial period, there were very few roads built in North Carolina and engineering and the technology knowledge required to construct roads was not widely held in the population. Therefore, relatively large scale trade was limited to the few coastal areas that had deep enough inlets to build ports for the trans-shipment of trade goods. These primarily consisted of grain, salt pork and beef, tallow, barrel staves, naval stores, lumber, tobacco, and skins.[4] This allowed establishment of larger farms near the coast.

Road technologies were slow to develop in the state, but there were a number of early efforts to pave roadways using whole or split logs. These are the so-called "corduroy roads" built by laying logs side by side which created the visual image of corduroy cloth. Some of these wooden roads were made of planks that were roughly eight inches wide and three inches thick.[5] These planks were then covered with dirt and gravel. Horse droppings would mix with the surface and harden it into a firm surface. One road in North Carolina, the Fayetteville & Western Plank Road, was the longest wooden highway ever constructed; it ran 129 miles. The road began construction in 1849 and fell into disuse in 1862.[6]

Later, there were a relatively few macadamized roads built in the state. Macadam is a road surface made of thick layers of crushed rock and sand that are packed using water and various forms of rollers (including steam rollers). Roads built of macadam require drainage and management of slopes so they are much more heavily engineered and require more advanced

technologies than traditional dirt roads. These types of roads are generally classified as "all weather" and support the transport of goods and people year round. While generally effective for wagons and animal-driven transport, these traditional roads did not hold up well to automobile traffic. One of the major limitations in North Carolina's development, therefore, was the lack of all-weather roads in much of the state. Therefore, throughout the eighteen hundreds and up until World War II many rural roads in the state remained unpaved and therefore did not provide great support for development of the community and the economy.

Aside from roads, 19th century North Carolinians relied on shipping to move goods and people. Starting around 1818, there was regular steam boat traffic along the coast and the rivers near the coast. By the Civil War there were approximately 100 steam ships operating in the state and steamboat construction operations had developed at Fayetteville, Wilmington, and Washington.[7] In addition, there were a significant number of steam flatboats and tugs that were able to navigate many of the more shallow areas of the coast and inlets. There also were several canals dug in the eastern part of the state which proved to be a boon to some of the coastal areas. Generally, however, water-based transportation was limited in much of the rest of the state. North Carolina's interior rivers did not lend themselves to boat traffic.

Because so few of North Carolina's rivers were navigable, larger settlements did not develop inland during this period. However, because many streams had relatively fast flow, it was possible to build small grist and other mills using the water wheel for power. It is interesting to note that these types of developments were most common where the settlers were of German or Scots-Irish ethnicity. Uses of these types of technologies were consistent with the experience and knowledge base of these groups. The lack of roads and navigable rivers led to development of relatively self-contained communities in which the artisans (e.g., blacksmiths, etc.) became the more well-to-do citizens.

Critical Technologies in the Agricultural Era:

- Plow; animal-drawn wagons and basic farm tools
- Steam ships , boats for shallow inlets
- Water wheel-powered grist and other mills to prepare products primarily for local consumption
- Turpentine, pitch, and tar processing distilleries technologies

In the early years of settlement, and up to the Civil War, the most important technologies were those that produced pine tar and turpentine. These products were the only major exports of the state, though they were later surpassed by cotton and tobacco.[8] According to Ready, "By the Civil War, North Carolina had 1,600 turpentine distilleries."[9] Two-thirds of the nation's turpentine came from North Carolina with approximately one-half of that amount coming from Bladen and New Hanover counties.[10] Turpentine, tar, pitch, and other products derived from the pine tree were known as "naval stores" because of their importance to the construction and operation of sailing ships. The technologies associated with producing these goods were, at the time, the most important source of trade income for the state.

The "Tar Heel State" and Turpentine

Critical to the development of North Carolina's role in the naval stores industry was the prevalence of the long leaf pine the eastern and southern forests of the state. The pine is tapped in a similar manner to way maple trees are tapped in the North. The gum that drains from the tree is distilled which results in turpentine pitch, tar, and resin.* The workers in the turpentine industry were most often poor individuals, both while and African-American. The process of producing products from the gum of the pine was often messy and resulted in tar being spilled on the floor of the distillery. According to many accounts, the poor workers did not wear shoes, so their "heels" became covered with tar — thus the tar heels.**

*http://www.auburn.edu/academic/forestry_wildlife/longleafalliance/teachers/teacherkit/turpentine.htm; retrieved October 19, 2009.

** Ready, M. *The Tar Heel State: A History of North Carolina.* Columbia, SC: University of South Carolina Press, 2005.

Over time, the importance of the naval stores industry declined compared to the other agriculturally based industries. With the development of the railroad and technologies for harvesting and processing cotton and tobacco, there were many changes in the nature of agriculture in the state—as well as many other aspects of life in North Carolina.

It should be noted that production of naval stores, tobacco and cotton are all labor intensive and require a great deal of unskilled or relatively low skill labor. In the early years, most slave owners had small-scale farms. However, the ability of the geography of the state to support these three industries was one of the most important factors in the wide-spread development of larger slave-labor based farms and plantations. (see, for instance, Powell, 1977 and 1989).[1112] The development of cotton as a key industry was enabled by the development of several critical technologies:

1. The cotton gin to separate seed from cotton and the "Spinning Jenny" which spun thread;
2. The means of transportation, especially railroads; and,
3. The water-powered mills that wove the cloth.

The popularity of tobacco increased markedly with the discovery of the technology of "flue curing" the tobacco leaf using charcoal to dry the tobacco quickly thus leaving it bright golden color instead of traditional dark brown. This process was discovered by accident by a slave named Stephen who lived in Caswell County:

Stephen was a slave on the farm of planter Abisha Slade near the Virginia border in Caswell County. He worked as a blacksmith on the Slade farm. Another of his jobs was overseeing the curing process of the tobacco crop. On one occasion, due to the warmth created by the fire, Stephen fell asleep during the process. A few hours later, he woke up to find the fire almost completely out. To try to keep the heat going, he rushed to his charcoal pit (part of the blacksmithing operation) and threw hot coals on the fire which created a sudden, immense heat. The heat from the charred logs cured the tobacco quickly, leaving it with a vivid yellow color

(http://www.learnnc.org/lp/editions/nchist-antebellum/5343, retrieved October 19, 2009).

The other major product, tobacco, grew significantly as a result of the development of the charcoal flue curing method that created "bright leaf" tobacco.

Railroads, Waterwheels and the Transition to the "Mill Economy"

Two of the most important and far-reaching technological advances in North Carolina were the development of the railroads beginning in the 1830s and the evolution of various technologies that enabled the large-scale use of water powered mills to produce fabric, tobacco products, furniture, and a host of other goods that could be exported.

Aside from the railroad, the other very critical technology was the ability to create larger scale mills that were powered by waterwheels that took advantage of the fact that many North Carolina's rivers had areas of rapidly moving water created by major shifts in gradient. When dams were built at those sites, enough water was available to power large numbers of spinning and knitting machines. This waterwheel-based mill technology dominated the state in the middle of the 19th century and up until about 1880. For example, at least nine water powered mills were built along the Haw River in Alamance County between the late 1830s and 1880.[13]

Across the major river systems in the Piedmont, mill towns developed along the various river "fall lines" where rapidly moving water could be harnessed. Since the waterwheel technology was critical to the success of the industry, settlements developed where it was possible to build mills of sufficient size to be competitive. Thus, many of North Carolina's Piedmont cities emerged out of the need to locate mills along these rivers. This is especially true for towns along the Deep, Haw, and Catawba Rivers.[14] This pattern of mill towns was, in large measure, responsible for the fact that North Carolina urban places tend to be moderate in size and the state is not dominated by any one large urban area.

Cotton Mills

The first cotton mill in North Carolina was most likely the small Schenck Mill that was built near Lincolnton between 1813 and 1815.* It was a small mill, encompassing about 25 square feet and probably employing only one or possibly two looms. This mill operated more as a cottage industry and it remained on its original site for only a few years. One of the first industrial-type textile mills was established at Rocky Mount in 1818 at the falls of the Tar river (Rocky Mount Mill, undated). In addition to its location near the falls, the surrounding area produced significant amounts of cotton.

By the early 1900s, approximately 100,000 bales of cotton were grown within a twenty mile radius of the mill. To service the mill, the owners developed a "mill village" of 160 homes. Many other mill owners in North Carolina followed this same model and created their own towns as a means to control the supply and cost of labor. At the Rocky Mount Mill, as at other mills throughout the state, the waterwheel was replaced by the stationary steam engine as the dominant means of powering the mills. Some, like Rocky Mount, also later used the falls to produce hydro-electric power. The Rocky Mount Mill remained in operation until it was closed in 1996.**

* http://www.historync.org/SchenchMill.htm, retrieved October 21, 2009

** Powell, 2006

Cotton and tobacco manufacturing dominated in eastern and much of piedmont North Carolina, but furniture mills also became very important after the Civil War. In the 1880s much furniture manufacturing began to develop around High Point. High Point had a number of advantages that included rail transportation, location near hardwood forests, and a substantial population from which to draw labor.[15]

Railroads

Critical to the development of the state was the advent of the railroad. Much of the technology for rail transportation was developed in Great Britain in the early years of the nineteenth century. The ability to generate high pressure steam and transfer the pressure to wheels required many complex technologies. The development of the steam boiler and steam locomotive were two of the most important technological inventions of the Industrial Revolution. Steam boilers coupled to pistons became the standard source of power for all varieties of industrial production and for large equipment such as traction engines that were widely used on farms as well as steam shovels and forms of earth moving equipment. Steam power literally drove America from a rural farming nation to an industrialized nation over a time period of less than a century. Steam power was revolutionary technology for its day.

In addition to the development of the steam engine, there were many experiments with the structure of railroad tracks and wheels for engines and cars. Of particular importance were technologies that linked water boilers to pistons and pistons to flanged wheels; and development of wrought iron rails and wooden tie systems. These key technologies emerged in Great Britain in the 1820s and they were imported to the United States. By 1829, the first railroad in the United States was operational and its first line was completed in 1834. By 1835, there were several dozen railroads in various stages of development, including the Petersburg Railway in Virginia, which would play a major role in development of North Carolina's railroads.
In 1833, the Petersburg Railroad extended its line nine miles into North Carolina to a new town, Bexeley.[16] This spurred significant interest in developing railroads in the state. While there was a short experimental railroad built in Raleigh in 1833, Wilmington created the first significant commercially-based railroad starting in 1835. In 1836, the railroad was organized and William Dudley was elected its first president. The railroad was named the Wilmington & Weldon and it designed to allow transshipment of produce from the Roanoke Valley to the steamship port at Wilmington.

It soon became clear that this railroad and another competing line were of great commercial benefit to farmers in the regions they served. Therefore, Governor John Motley Morehead recommended to the legislature that the state develop a network of railroads. And in 1849, a bill was introduced in the legislature to create the North Carolina Railroad.[17] Former Governor Morehead became the leading figure in developing this important resource for the state. By 1856, the railroad ran from Goldsboro to Charlotte — a distance of 233 miles.
As William Powell notes:

> The new railroad made a great arc across the map of North Carolina, passing through Hillsborough, Salisbury, and Concord, the hometown of William A. Graham, John W. Ellis, and Rufus Barringer, respectively, all of whom had taken an interest in the development of this mode of transportation. Old freight rates by wagon were now halved, and new markets were available. The railroads united the people of the state, created a new pride and patriotism, and helped stop the flow of people out of North Carolina to other states.[18]

In addition to the towns mentioned by Powell, the railroad also passed through Greensboro. While politics played a significant role in development of this phase of the railroad in North Carolina, it is important to note that the railroad also ran along the lines of the rivers where many mills were being developed. Because roads in the state were notoriously bad, the railroad became the single most important technology of transportation for goods and people in the years before the Civil War. It also set the stage for increasing the prosperity of this regional arc and for shipment of farm and mill goods to markets out-of-state. Charlotte and Raleigh became major commercial hubs because of the railroads.

In addition to this "great arc" formed by the North Carolina Railroad, other rail lines were developed in other parts of the state. Rocky Mount became a rail hub in the east, greatly benefiting the mills in that area, and the rails were extended into the mountains over time. In their day, railroads were the most significant transportation technology in North Carolina. The combination of the natural resources of the state, a geography that supported development of water-based mills and the network of railroads were key factors in the state's economy for nearly a century.

It also should be noted that this legacy of mills and railroads has continued to have impact today. If one looks at the development of North Carolina in the modern era, the "great arc" defined by the North Carolina Railroad approximates the area of the state that even today has the greatest wealth, is the most urbanized, and has the bulk of the state's population. It also is interesting to note that the I-85 corridor that is so important to the state today, throughout much of its length, follows a very similar route to the antebellum North Carolina Railroad.

As the state transitioned from the "mill" to the "modern" era, the overarching importance of railroads declined. As with the mills themselves, they have been superseded. But they remain an important variable in North Carolina's future.

The Modern Era

Transitions from one era to another are long-term processes that involve many people, a great number of decisions, and large scale changes in society. This is the case when one looks at the transition from the Mill era to the Modern era in North Carolina. The roots of this transition can be seen as far back as the 1700s with the founding of the first public university in the country, the University of North Carolina at Chapel Hill. It also can be seen in state investments in education and the willingness of North Carolina to experiment with new forms of education in

the late 1800s. For example, Western Carolina University was chartered as the state's first rural normal school for the education of teachers in 1889. These and other investments positioned North Carolina to take advantage of changes that were occurring in many areas of technology after World War II. And, although the modern era in North Carolina might be seen as a time for applications of "high technology" in medicine, biotechnology, information technology, and the like, one of the most important technologies defining this era, and the structure of the state, is the omni-presence of the automobile and road transportation. The evolution of this technology in the state can be traced to the early 20th century.

Automobiles and Roads

One of the most important technological changes that affected North Carolina was development and nearly ubiquitous use of the automobile and other forms of road-based transportation. Until development of the automobile, the most common forms of travel involved mass transit such as trains and, in large urban areas outside of the state, subways. This type of transportation tends to be associated with relatively high density settlement of towns and cities and the clustering of people near tracks or omnibus routes. It also tends to lead to broad patterns of settlement often defined as "hub and spoke." That is, to change from one transport system to another generally required the individual to change vehicles. In urban areas, this tended to create strong central cores and large downtowns where people could easily access work, shopping, recreation, and the like.

During the 19th century, railroads were the dominant mode for transporting goods and people across distances in the state. The major North Carolina Railroad ran along the crescent from near Raleigh to Charlotte following the mill towns that were located along the major falls of the rivers in the Piedmont. This was among the more important factors that lead to settlement of North Carolina's mid-section in a series of small to middle-size cities and towns based on mill production.

By the 1920s it had become clear that road transportation would be critical for the future of the state. Harriet Morehead Berry of Hillsborough became the head of office in charge of the state's geographic and economic survey. She led a move to gain legislative support for a network of all-weather roads across the state.[19] She and others convinced Governor Morrison, who held office starting in 1921, to focus attention on roads and he became the first of several "good roads" governors.

The move to automobile and road transportation in North Carolina preceded in large measure rapid urbanization of the population and significant increases in in-migration from other parts of the country. North Carolina's cities had remained relatively small and therefore their expansion was based largely on the automobile rather than on mass transit. This led to a different pattern of settlement for most cities in the state that can be typified as "multiple nuclei" rather than "hub and spoke." That is, people tend to locate at distance from the center city, they do not

have to locate near mass transit lines, and they tend to build their homes at lower densities. Similarly, employment and retail tend also to locate at distance from the center city leading to what is sometimes referred to as "ring cities" where transportation circulation is around the metropolitan area rather than toward its center.

An example of this type of development can be found in the Triangle. While downtown Raleigh and Durham are employment hubs to some extent, there are major employment developments spread across the region. RTP, and dozens of other employment centers have sprung up across the region. In 1950, both Raleigh and Durham were small, compact cities. Today, they have nearly interpenetrated and the distinctions between Raleigh, Chapel Hill, Durham, and other communities in the Triangle have become blurred. Where one ends and the other begins is a matter of political history and decision, not of economic or transportation function. (See summary map in Little, [2008] for a clear image of this growth.)

For another example, Charlotte, the state's largest metropolitan area had only 702,300 people in 1960. By 2000, its population had increased to approximately 1.5 million.[20] This rapid urbanization and growth was accomplished not by increasing density in the Charlotte core, but by decentralizing the population into a wide range of suburbs. Of its total population, only about 610 thousand people live in charlotte proper. Charlotte has developed with a very low population density across its urban region and it is sometimes seen as having the worst "urban sprawl" of any city in the country.

Generally, the availability of water and the relative ease of construction of low density settlements are two important factors in decentralization of the population. North Carolina's urban population distribution tends to be relatively low density with regard to the number of people per acre. This is a reflection of many variables including the timing of urban development in the state, the availability of water, the lay of the land, and the perceived desirability of reliance on individual automobile transportation as the dominant mode of movement. The automobile and the wide-spread development of all-weather roads (including super highways and the Interstate system) have had a very significant effect on the development of North Carolina in the modern era.

The Research Triangle Park

One of the most important innovations created by North Carolina in the modern era was the founding and development of Research Triangle Park (RTP). RTP represented a different model of economic development based in new technologies and a beginning of understanding of how those technologies interplayed with one another. At the beginning of this paper, a general thesis was proposed that North Carolina's development was affected greatly by the interplay of geography, culture, and technology. No example of the interplay of these three variables is more clear than in development of RTP. Location, state cultural predispositions to focus on the future and how to improve the lives of the people, and the advent of various new technologies starting

in the 1950s gave rise to a new form of development: the research park. Now that RTP has been successful, many others have tried to emulate its development; most have not been as successful and some have failed. The lessons learned from RTP may be generalized to other areas of the state and nation, but it is doubtful that the RTP model should be replicated in exactly the same fashion in any other location.

The success of RTP was dependent on many decisions made by business people and political leaders. It also was greatly assisted by its location. There are three key locational variables that affected RTP's success: 1) it is in close proximity to three major research universities; 2) it is a large area near the state capital and in the traditional development crescent of the state; and 3) it is only a short flight from Washington, D.C. All of these elements contributed to the success of its development.

First, the University of North Carolina -- Chapel Hill, Duke, and North Carolina State all are relatively close to RTP and all have significant specializations in the life sciences, engineering, and information technology. They produce large numbers of college graduates and they have very active research agendas. In the early days of its development, many faculty members at the three institutions were not particularly actively engaged with RTP, but the presence of these institutions were keys to establishing the culture and climate necessary for the park to be successful. That is, research was already a critical component of the triangle area. Adding a park based on research was, therefore, a reasonably natural extension.

Second, as was described above, North Carolina's development was shaped in many ways by the fact that its rivers were not navigable, and that they contained many falls that were capable of providing power for mills. This led to development of a crescent of relative wealth that continues to the present day running from Raleigh to Charlotte through Greensboro. It also has been an area in which the state has invested many resources over the course of decades. These resources include educational institutions, roads, railroads, airports, and utilities. RTP's location was within this crescent and, therefore, could benefit from these previous state investments. At the same time, RTP was a very large site. Its 7,000 acres dwarf the typical American technology park that is only 358 acres. Today, the typical competitive park in China is over 10,000 acres, but for its day, RTP was a grand experiment in aggregating technology and science-based enterprises in a single location.[21]

Third, and perhaps most important, RTP is relatively close to the nation's capital. This made it relatively easy for the state to convince federal agencies to build facilities in the park. Communication with the capital was simple and it was only short flight if it were necessary to go to the capital for a meeting. It also made it relatively straightforward for state leaders to keep close contact with political powers in the capital.

The original idea for a research entity that could benefit by location near the three major research universities in the state was proposed by Howard Odum. Odum was a sociologist at UNC-Chapel Hill. As was true for many sociologists of his day, Odum was highly involved in issues of social and economic welfare. He was involved in founding the department of school of social welfare, the sociology department, the Department of City and Regional Planning and the Institute for Social Science Research at UNC.[22] Odum had long been involved in linking social science research, regional planning, and human welfare. And, he had an abiding interest in development of the southern states. Therefore, he saw the advantages of using the resources of the three major research universities to establish what became RTP and suggested development of a park near the airport.

In the early 1950s, North Carolina faced several critical issues: [23, 24]

- Its industries were dominated by low-wage sectors including textiles, tobacco, and furniture. These industries also were in decline due to automation and increased competition.
- Because of the nature of the land, many of the state's farms produced only marginal incomes.
- And, because there were few jobs for educated people, many college graduates left the state.

In 1954, state treasurer Brandon Hodges and Robert Hanes, the president of Wachovia Bank and Trust, and a builder/developer from Greensboro, Romeo Guest adapted Odum's concept.[25] Hodges and Guest then enlisted the assistance of deans and faculty members at North Carolina State University who then convinced Chancellor Carey Bostian to approach Governor Luther Hodges with the idea. In 1955, Governor Hodges established a committee to study the concept and a 10 page report was developed. Following the report, Governor Hodges enlisted the support of the heads of UNC Chapel Hill and Duke University. He also appointed a committee of university and business leaders and appointed a director.

Despite its success today, RTP was not immediately successful. Land had to be purchased and the plan had to move from concept to reality. There were a number of critical decisions that were important to RTP's development. Some of the most significant include:

- RTP was developed as a nonprofit entity. Land was purchased primarily through donations, but the land was held by the Research Triangle Foundation of North Carolina. This decision kept RTP from becoming a competitive, for-profit development or from being a government entity.

- The Research Triangle Institute was developed as a separate non-profit corporation with a separate board.[26] This allowed it to work closely with business, government, and educational institutions. Today, RTI has more than 2800 employees in 40 countries.[27]

- Because of Governor Terry Sanford's relationships with President Kennedy and his administration, he was able to convince the administration to build an Environmental Protection Agency research facility in RTP. This resulted in the development of several programs in the park including the National Institute for Environmental Health Sciences and the National Center for Health Statistics. The National Environmental Research Center was established on land donated by the Research Triangle Foundation and it opened in 1971.[28]

- In its early days, the park grew primarily because of business relocation and development of major federal facilities. The universities impact had been relatively modest other than creating a local culture that was supportive of education and research. In 1975, the Research Triangle Foundation, under the leadership of Archie Davis, founded the Triangle Universities Center for Advanced Studies, Incorporated (TUCASI) and deeded 120 acres for its use. The proposal for the Institute had been created by faculty members and it had the support of both Governor Sanford and President William Friday. The purpose of TUSCASI was to promote university-related development in the park. This became a critical decision related to development of key relationships with federal agencies and the later creation of important entities such as MCNC, and the North Carolina Biotechnology Center. In late 1976, TUCASI submitted a proposal and was awarded the National Humanities Center which provided the anchor tenant for its campus.[29] To date, TUCASI has supported development of the National Humanities Center; MCNC including the Research and Education Network and the North Carolina Supercomputing center; the North Carolina Biotechnology Center; the National Institute for Statistical Sciences; and the Burroughs-Wellcome Fund. It also has participated in creation of the Triangle Universities Library Network; Triangle Universities Licensing Consortium; North Carolina Network Initiative; and Sigma Xi Science and Engineering Society.[30]

Critical to the development of RTP was the influence of a number of progressive political leaders including Governors Umstead, Hodges, Martin, Sanford, Holshouser, and Hunt, among others. It also was the result of strong progressive leadership by business people, especially Archie Davis, Romeo Guest, and Robert Hanes. It also involved university leadership including Howard Odum, George Simpson, William Friday, and Carey Bostian. The financial community of the state backed its development as did the legislature. RTP was the result of strong leadership and a willingness on the part of the people of the state to back new ideas that held promise for the future.

Today, RTP houses a wide range of businesses, government agencies, and research entities. Its initial development was relatively slow. The first tenant, Chemstrand Corporation, came in 1959; the second, IBM, did not arrive until 1965. Developments in the 1970s, specifically the founding of TUCASI and the location of the EPA facilities were critical. They

set the stage for the future. Currently, RTP is still seen as a very important example of how to create a successful innovation strategy. As of 2008, it had more than 160 tenants employing 40,000 people with an average annual payroll of $2.7 billion.[31] It has created strong capacities in such key technologies as life sciences, material science and engineering, information science and technology, and environmental science. RTP also is the major foundation site biotechnology in the state. And, its impact has been widely felt in the Triangle area. Around the region there have been more than 1,800 technology-based start-ups and spin-outs creating more than 80,000 jobs. There also are more than 50 other "satellite" parks within the region that create among them more jobs than RTP.[32]

There also is a downside to RTP. Generally, North Carolina has so focused development on this one area of the state that it has not implemented a comprehensive approach to regional technology-based economic development in other areas. Likewise, RTP drew imitators, some of which now have surpassed the region in competitiveness. These include locations both in the United States and around the world. All of that said, RTP was a great experiment in technology-based economic development that proved highly successful. It is one of the first, if not the first, experiments in which business, state, local, and federal government, and universities came together to create an entity focused on the future and the role of scientific and technological research on the economic future.

Governor Hunt and State Re-Positioning

RTP may have set the stage for technology based development in North Carolina, but the process came into full flower during the administrations of Governor James B. “Jim” Hunt. More specifically, during Hunt's first two terms (1977-1985), North Carolina experimented with very significant new technologies and positioned the state to be an international leader in computing, biological, physical, and medical technologies. During his second two terms (1993-2001) he focused more intently on reform of K-12 education. However, it was during this period that he had very significant influence on development of the Centennial Campus at N C State University and he signed into law the Millennial Campus Act which provided opportunities for all UNC campuses to develop public-private partnership entities.

Hunt's administration can be typified by a number of characteristics which enabled many of the most critical changes that the state experienced at the time. First, his abiding interests were in helping the state develop for the benefit of the people. This stemmed both from his personal upbringing in a home that did not have a great deal of money, but one that valued education and innovation. His mother was a school teacher and his father ran a farm. And, as one interviewee put it, "his childhood may not have been one of financial wealth, but it was one of great wealth because of his father and mother." Hunt's father was very active in the soil conservation movement and organized the Granges in the eastern part of the state.

Hunt was taught to value people as people and that working together one could build prosperity (this was often caught in the phrase "burgeoning out all that is within you"). Hunt saw this approach as fundamental to his philosophy of governing. To quote Governor Hunt directly:

> "I've always had a deep feeling about people being treated right. I know what God wants for us, and I know how he wants us to treat each other. So I've always cared about people, and people of all races. My feelings about treating people right and helping them kind of blended with my understanding about how you can increase building an economy....provide jobs, increase income, both morally the right things to do, and technologically possible things to do."

Second, Governor Hunt's administration was involved in reaching out. He recognized early the importance of Asia to the state's future and he focused a great deal of attention on developing relationships between officials from North Carolina and officials in various Asian countries. He also reaffirmed the traditional relationships between the state and Europe:

> "When I became governor I started traveling the world. I have been to Japan 25 times.... Probably 15 times as governor or more, I would sometimes take up to three trade missions a year.... I was constantly out there learning. I would go to those Japanese companies; I would go into their plants. I would watch them; I would see how they were operating. Same things around the world. I would go to Germany and say, 'How? How?' You got such a great skill level here, and you got this wonderful program, and you do it so thoroughly. You know that's where it started… the best work in the world done there. How do you do it? What do you do to it? How do you do it? Always trying to figure out what we can do here."

Highlighted in the above quote is the third characteristic of Governor's Hunts administration: it was always in the learning mode. Learning from others; adopting and adapting best practices; and determining how those practices might be applied to North Carolina was critical to the early successes with regard to technology and technology innovation. This characteristic was also recognized by others. According to Governor Hunt:

> "If we walk in our conference room here I will show you a cartoon of me and Jerry Brown [the Governor of California]. I am stealing microchips from him. He is holding a little bag of microchips like potato chips and I'm getting them from him."

By being in "learning mode" the administration sought information and perspectives not just from outside the state, but also from within. Key members of the team were drawn from higher education and business and linked to the administration through advisory boards, service in key positions, and informal conversations. Some of the most important players with regard to development of science and technology in the state were such people as Bob Jordan, who had served as Lieutenant Governor and Dr. Quentin Lindsey, who was the governor's advisor at North Carolina State University, Bill Friday, the President of the University of North Carolina,

and various chancellors, scientists, and business people. As one interviewee put it, "the governor surrounded himself with smart people and learned from them."

A third critical element in this administration was interest and respect for innovation. Innovation was not just directly related to modern technology. As was stated earlier in this paper, technology is a social product that has to be applied within a cultural and resource context to be effective. Governor Hunt's administration innovated in key areas such as education, equal opportunity, and a willingness to adopt new ideas if those ideas were seen as helping the people of the state. Again, according to Governor Hunt:

> "Well, my first science advisor had been my professor at NC State. Dr. Quentin Lindsey. He was the guy who headed the Ford Foundation team of economists in Nepal. He is the guy that recruited me to come over there. He was brilliant, Harvard trained and from Nebraska. He really got it about the process of development. I mean development not just of economy but development societies. ...[He] helped me spot the coming issues of things that had potential, including biotechnology....information technology was coming along pretty [well] already. We just needed to get into the game and do something big like we did with microelectronics. People were just beginning to think and talk about biotechnology. We spotted it early and it got us out there really early.
>
> "I was always open for [Bill] Friday. When Friday called and needed to sit down, we did it! He came over here generally. The same thing would be true for the chancellors. These are people that I knew were out there with the ideas, education, and they are the most valuable partners a governor could have; and they were my partners! I make speeches even today to governors because I still educate them about how to lead education. Saying listen, your university people should be your best partners. Don't let them just be separate and only see them at a public gathering every once in awhile. Talk to them, find out what they are doing; they can help you."

What is key to this approach to policy-based technology development is that it recognized the link between technology and the surrounding culture. That, in itself, is an innovative approach. Technology-based development was viewed within a broader context of the goals of the state and the ability of the people of the state to adapt and adopt the technologies.

A fourth very important element in this administration's approach to technological innovation is the concept that innovative ideas have to be operationalized, put in appropriate political context and funded. Without these three elements, little will be accomplished. Again, quoting Governor Hunt:

> "There are two things that are critical to making it to come to full; well three. People obviously have to be smart enough to invent it or in envision it or develop it. But in terms of public leadership, you have to have leaders who will grasp it and who will explain it and get people to understand why we need to do it. That's a good thing to do in a campaign by the way, but then you have to be constantly out there leading the people and educating the people. The biggest job

> of a public leadership is educating the voters, the people. Secondly, you have to have a program that will find the funding to make these things happened, this new knowledge development and the applications of it in different ways. You [have] to understand how the process works and then you've got to explain it to the people and get them to understand it and be willing to support it, including with their tax money."

This approach to government resulted in some of the most important modern technologically-based developments that North Carolina has experienced in its history. His first two terms saw development of such important entities as the North Carolina Biotechnology Center, MCNC, and the state-wide digital network. His second set of terms was marked by a strong emphasis on reform of K-12 education, but it also included his leadership in the founding of the Centennial Campus at North Carolina State University. In the remainder of this section, three of these very important technology-based developments will be highlighted: the Biotechnology Center, MCNC, and the Centennial Campus.

North Carolina Biotechnology Center

Biotechnology, in its simplest form can be defined as the modification of organisms by human beings. People have been modifying plants and animals almost as long as there has been agriculture. However, the term "biotechnology" generally is used to define the modification of organisms by humans using scientific techniques. In principle, however, traditional agricultural hybridization and biotechnology can be seen as being within the same family of processes. And, it was his connection to agriculture that allowed Governor Hunt to understand and focus on developing the state's Biotechnology Center.

> "I grew up on a small dairy farm east of here. We put it in, in 1944 when the government wanted the farmers to produce more milk for the troops for World War II. I saw agriculture technology develop. I started out milking cows by hand; I can milk them in three or four minutes. But boy it is something that we got electric milkers. I saw at the time we were developing new varieties and when we learned about hybrids.... I understood about technology and what it could do to help people's lives and coming out of the land grant traditions [of North Carolina State]. Breeding like artificial insemination....I understood what it could do for people, and I also understood that it came from the minds of bright people and it can also come from workers out here. I often tell people: this is not just about innovation. It's not just about the big breakthroughs; it's a lot of the little stuff."

The process for developing the Biotechnology Center began in 1981 and came to fruition in 1984. In the late 1970s and early 1980s there were many significant discoveries and an important Supreme Court decision that spurred development of biotechnology-based industries across the country. In 1980, the Supreme Court ruled that genetically engineered life forms can be patented and within the next couple of years, the first gene synthesizing machines were developed and the first biotechnology plant was built.[33]

It was within this early timeframe for the development of biotechnology as an applied science that the State of North Carolina created the Biotechnology Center. The idea for the Center was created by the North Carolina Board of Science and Technology. Quentin Lindsey was its chair and, according to Governor Hunt:

> "[The] Biotechnology thing as you say was just then beginning to come along, but my science background and my understanding of how we can manipulate things and develop the things that are sort of the seeds of where we start and how it happens and how we can develop the new crops and trees and medicines and everything else. I knew that these kinds of things were possible because of my background. I was watching the scientists and what they were doing, and said 'listen this is what is going to be the future.' This is particularly the case when you're dealing with medicine."

Lindsey and the members of the Board of Science and Technology recommended a center be created and in 1984, the North Carolina Biotechnology Center became the first state-sponsored center in the nation.[34] It was established to:

- Strengthen North Carolina's research capabilities in its academic and industrial institutions
- Foster North Carolina's industrial development
- Inform and educate the public about biotechnology
- Develop mutually beneficial partnerships among all parties involved in moving biotechnology from research to commercialization
- Establish for North Carolina a leadership role in biotechnology and its commercialization[35]

The Center fulfills its mission by focusing on four key areas:[36]

- Bioscience R&D
- New business formation
- Business development, retention, and expansion
- Education and workforce development

It is important to understand that biotechnology represents a set of scientific approaches to creating products or processes; it is not in and of itself an industry. By the middle of the last decade, North Carolina had established significant enterprises in such key biotechnology areas as drugs and pharmaceuticals; research, testing, and medical labs; and agricultural feedstock and chemicals. As of that same time period, North Carolina ranked fifth and between 2001 and 2006 its growth rate in biotechnology enterprises was the highest among comparison states.[37] And, biotechnology industries in the state employed more than 53,000 individuals.

As significant as biotechnology has become in the state, the founding of the North Carolina Biotechnology Center becomes even more prescient. The biosciences and their off-shoots will

undoubtedly drive much of the future of the world's economy. Every year, there are new areas of application for biotechnology. North Carolina, with appropriate planning, development and funding, can remain a major player. Several of the most significant areas for further development include:

Nanobiotechnology

Nanoscience is the study of particles that are very, very small ranging down to 100 billionths of a meter.[38] Nano-level work is becoming very significant and has huge potential in such fields as medicine, medical diagnostics, and DNA-based computer circuits. It may be possible to, for instance, specifically target a pharmaceutical to affect only very specific cells in the body so that there are no, or minimal, negative side effects from treatment. It may also be possible to use these technologies in gene therapy to cure genetic-based illnesses. Nano-level biotechnology is a new field that is just now being explored and its implications can be significant.

Advanced Medical Technologies

A burgeoning field for development is in the broad range of medical applications of biotechnology. These applications not only include biotechnology itself, but an entire range of allied sciences that, in themselves, have significant potential. In the medical arena, traditional biotechnology can be applied in such fields as pharmaceuticals, diagnostics, and medical research. When combined with information sciences, there are critical areas of development that include genomics and bio-information processing and analysis; DNA and other protein analysis (proteomics) as well as development of hardware, software, data mining tools, and communications technologies capable of managing the massive databases associated with medical applications of biotechnology.

And, when combined with nanotechnology, there are major opportunities in such fields as bioelectronics, micro fluidics, drug delivery, biosensors, and biochips (such as computing chips).[39] Biotechnology is an emerging science with broad application potential. As will be discussed below, there are some very significant policy issues that the state will need to address if it is to remain a major player in critical biotechnology fields. During the Hunt administration, the stage was set for North Carolina to benefit from the explosion in the biosciences.

MCNC

In addition to biotechnology, the Hunt administration developed a strong program to support electronics technology and the push the Research Triangle as a center for development of computing and microelectronics. The area already had attracted some significant private investment, for example, development of the IBM facility in RTP, but there was significant need for more state investment if the North Carolina were to be a major national player. In 1980, the North Carolina General Assembly provided initial funding for the Microelectronics Center which was to be a technology-based economic development catalyst throughout the state.[40] One of the most critical elements in Governor Hunt's strong support for microelectronics involved the attraction of a GE microelectronics research center to RTP:

> The clincher for setting up the microelectronic center was when GE came and said, 'If you set this up or something like it, we will put our GE microelectronic center here,' knowing that meant jobs right away.

By 1985, MCNC was asked by the state to provide service to educational institutions in the state by developing a high-speed electronics communication network. This network originally connected NCSU, UNC-CH, Duke, NC A&T, UNC-C and the Research Triangle Institute. It became known as NCREN. Originally, the network was based on microwave technology, but today it is composed of a very high speed fiber backbone that serves the entire UNC system and other educational institutions.

In addition to networking, MCNC focused on operating a super computer, providing network resources, and conducting research. In 2000, it spun-out Cronos which manufactured micro-electronic technologies used in electronic switches. This produced a significant endowment for MCNC, which has been used to support the organization's core mission, particularly networking. It also assisted the e-NC Authority in developing grants and programs to support rural internet access and rural internet capacities. In 2003, MCNC split into two companies. The current MCNC focuses heavily on high level networking and MCNC-Research and Development Institute. MCNC-RDI remained heavily involved in developing in assisting new technology development especially associated with venture capital. Its research enterprises were sold to RTI and MCNC-RDI changes its name to NC IDEA and focuses on early-stage capital.

With the split of the two companies, MCNC focused fully on its most important core mission: providing high-speed, highly reliable, networking to the educational community. With this strong focus, MCNC was selected in 2008 to provide networking to the K-12 community in North Carolina so as to create an integrated K-20 network. In looking to the future, MCNC is clear about its mission: MCNC has three key roles: convener, supporter, and enabler for education and research.[41]

As it moves to the future, MCNC has clarified its mission and goals and linked itself well to K-12 and other state-level networking initiatives. At the same time, as the competition for network technologies becomes more intense, MCNC faces threats from private sector providers who have significant interest in market expansion. As will be more fully discussed in the next section, North Carolina has a public interest in the future of networking and wireless technologies because of the roles that these technologies play in the economic future and welfare of the state. How North Carolina balances private sector and state interests will, in large measure, determine the state's success over the next decade.

Through the last decade MCNC has been highly successful in achieving its core mission and the vision of the Hunt administration in creating it has been realized. At the same time, it

should be recognized that MCNC has not been without its controversies. The process for spinning out Cronos created a difficult political environment and it resulted in a major lawsuit.[42] While the suit was settled through arbitration, issues surrounding the spin-out may make it difficult for the state to again consider partnering in similar ventures. Because of the importance of this type of development for the future of the state, determining how to effectively structure future partnerships will be vital. Governor Hunt's administration documented that these types of organizations could be successful both with MCNC and the North Carolina Biotechnology Center.

Key Technologies in the Modern Era

- Automobiles and roads
- Biologically-based technologies and biomedical technologies
- Silicon-based computing processing and high speed communications networks

The Centennial Campus

The Centennial Campus of NC State deserves special mention in this paper not because it is "another technology park," but because in recent years it has focused its development on a new model of university technology campus that increasingly integrates technology-based business with education and broader community elements. The Centennial Campus is evolving as an "educational community" within the greater Raleigh-Durham metropolitan area. Because of its efforts to create synergy among various components, it is an important experiment for the future. In many ways, it may give a glimpse at the future of higher education both in North Carolina and nationally. As advanced technology becomes increasingly the basis for prosperity, finding ways to make technological innovation and creativity a core component of community life may well represent a shift in the traditional roles that higher education institutions play in America's society and economy.

The Centennial Campus houses businesses, colleges of the University, a middle school, residences, and shops. It also has recreational walking trails, a lake, and a championship golf course which provides educational opportunities for students in such programs as turf management, but it also contributes significantly to the campuses "sense of place." While development of the golf course was, itself, controversial in the Raleigh community, part of this controversy was based on concern for competition. Part also was most likely the result of the different model of development on which the Centennial Campus is based. That is, it is decidedly not a technology park developed in the tradition of RTP. "Community integration" is a different concept that draws its roots from both RTP and notions of community that are based in sociology and town planning.

Toward the end of Governor Hunt's second term, 385 acres that had belonged to Dorthea Dix Hospital was deeded to NC State to begin developing the Centennial Campus. Many in the

legislature wanted to sell the property, but Hunt saw the potential for this type of development associated with the state's largest Land Grant institution. When Governor Jim Martin took office following Governor Hunt, he agreed to transfer an additional 450 acres to the project.[43] And, since then other parcels of land have been added so that the current Centennial Campus is approximately 1,300 acres in two separate locations. (The Centennial Biomedical Campus was established in 2000.)

For all political individuals involved, both Governors Hunt and Martin, and for the university administration, development of the Centennial Campus was a risky shift. There were many who opposed it. According to then Chancellor Bruce Poulton:

> Of course, everything sounds wonderful in retrospect, but as I recall there were those who were not particularly enamored of this whole idea, and there were some legitimate concerns. There were concerns about what we might do to the environmental quality; there is Lake Raleigh, back up water for the City of Raleigh and we have concerns about how we do our construction project out there that we don't disturb the quality of that water. There were people who were concerned about more roads. Quite honestly there were faculty members that somehow resources that went to develop the new campus were resources that might be used on the current campus....
> Quite honestly, I think it's fair to say that the City of Raleigh was not happy. The City of Raleigh had a very sophisticated development plan for all of that property. They wanted, and you can understand this, to increase the tax base for the City of Raleigh. The problem with what they wanted to do was it was state owned land and there was no way the city of Raleigh could buy that land unless the state considered it should meet their needs.[44]

Despite substantial opposition, Chancellor Poulton and the Board of Trustees continued with the planning of the campus and in 1986 a master plan was approved. The University also began development and a site was chosen for the Research I Building. In June of 1987, the master plan was approved by the Governor and Council of State and development was begun. In 1988, the City of Raleigh and the Council of State agree to a "mixed-use thoroughfare district." This plan laid out road modification and mass transit plans for the campus. It also provided for greenways and open general use recreation spaces--decisions that were very important for development of the total Centennial Concept. And, the plan also provided for retail spaces, university and private residential facilities, corporate and university educational facilities, and general corporate use space.[45] The Centennial Campus was beginning to take form as a "living-learning" center focused on technology-based education, research, and commercialization.

According to Meszaros, there were seven planning strategies and eight goals for implementation of the Centennial Campus.[46] The strategies were:

- To plan the campus through the approach of *mixed-use clusters/academic neighborhoods* and to structure and focus activity with an arrangement of buildings and open courtyards.
- To base the planning of various networks of the campus on the *natural characteristics of the site.*

- To establish *character areas* by matching prominent site features or well-defined land units with particular mixtures of users.
- To emphasize *accessible linkages and connectedness* across the campus by giving special attention to the relationships between pedestrian, bicycle, vehicular networks, and their nodal intersections.
- To promote the understanding that *individual building projects are to respond to the context of the campus* as a whole as expressed by the natural systems, circulation networks, academic neighborhoods, clusters, and character areas.
- To *relate the campus to the larger community* through access, transportation, amenities, recreation, retail, and other uses.
- To implement project design according to the specific Project Brief that will be prepared for each project and area development.[47]
-

Using these strategies, it was expected that the development would achieve the following goals:

- To proactively assist the consultant architects and development partners in the design and development process.
- To support the mission of the University.
- To direct the establishment of an academic community which, encourages communication, interaction and collaboration between the University, private industry, and government.
- To ensure that this community is integrated into the physical and social context of the City of Raleigh.
- To establish a long-term commitment by the community to responsible stewardship of the land, of the built environment, and of the management of the design, and development process.
- To provide a high-quality environment that supports communication among the campus participants.
- To plan, build, and support campus development to encourage a high quality of life.
- To fulfill the Physical Master Planning Goals approved by the University Trustees.[48]

These goals and strategies are very important to future developments at universities and NC State has documented that it is possible to be true to basic planning principles and successfully develop a public-private partnership campus. One of the most important concepts undergirding the Centennial Campus was the development of "clusters" in which there would be a mix of educational, business, residential, open space/recreation, and commercial uses of the land. The purpose of this type of development is to encourage relationships among the various occupants of the space and, thereby, increase productivity, innovation, and creativity. At the time of its implementation, it was relatively unusual. And, even today, most technology parks separate educational and commercial uses.

As is true for most of these types of developments around the world, the Centennial Campus has developed relatively slowly and some components have been more successfully developed than others. For instance, residential development has lagged while small and medium sized business development and location of educational facilities have moved ahead. It is important to note that differentials in development do not represent failures of concept or implementation. NC

State's Centennial Campus was conceived as an "organic whole." By the way communities evolve, even planned communities like this campus, it should be expected that there will be different rates of development. That is, this type of evolution of community is normal.

Second, because of the rapid change in various modern technologies, and because of the evolution of the education and research enterprises themselves, it should be expected that the focuses of the campus and the expertise necessary to exploit new technologies also will change. Because any master plan has to be dynamic, the evolutionary nature of the Centennial Campus enhances the ability of NC State to address emerging technologies and issues. The size of the campus, its development in clusters, and its active management all position it well for the future.

As Meszaros concludes from her research on the Centennial Campus:

> Today Centennial Campus is involved with a number of innovative and exciting partnerships. The computer science department at NCSU is actively engaged with Red Hat, Inc., a company focusing on Linux operating system development. Red Hat, Inc. is headquartered at Centennial. The department of engineering has benefited from work with NASA's Mars Rover Robotics Project. The National Oceanic and Atmospheric Administration's (NOAA) weather forecasting headquarters has given additional opportunities to students in both undergraduate and graduate programs. The College of Education has had real teaching and learning experiences to offer its students via the Centennial Campus Middle School. Although 1,000 acres seems almost too much land for one university to develop, the timeline for the project is 100 years. It took a century for the main campus to exhaust its resources; Centennial has over 75 years left to catch up to the original land grant campus.[49]

Governor Hunt's Second Two Terms

During Governor Hunt's second two terms most of his focus was on reform of K-12 education to improve the performance and competitiveness of the state. He did, however, support the 2000 bond issue which had major implications for development of the technology capacities of the UNC system and the state's community colleges. He also supported his staff's continued focus on implementing technology-based economic development strategies.

In 2000, the North Carolina Board of Science and Technology published a report focused on tracking technology-based innovation in the state and comparing that innovation to other states.[50] Major indicators showed that despite significant investments and innovative policies that were put into practice, in many ways, North Carolina continued to lag the nation. In 1998, for example, technology intensive compared to other states in its comparison group. It was also noted that while the technology sectors were rapidly growing, they were significantly concentrated in the Triangle area. And, the trend was highest for "very technology intensive" industries.[51] Fully two thirds of all new very high technology jobs added in the state were in the Triangle region. In terms of technology transfer from universities, North Carolina saw significant increases, but license income represented 0.003 percent of the state's GSP compared to a national average of 0.008 percent (Board of Science and Technology, 2000: 39). On a very small

comparative base, North Carolina lagged. Similarly, North Carolina lagged in the availability of venture capital compared to other states, and in initial public offerings of technology-intensive businesses. And, as remains true today, industry-based R&D in the state remains relatively low. Recognition that North Carolina had made progress but that it still had a long way to go led the Hunt Administration to develop "Vision 2030," a strategic plan for continued state repositioning.[52] This plan recognized the over-riding importance of innovation as the driver of a technology-based state economy and it discussed many of the best practices that could be applied to support development of the state's capacities. They recommended following four core approaches or strategies to implementing a successful state-level science and technology policy:

- Support high tech companies and facilitate R&D
- Facilitate university-industry partnerships
- Invest in human capital
- Harness information technology

These studies and other discussions led to development of a comprehensive plan for implementing Vision 2030.[53] This document lays out in detail significant recommendations--many of which have not yet been implemented--that could be the basis for effective state science and technology policy more than a decade later:

- Improve R&D tax credits
- Create tax incentives for collaboration with education
- Promote e-government and the applications of technology in governmental processes
- Modify the Umstead Act to promote technology access in rural areas and create a standard licensure for IT for teachers
- Budgetary support for inter-institution collaboration for economic development
- Focus on hiring and retaining high quality instructors in technology, science, and math fields
- Recruit students to scientific and technical fields
- Provide high quality science and technology education across all areas of the state
- Create a Department of Science and Technology headed by a Secretary for Science and Technology
- Establish a central resource center for data on North Carolina's economy
- Utilize dynamic revenue modeling to assess the impact of policy or program changes
- Brand and market North Carolina as a "high-tech" state
- Teach North Carolina's citizens to think and work in a borderless world
- Develop a comprehensive transportation plan that includes all modes of transportation
- Integrate planning for all levels of education
- Create a network access point in North Carolina to reduce the cost of Internet access
- Create regional community college administrations to better improve coordination

- Develop public awareness of the social and ethical issues associated with technology-based development
- Develop policy regarding personal information privacy
- Ensure public access to public information

As can be seen, this was a far-ranging vision of what it would take the state to retain and develop its competitiveness in the globalized, highly technological economy of the 21st century. Many of the recommendations of the Board of Science and Technology remain to be implemented a decade after the publication of this document. And, as far reaching as the document is, other studies since have added dimension and depth to the issues that were discussed in Vision 2030. It also is safe to say, however, that the authors of the documents understood the changes that were coming in society and the economy. Many of their recommendations are as important today, if not more important, than they were in the waning years of the Hunt Administration.
In the years since the Hunt Administration there have been important actions taken. But North Carolina does not currently have in place a comprehensive approach to technology-based economic development focused on the quality of life of its people and future generations. The remainder of this paper will focus on many of the most critical elements necessary to create such a planning framework.

North Carolina's Technological Future: Making Difficult Decisions
Below are summarized many of the most critical areas which will need attention if North Carolina is to develop an effective approach to technology-based economic development. The focus of this discussion is on assuring that the people of the state and their children have high quality of life and that the state remains competitive in the rapidly changing, global economic system. The themes below in many ways mirror the recommendations of Vision 2030; but they also extend those recommendations by recognizing the restructuring of the state's and nation's economy in ways that were not clear in 1999 and 2000.

Recreating an Innovative, Creative, Entrepreneurial State Culture
One of the major lessons of the history of the state presented above is that at various critical times leaders came together to act in a way that was "non-traditional". At no time in the last century was this type of action more evident than it was during the first two terms of Governor Hunt. The state invested in its people and their future. They created new approaches to supporting government, business, and the development of the people. Changes including development of the Biotechnology Center, MCNC, and the state computing network were important. But, so too were the emphases on minority rights and participation, women's equality, and social inclusion. At the same time, different forms of investment in the future also were explored and experimented with. According to some commentators, moving the state from the position of the "owner" to one of many "investors" represented a major change in public policy. For instance, the state invested in both the Biotechnology Center and MCNC, but neither were

state agencies. Both were spun out as 501c3 organizations that could, and did, seek funding from businesses, the federal government, and others.

This move from the "state as owner" to the "state as investor" is a very important policy shift. As an investor, the state is one of possibly many partners that may include the private sector or non-governmental organizations. This represents a very modern form of state investment and policy that is becoming increasingly typical as the 21st century develops. This is the case not only in the United States but also globally. In fact, it is probably more typical outside of the US than in. This has significant implications for the future that will be discussed in the last section of this paper. However, the Hunt administration made effective use of this approach and documented that it can be an important tool in economic development.

During the first two Hunt administrations the state also reached beyond its borders in a formal and significant way. It renewed relationships with many European nations and also created strong relationships with a number of Asian countries. And, as a result, the state benefitted from trade relationships and investment. With all of this innovation, North Carolina became defined as both a regional and national leader.

A similar, though less extensive, period of innovation can be seen in the 1950s with establishment of the Research Triangle Park. There are excellent published histories of the development of the park, but several elements are not highlighted in these histories at a level that they deserve. First, the creation of the not-for-profit entity as a part of the park was key. This was highly innovative and in some real ways very risky. It was a concept of a new type of development that focused on the future and the interaction of business, education, government, and the people of the state. That was a crucial decision. Of similar importance was the role of former Governor Terry Sanford. By his relationships with the President Kennedy, he was able to convince the federal government to locate facilities for the Environmental Protection Agency and the National Humanities Center in the park. This gave RTP a "critical mass" around which to develop. There is a third critical element that also is very important: the work of Walter Davis who saw the potential for the park and worked tirelessly to raise private funds to purchase property and support development of the park was of very great significance. Again, there were state investments, and there were many, many important decisions regarding the park, but without these three sets of actors, it is not clear that RTP would have been the highly successful development that it has become.

Undergirding all of this development are the people of North Carolina. They were willing to support leaders who were therefore able to take risks. The culture of this state includes a strong element focused on the desire to assure that the future is brighter than the past. Leaders through the years have capitalized on this cultural element. When they shared with the people the importance of the changes they were recommending, the people responded. It also is important to recall that technology and its development are both cultural. That is, they learned behaviors that

exist within a broader cultural structure. For the state to take advantage of future technologies, it will need to develop policy frameworks, habits of mind, educational systems and governmental, business, and social institutions that promote the natural abilities of the peoples of the state to engage.

Today, North Carolina is faced with a future that is dependent on its ability to compete globally. This means that the people of the state need to be supported in their development by institutions that are, themselves, innovative, creative, and entrepreneurial. The move to globalization of the economy and the emphasis on technology-based trade represent "risky shifts" for the state. As one interviewee stated, "we are currently standing in place and the sand is shifting beneath our feet." The discussion below focuses on many of the most important areas in which the state can, and needs, to act if it is to continue to realize its common dream of a tomorrow that is better than today.

Building on Not Being "First"

Since World War II, North Carolina has been a state of firsts: the first successful technology park; the first biotechnology center; the first southern state to embrace a technological future; and the first state to make university education and research a top priority. But, one of the difficulties of being in the lead is that one tends to expect that the future will be like the past: because we were first, we will always be first. But, that is no longer true. Other states have passed North Carolina in computing technology; Silicon Valley dwarfs RTP; and other states and countries have already passed North Carolina in biotechnology (*e.g.*, California, Massachusetts, Singapore, Germany, and the United Kingdom). In critical technologies such as nano-manufacturing; nano-medicine, and nano-materials, North Carolina is playing catch-up. Even such key equipment as nano- and micro-laser manufacturing technologies are better imported than purchased from a company located here. An important step in the next phase of the state's development of policies related to technology-based economic development is to recognize that with regard to many current technologies, others are now first.

And, when one looks at University systems, North Carolina's remains among the best, but it is no longer alone at the top. Other states, including Texas and Wisconsin, have made very significant investments in their educational future and significantly improved their entire university systems -- or in the case of Texas, multiple systems. Other states including Kentucky and Virginia have created state-level policy frameworks that clearly link their higher education systems to the future prosperity of the state. There are lessons from both of these examples and from international experiences with higher education and technology-based economic development from which North Carolina can learn.

The single most important policy question facing North Carolina does not involve investments in individual technologies. Instead, the key question is: how do we as a state regain our sense of urgency in making the critical policy changes that will position North Carolina to be

successful as we move to the future? This will require a very different policy framework than the one that was so successful for the state in the past; but it builds upon the culture and ethics of our people. They are hard-working; have a core sense of values; respect their state; and deeply desire a better future for their children. They also have a history of willingness to make difficult decisions when given the chance and the evidence. Below are some of the most critical areas about which important decisions are required to assure a bright future for the state.

An effective policy framework for the future has to recognize a number of new variables that were not in the equation in the last century. Specifically:

- Advanced technology and new sciences are complex and require major investments. Many of these investments are of such a magnitude that developing and managing interstate alliances may become critical to the state's success. There have been some modest moves in this direction involving Virginia and Tennessee, but, in reality, these are not likely to be the most productive. North Carolina's natural economic linkages follow a different path, which is discussed below.

  What is clear is that in this new environment North Carolina may need to re-cast its approach to policy from viewing other states as competitors to seeing other states as partners in a symbiotic system. In business, this type of relationship is often referred to as "co-opetition." That is, businesses may compete on some level, but they cooperate on others.[54] This approach to large-scale regional development will be critical for the state for the future. And, it indeed, will make the relationships with other states more complex. Where will the states compete? Where will they jointly invest in particular technologies so that both can benefit? These are difficult decisions, but they may become increasingly necessary.

  There currently is not a policy framework for this type of interstate relationship that involves North Carolina. This will need to become a common mode of interaction among the states. And, it may take the state's representatives in Washington, DC acting with others to promote the ability and willingness of the other partner states to work together.

- There are so many technologies being developed today that it will be critical for North Carolina to determine on which it intends to focus. It is no longer viable to talk about investing in "nanotechnology" or "biotechnology." These are very broad categories of technology and state policy will need to make judgments about which subset of these technologies will be the state's focus.

- North Carolina has positioned itself reasonably well with regard to university-based R&D, but it has not created an overarching policy approach to linking R&D to economic stabilization and growth. This is discussed in detail below, but it will

require a different framework for planning and state development than approaches that were very successful in the last century.

- There will need to be a comprehensive review of education from pre-school to college. North Carolina has invested many millions of dollars in improving its schools and there has been positive movement. However, recent analyses of the state's position with regard to economic recovery points to low school achievement as one of the most important factors in the severity of the recession in this state.[55] Similarly, the state has historically made very significant investments in its post-secondary education institutions. But, it is not clear that the investments have been targeted in such a way as to position the state for the future. Under the leadership of Chairman Jim Phillips and President Erskine Bowles, UNC has created a very important policy approach that can generate such a positioning for the state that is memorialized in its *UNC Tomorrow* report. Implementing the recommendations of this report will be very important for the state's future. At the same time, when the recommendations of *UNC Tomorrow* are combined with the National Governor's Association's "Best Practices" recommendations, there may be a strong framework to drive the state forward. This, however, will require broad discussion involving the executive, legislative, and education branches of government if it is to be effective.

- The last legislature began a discussion of tax reform, but much remains to be accomplished. For North Carolina to effectively implement a technology-based economic development policy, it may be necessary to focus much more attention on linkages between what the state is trying to accomplish and how it structures its taxes. For example, many larger businesses are calling for a reduction in marginal tax rates to improve the economic climate. If, however, the state focuses instead on tax incentives for advanced R&D or advanced manufacturing, it may find the impact of tax reform to be much greater. At the same time, it is clear that in this state most new jobs are created by small business rather than large corporations. If policy is aimed at creating new technology-based business, it may be more appropriate to focus a business tax approach that exempts the first $100,000 of business income or that eliminates capital gains tax on a percentage of founder's stock.

- It has been widely recognized in North Carolina that the state is composed of two broad categories of regions with regard to the economy. Generally, the I-85 crescent tends to be relatively wealthy compared to the eastern and western regions of the state. There are good reasons why investing in the I-85 crescent will continue to produce positive economic outcomes. However, with the restructuring of the economy around global trade and technology-based development, many eastern and western regions of the state could also become much more competitive. For this to be possible, the state may need to review its broad economic development policies.

As was described in various sections of this paper, there were critical times in the state's history where private citizens and government officials stepped forward and made important decisions that changed the future of the state in a positive direction. North Carolina can build on this legacy as we move to a technology-based economic future. In this instance, not necessarily being first gives the state the opportunity to learn from other's successes and failures. Given the speed of change in this arena, this may be a significant advantage.

North Carolina as Part of an Interstate Region

There is increasing evidence that as the economy becomes more global and technologically based there is a world-wide trend for "super-regions" to evolve. According to researchers at Virginia Tech, there are 10 such super-regions in the United States.[56] Richard Florida conducted a similar analysis and concurs that ten of these regions are maturing in the U.S., but he extends the analysis and documents development of forty such regions world-wide.[57] For North Carolinians, the most important region is termed the "the Piedmont Megalopolis". It stretches from Central Alabama to the eastern suburbs of Raleigh. With regard to technology-based economic activity, this region's most significant center is Atlanta followed by Raleigh-Durham. However, while Raleigh-Durham has very strong technology based economic activity as a percentage of its total economic product, its actual total economic output is dwarfed by that of greater Atlanta.

What is particularly interesting about the structure of the Piedmont super-region is that it has a backbone that is defined by Interstate 85. And, while it is likely that other nodes of technology-based economic activity will continue to develop (e.g., the BRAC-related developments starting near Fayetteville and NASA-based growth in Huntsville, AL), the core of this region's development will most likely be I-85.[58] Currently, North Carolina does not recognize the importance of this development for its future and there is little in the state's policy framework that can magnify the impact of this region's development for the benefit of the state. In addition to the significance of the Piedmont super-region, northeastern North Carolina is very close to a second super-region that is centered around New York and Washington, but which extends to the Tidewater area of Virginia. Again, North Carolina has little in its policy framework to allow northeastern North Carolina to benefit from its proximity to this region. One of the most important questions for North Carolina's technological future, then is: *'What state policies can magnify the relationships between North Carolina and the major technology-based economic engine of the I-85 Corridor and the Atlanta hub?'*

In addition to considering the importance of North Carolina's positioning within the Piedmont super-region, it is critical that the state's policies recognize the importance of smaller functional regions that are centered on urban areas. There are beginnings of discussion of this question at the state level, but there is not yet a framework in place that recognizes the importance of these larger urban regions. Furthermore, despite the tendency to consider technology innovation as a strictly urban phenomenon, many rural areas of the state could be

involved in significant technologically-based economic activity. Michael Porter's group at Harvard has studied the structure of rural economies and they have found very significant differences in the ability of rural regions to develop and support technology-based businesses.[59] These differences are based on the proximity of the rural area to urban centers that are, themselves, highly technologically competitive. Unfortunately, most urban centers in North Carolina are not competitive and lack the systems and infrastructure to support technology-based economic development, so their surrounding rural areas remain undeveloped.[60] And, even the state's largest metropolitan area, Charlotte, does not yet possess sufficient innovation infrastructure to cause it to be higher than average compared to other metropolitan areas in the south.

It also is significant, as the state positions itself for a technological future, that it recognize that many of the most important urban areas that could drive technology-based economic development are located out-of-state. In the case of northeastern North Carolina, the Tidewater could become very important. In the case of southwestern North Carolina, the important metropolitan linkages are to Atlanta and Greenville-Spartanburg, South Carolina. Recent work at Western Carolina University that examined the location of employment and businesses along the I-26 corridor showed that the geographic centers of those distributions were already south of Asheville (near Fletcher).[61] As the economy recovers from the current deep recession, the importance of the link to I-85 and upstate South Carolina can be expected to continue. And, the far southwestern region of the state will be increasingly linked to greater Atlanta. Even when one considers the technological future of Charlotte, understanding the importance of I-85 and developing policies to promote interaction with other states along that corridor should be seen as critical.

Thinking Differently about R&D

North Carolina is rightfully proud of the volume of university R&D funding that is obtained by public and private universities in the state. This type of research is very important for the state's long-run health. Over the course of several decades, university R&D will generate new technologies and new businesses that may continue to propel the state and the people's quality of life forward. What is most interesting about the current situation in the state is that there is very little that is being done to assure that North Carolina has "first crack" at these technologies. Universities can, and do, license their discoveries to businesses from around the world. Moreover, there are other major issues with R&D in North Carolina that should be addressed if technologies are to be at the center of the state's future prosperity:

- While North Carolina produces a great deal of university R&D, its business-based R&D is relatively low as a percentage of total state R&D.[62] And, in the short- and medium-terms, business R&D is much more closely associated with state prosperity than is university R&D. According to the National Science Foundation, North Carolina ranks 10th in population, but 18th in total federal R&D obligations and 13th in industrial R&D.[63] Of the more than $1.7 billion of federally-sponsored research conducted in the state, only

$402 million was conducted by industry. Therefore, North Carolina's key indicators of near and medium-term technology-based innovation lag the state's population size. There is a great deal of opportunity here for developing state policy that promotes business and government, especially military, R&D that produce economic wealth in a relatively short time cycle.

- Research Triangle Park and the Centennial Campus notwithstanding, North Carolina is not among the nation's leaders in its number of Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program grants. (These grants are often seen as proxies for the value of technology-based innovation in a state's economy.) According to the latest National Science Foundation data, in 2006, North Carolina ranked 19th among the states in SBIR awards. [64]And, within the state, the majority of SBIR/STTR grants are received by businesses in the Raleigh-Durham area.[65] SBIR and STTR grants are important indicators of the value of emerging technologies in the state's economy. This is especially so when combined with the percentage of total R&D in the state that is performed by existing business. North Carolina is relatively low on both indicators. This relatively low business R&D activity, as well as the aggregation of R&D in a relatively few sites, may be major contributing factors to both the depth and duration of the current recession in the state.

- The low level of SBIR/STTR grants reflects the state's emphasis on university R&D. Although there are relatively few studies of this issue, Audretsch and his colleagues found that few university scientists make use of the SBIR/STTR process.[66] They also found when looking at National Cancer Institute funded research that there was a statistical inverse correlation between the size of the grant and likelihood of licensing or patenting results of the research. Further, there is evidence both from Europe and the U.S. that the number of college graduates, and especially the number of college graduates in the sciences and technology, is a better predictor of business start-ups in the vicinity of a university than is the university's R&D receipts.[67] From factor analyzing Small Business Administration data, Bardo and Evans found that there is a pattern of distributing federal R&D funds that may militate against their supporting business start-ups.[68] Funds tend to be granted to larger metropolitan areas that are dominated by large businesses. Business start-ups tend to be located in areas that have significant infrastructure to support the start-up as well as a relatively higher percentage of college graduates in the population. There may be great value for the state, and especially UNC, to examine carefully developing policies that promote increasing the numbers of science and technology graduates in various regions of the state and in promoting development of emerging business infrastructure.[69]

- According to Robert McMahan, technology-based new business start-ups tend to follow the interstate corridor of I-85 and to a lesser extent I-26 followed by a section of I-40 that

is near I-85.[70] This pattern fits with the general structure of the interstate region of which North Carolina is a part. Further analysis by Ostergaard documents that this innovation pattern is consistent with the employment and business distribution pattern along the I-26 corridor. There is an opportunity here for the state to examine these patterns and develop policies that can enhance the formation of technology-based businesses in these naturally occurring corridors.[71]

- There is no relationship between university R&D conducted in a state and the state's current economic health, nor necessarily with the state's per capita income.[72] This overall pattern fits North Carolina. According to the NSF, North Carolina is 7th in total university R&D but 37th in per capita income.[73] This is not a new pattern since North Carolina has been a leader in university R&D for decades. Universities are under no obligation to transfer the products of their R&D within the state. Under the Bayh-Dole Act, university R&D can be licensed to anyone in any state, and often internationally (with certain national security restrictions). And, according to work by, it often takes two decades or more for technologies developed at universities to be transferred successfully to business.[74,75,76] Neither the nation nor the state have policy frameworks to create "innovation systems" that could formalize and regularize this transfer to assure that it benefits the people of the state or, more broadly, the nation.

- Even at universities that have a focus on technology-based business development, the rate of business spin out is very low. Most member institutions of the Association of University Technology Managers (AUTM) spin out one or fewer businesses annually and only a few institutions have a track record over the course of years of spinning out ten or more businesses per year.[77] Institutions that are members of AUTM have, by their membership, identified themselves as interested in this type of technology development.

- Universities tend to document their successes in spinning out businesses or licensing technologies in anecdotal form. They point to a rousing success (such as SAS), but they do not have means to report the effectiveness and efficiency of their technology transfer operations. That is, there is no compelling report card of business-related technology-transfer activities. Further, most universities have reward systems that only minimally encourage faculty members to focus on technology transfer as their key research activity.

- Because the economy is increasingly regional, it is important to understand the actual regions of the state and their potential for technologically-based economic development. The state's nine current economic planning regions do not necessarily conform to actual emerging economic regions. And, there is little formal policy to promote appropriate development in the various regions or to recognize and encourage interstate relationships that could promote development.

- Most studies show a reasonably strong link between the level of education of the people in a region and that region's ability to develop and apply technologies that can support the people of that region. However, there also is significant evidence that there needs to be concerted investments in educational infrastructures in the region for it to be successful.[78] North Carolina has not yet developed such a policy framework for educational investments.

- In 2000, North Carolina passed the Millennial Campus Act that gave universities the authority to create public-private partnership campuses to promote innovation and economic vitality of the various regions. This is an important act, but the state has not followed-up with an implementation framework, nor with consistent, targeted funding to promote the effective development of these campuses. This seems to be a major opportunity for policy review.

- There is a very modest, though statistically significant, relationship nationally between university R&D and the current economic prosperity of an urban area.[79,80] Much of the short- and medium- run value of research universities is the physical location of high quality faculty members in the region rather than the value of the research produced. That is, it is the faculty member's teaching and consulting that seems to affect the short- and medium-run link between the economy and technology rather than his or her research, per se. Moreover, both in Europe and in the United States, most studies of the impact of universities on new businesses start-ups and other forms of business development show that there is a strong geographic correlation (for some technologies). That is, for technologies that are affected by universities, those universities have greatest impact within approximately 50 miles (or as much as 75 miles) of their campus[81,82,83,84,85,86,8788]. Therefore, the actual investments in faculty members in various locations are very important. North Carolina might benefit from consideration of this type of policy discussion.

- Computing-related and many other technology-based new businesses show little propensity to locate near universities (most likely because of the broad array of these technologies already in wide use). Therefore, other state investments may be more important than university R&D in promoting broad application of computing technologies (such as the state's abiding interest in assuring the cost-effective availability of broadband networks in rural and inner-city areas). However, biotechnology businesses do tend to locate near universities that can support biotechnology research.[89] This has significant implications for future state investments generally and specifically with regard to the research campus at Kannapolis.

There is a great deal of literature on how to create a strong state-level policy framework that links education, business, and technology-based economic development. It may be time for

North Carolina to involve itself in a thorough review of this literature. Clearly, innovation, creativity, and entrepreneurship need to be encouraged. There, in fact, may be ways to harness the state's resources to promote these three issues into what is known as an "innovation system."[90] Innovation systems are policy-based frameworks that encourage development, dissemination of information, and moves to production for innovative technologies. They are not focused on specific technology products, but instead on the creation of processes that spur creative, innovative ideas and reduce the time cycle to bring the products based in those ideas to market. Currently, North Carolina does not have a state-level approach to create such systems.

Learning from Others: Implementing "Best Practices"

Over the course of the last decade, there has developed a significant literature on state-level policies regarding technology-based economic development. These policies have been reviewed and summarized in several "best practices" papers published by the National Governors Association (NGA) [91,92,93,94]. These papers all recognize that for a state to be successful in establishing and maintaining a technology-based, globally competitive economy, there must be firm linkages between post-secondary education and other state policies. NGA calls for a "compact between the state and higher education."[95] The core elements of this compact are focused on promoting innovation and they include the need for higher education to:

1. Foster among its graduates the critical skills and capabilities needed to enhance state economic competitiveness.
2. Produce a well-qualified K–12 teacher corps that is highly skilled in the science, technology, engineering, and math (STEM) disciplines.
3. Create new knowledge by investing in research and development (R&D) and by establishing policies that facilitate the translation of new ideas into innovative products, processes, and services.[96]

NGA goes on to define key areas for negotiating this new compact with universities. These areas include setting goals and accountabilities, stabilizing resources, and rewarding performance. What NGA is recommending is that states re-think their expectations of higher education and that they align the goals and funding for public higher education with the emerging needs of the state.

In other policy papers, NGA has further summarized the importance of the links between higher education and state-level development policy.[97,98,99,100,101] They particularly note that in all states, various segments of the state can add to the overall ability of the state to support its people by closely linking regionally-based economic cluster development with higher education policy. Specifically, NGA recommends that:

- There needs to be close ties between the clusters of companies that can be competitively supported in a region and the allocation of programs and resources to that region's community colleges and public universities;

- Rural areas of the state can be engaged in such a way as to promote economic vitality by focusing resources to higher education institutions that serve those areas of the state; and
- Universities be viewed as the linchpin in the regional development process and that in addition to traditional university teaching and research agendas, universities across the state's regions need to be focused on technology transfer (consistent with the Bayh-Dole Act).

North Carolina has recently created an Innovation Council. This might be an appropriate vehicle through which to discuss creating and institutionalizing practices in North Carolina that align with NGA's recommendations on "best practices." In the longer term, however, the state will need a way to assure that it understands and addresses the rapidly changing globally competitive, technologically-based economic changes that will define the decades ahead. Key questions remain, however, as to how the state will develop the means to continue to scan the global competition, developing strategies to address the changes in the competition, and developing the legal and budgetary processes that will allow the state to move quickly.

Setting Technology-Based Goals and Objectives: Which Technologies, Where?

It is clear from the above discussions that there are significant opportunities in many, if not most regions of the state. Technology-based economic development does not have to be limited to only a few urban regions in the state's Piedmont core. To address potentials for other regions will, however, require a different view of the situation. As has been discussed above, the western and eastern portions of the state have potential linkages to major economic engines that are out-of-state. This also is true for other states—such as Kentucky in relation to Ohio, Kansas in relation to Kansas City, Missouri, New Jersey because of the proximity to New York and Philadelphia; Delaware, and much of Maryland and Virginia. Some of these states may have models that assist them in drawing on the major resources nearby. Regardless, based on the NGA recommendations, and the literature on development of interstate regions, it should be possible for North Carolina to determine which policies and what investments can create a more viable economic future in these ends of the state.

Focus on P-20 Education and Innovation and Creativity

Current federal policy does not effectively promote the types of education necessary for the state to improve fundamentally the quality of education. Testing, in and of itself, is not the answer, though tests will need to be part of the solution. The critical questions involve turning students on to learning and then assuring that they have a strong foundation in the skills needed to function. There is not yet a clear relationship between test results and the ability to use what was learned in a creative, innovative way.[102] Too often, teachers teach to the test--since so much is riding on the results--without a concomitant incentive to assure that students can use the information learned in innovative and creative ways. The future is based in innovation; traditional tests are not. Albeit, to be innovative in a technologically sophisticated world requires

core learning skills and information, but these represent a critical baseline, not successful education.

Testing and assessment are best accomplished when there are specific goals in mind. For testing to be effective, it must be both reliable and valid. "Reliability" means that the test is measuring the same thing each time it is given. "Validity" answers the question: "Is the test measuring what we want it to measure?" This is not as easy a question to answer as it may seem. Many tests are highly reliable, but invalid with regard to what they were intended to measure. Or, more importantly, they may be invalid if the goal of education is to develop creative, innovative, and entrepreneurial individuals who are capable of applying knowledge in the global economic environment.

If the technological future requires innovation and creativity, then educational assessment needs to measure the degree to which students have become more creative and innovative. Assessment needs to address the questions regarding underlying skills that are required and then assess those skills efficiently, reliably, and validly. That approach takes a very different framework than those that are being applied today. Foremost among the requirements for that framework is a clear understanding that it needs to be focused on creating educated, responsible, innovative, and creative citizens. Such issues as science, technology, innovation, and creativity cannot be separated from citizenship and be effective as a policy framework.

Second, it is clear that there would be value in re-conceptualizing basic education as beginning in pre-school and continuing through the first two years of college. This is what is referred to as the "P-20" approach. There is not a clear understanding of how each level of education should build on the previous one and how all of these areas link to innovation, creativity and entrepreneurship. Planning among the various levels is episodic and the curriculum linkages are not yet well codified. There are many opportunities here to create more effective and efficient educational outcomes.

The need to re-think policy and its relationship to a highly technological future extends to university and community college education; it does not involve only K-12. Specifically, while the Southern Association of Colleges and Schools (SACS), the organization that accredits universities in this state, requires institutions to assess their expected general education outcomes, the membership of the association is so broad that it is not in a position to specify what those outcomes should be. And, while there is clear evidence that general education benefits the students, the evidence is less clear that general education includes all, or at times even the most important, elements in a student’s need for general knowledge. The American Association of Colleges and Universities has a series of papers that make cogent arguments about the nature of general or liberal education that is required in today’s world. However, these papers are not being widely discussed at the state level and there is little oversight of the actual outcomes of general education with regard to the interests that the state obviously has in having

educated, responsible citizens. (This remains, after all, the most basic reason for state support of education.) North Carolina might well benefit from a broad-based discussion regarding what it means to be educated in a global, highly technological system.

Key Elements in a Plan for North Carolina's Technology-Based Future

North Carolina can take significant actions to create a brighter future. These will depend on clear communication from leaders and development of a framework for the future. This framework will be very different from those that worked in the past. Tomorrow's framework for success must be based in entrepreneurship, creativity, innovation and nimble movement to implement change. And, there has been a great deal of research on the nature of state-level processes and decisions that can position North Carolina for a bright future. This research has resulted in broad policy recommendations that, taken together, begin to address the state's re-positioning. This work is, unfortunately, not yet summarized in one place and it is not yet the basis for a comprehensive state recovery and repositioning plan. Below are summarized many of the key elements:

1. Create a sense of urgency with regard to state repositioning. This repositioning must lead to a focus on technology-based jobs and broad economic recovery across the state.

2. Research the specific implications of the development of the Piedmont Super-region for growth of various sectors of the state.

3. Implement National Governors Association's "Best Practices."

4. Examine successful and unsuccessful practices from other states and countries to determine how lessons learned in these approaches may be applied in North Carolina.

5. Develop a comprehensive plan for exploiting expansion of industry clusters in the various regions using similar techniques to those employed by Feser (2000), but to include clusters that relate to out-of-state critical economic centers such as the I-85 corridor, the Tidewater, and greater Atlanta.

6. Create a strong state-level plan for investment in facilities, infrastructure, and personnel necessary to support development of the competitive capacities of North Carolina's metropolitan areas. This process must include developing infrastructure to support participation by rural communities that can be linked to the various urban hubs.

7. Create a state-level plan for linking rural northeastern and rural southwestern North Carolina and Greater Charlotte to the major economic drivers out-of-state.

8. Re-consider the possibility of several technology corridors to include portions of I-85, I-40, and I-26.

9. Hold a state-wide conversation regarding the people's interests in technology-based infrastructure, including broadband, "gap funding" for emerging business, and education, to support North Carolina's competitiveness. There are many examples from history of

the state coming together to make the necessary decisions, investments, and at times sacrifices, to assure that the children of the state have a bright future.

10. Consider restructuring state government to institutionalize technology-based innovation as discussed by McMahan.[103] This would include possibly creating a cabinet level position focused on science and technology innovation and a re-focusing of the culture of state government.

11. Examine the tax code to focus revisions on such issues as exemption of founder's stock from capital gains, enhancing the R&D tax credit, and exempting or reducing the tax on the first $100,000 of business income to support entrepreneurship.

12. Expand the capacities of the SBTDC and the small business support centers at community colleges to enhance their capacities to support their abilities to support technology-based business development.

13. Recognize in policy that education is at the core of state recovery and long-term competitiveness. Develop a strategic plan that better coordinates and focuses the various educational segments on state competitiveness for the future. Focus on assessing those elements of education that lead to competitiveness in technology and applications of science.

14. Charge the colleges of education to work with the Board of Education to focus on improving basic skills education and to develop experimental programs to enhance creativity, innovation, and entrepreneurship as critical elements in pre-school through high school education.

15. Support and fund experimental programs that enhance the number of students who qualify for education in science, technology, and engineering. Broadly deploy those that are successful.

16. Charge the Board of Governors to systematically implement ***UNC Tomorrow*** including development of specific assessment indicators. Charge the community college board to develop and implement a similar planning process that includes goals, objectives, and assessment indicators.

17. The current funding formula for UNC focuses nearly exclusively on credit hours generated. There is no state-level funding policy governing the role of UNC campuses in basic or applied research, development, technology transfer, or faculty consulting to promote state competitiveness. This issue also does not include the absence of state-level policy governing allocation of R&D facilities to "non-research" universities (as appropriate under the National Governors Association's Best Practices) nor does it systematically address the allocation of research facilities at "research universities" to promote technology-based industry cluster development.

18. Include summer school in the funding formula and examine the differentiation of "distance education" and resident credit." Focus funding on the effective delivery of education and degree completion rather than on artificial distinctions between distance and resident-credit education.

19. Charge the Board of Governors and the North Carolina Community College board to examine general education for the purposes of defining outcomes that enhance the state's capacities to compete globally and that appropriately assesses development of innovation, creativity, and entrepreneurship skills. While specifics will, and should, vary by campus, the state has a strong interest in assuring that its college graduates are competitive.

20. Charge the Board of Governors to review and develop a plan on how to create an innovation system that involves the various campuses of UNC. This review will need to focus on how to more systematically create applied research and development within the university and, therefore, must include strong support for faculty reward systems that encourage applied research, development, and technology transfer.

21. Charge the Board of Governors to review technology transfer policies to enhance the ability of the state to create technology-based businesses within the state.

22. Working with federal representatives, focus on creating federal policies and laws that promote:
    a. Inter-state co-opetition within naturally-occurring economic regions.
    b. Investment in public-private partnerships, including "gap funding."
    c. Modification of tax laws to allow public-private partnership research and technology transfer programs in public bond-funded facilities at universities and community colleges. This should especially be focused on development of technology-based small business.

23. Continue the work on developing BRAC-related research and technology transfer programs in various regions of the state.

24. Provide a comprehensive plan and financial support for developing "Millennial Campuses" to enhance regional competitiveness.

25. Develop state policies that recognize the unique roles of university and business R&D and develop a comprehensive plan to support development of business-based R&D in the state.

There are a number of recommendations regarding how these issues might gain support in state government, but, history shows us that making the types of transformation that will be mandatory to keep North Carolina competitive requires a commitment to change and to institutionalizing rapid change in government.[104] At the same time, it also requires a recognition that business, large or small, will need to focus on innovation, creativity and entrepreneurship. Likewise, educational reform and recognition that our future as a state is tied to educational attainment not just in the traditional sense but also involving the three elements of innovation,

creativity and entrepreneurship will be required at all levels. That may well take a rethinking of what we reward and how we conceptualize the educational outcomes and attainment.

North Carolina's history has been largely shaped by the relationships between the peoples of the state, the environment, and technology. And, North Carolina has a distinguished history of being a leader in the south with regard to technology-based economic development. Especially since World War II, North Carolina has had a series of political, business, and educational leaders who had the vision and will to make sure that the people of the state could aspire to a very high quality of life. With globalization and the shift to increasingly complex technology-based innovation as the key to the economy, North Carolina is at a crossroads. It can step up to the new and daunting challenges it faces or it can slide backwards. Given the people of the state, their values and work ethic, the strong history of leaders stepping forward at critical times, and the willingness of this state to pull together to solve problems, there is great potential for a very bright future.

References

[1] http://atschool.eduweb.co.uk/trinity/watistec.html, retrieved October 8, 2009
[2] Powell, W. S. *North Carolina Through Four Centuries.* Chapel Hill, NC: University of North Carolina Press, 1989.
[3] Powell, 1989: 131
[4] Powell, 1989: 131
[5] Powell, W.S. *Encyclopedia of North Carolina.* Chapel Hill, NC: University of North Carolina Press, 2006: 978
[6] Powell, 2006: 978
[7] http://www.historync.org/NCsteamboatlist1812%20-%201849.htm, retrieved October 30, 2009
[8] Ready, M. *The Tar Heel State: A History of North Carolina.* Columbia, SC: University of South Carolina Press, 2005.
[9] Ready, 2005: 183
[10] Ready, 2005: 183
[11] Powell, W. S. *North Carolina: A History.* Chapel Hill, NC: University of North Carolina Press, 1977.
[12] Powell, 1989
[13] http://www.textilehistory.org/AlamanceCountyNC.html, retrieved October 20, 2009
[14] Gade, *et al*, 2002: 166
[15] Powell, 1989
[16] Ready, 2005
[17] Powell, 1989
[18] Powell, 1989: 289-290
[19] Powell, 1989: 470
[20] CensusScope. Charlotte-Gastonia-Rock Hill, NC-SC: Population Growth. http://www.censusscope.org/us/m1520/chart_popl.html (retrieved, January 10, 2010).
[21] Research Triangle Foundation. The Research Triangle Park: Competing in the Global Economy. Durham, NC: Research Triangle Foundation, September, 2008.
[22] University of North Carolina at Chapel Hill, "Howard Washington Odum Papers, 1908-1982, retrieved, January 4, 2010.
[23] Little, W. F. "The Research Triangle of NC: Fifty Years of Achievement." Durham, NC: The Research Triangle Foundation, March 6, 2008.
[24] Link, A. N. and Scott, J. T. "The Growth of Research Triangle Park." Nottingham, UK: Conference to Promote Entrepreneurship in a Knowledge-Based Economy, September, 2000.
[25] Link and Scott, 2000
[26] Link, A. N. *William Friday: Power, Purpose & American Higher Education.* Chapel Hill, N.C.: University of North Carolina Press, 1995.
[27] Research Triangle Institute, http://www.rti.org/page.cfm/Corporate_Information. Retrieved, January 4, 2010.
[28] Environmental Protection Agency. *EPA at Research Triangle Park: Twenty-five Years of Environmental Protection.* National Service Center for Environmental Publications, retrieved, January 4, 2010.
[29] Research Triangle Park. "Triangle Universities Center for Advanced Studies, Inc.: A Brief History." www.rtp.org, retrieved January 4, 2010.
[30] Research Triangle Park, 2010.
[31] Little, 2008
[32] Little, 2008

[33] Biotechnology Institute, Historical Events in Biotechnology, http://www.biotechinstitute.org/what_is/timeline.html (retrieved, January 6, 2010).
[34] North Carolina Biotechnology Center: A Progress Report. Durham, NC: North Carolina Biotechnology Center, 1999.
[35] North Carolina Biotechnology Center, 1999: 6
[36] North Carolina Biotechnology Center. Evidence and Opportunity: Biotechnology Impacts in North Carolina. Durham, NC: North Carolina Biotechnology Center, November, 2008.
[37] North Carolina Biotechnology Center, 2008: 12
[38] Jackson, S., M. Rapoza, R. Juliano, K. Gonsalves, and K. Tindall. Nanobiotechnology in North Carolina. Durham, NC: North Carolina Biotechnology Center, April, 2007.
[39] North Carolina Biotechnology Center. North Carolina's Strategic Plan for Advancing Medical Technologies. Durham, NC: North Carolina Biotechnology Center, October, 2007.
[40] MCNC History--A Brief Timeline. https://www.mcnc.org/about/who-we-are.html, retrieved, January 8, 2010.
[41] MCNC. MCNC Strategic Plan 3/13/2009. http://redwidow.mcnc.org/files_static/MCNC_StrategicPlan_Rev0_FINAL.pdf (retrieved, January 9, 2010).
[42] MedCam v. MCNC
[43] Meszaros, P. Centennial Campus Timeline. Special Collections Research Center: Centennial Campus Documentation Project. Raleigh, NC: North Carolina State University Libraries, 2004a.
[44] North Carolina State University Libraries. Centennial Campus Interviews--Poulton. http://www.lib.ncsu.edu/specialcollections/centennialcampus/oral_history/cs_poulton.html (retrieved, January 10, 2010).
[45] City of Raleigh, 1988
[46] Meszaros, P. The History of North Carolina State University's Centennial Campus. Centennial Campus Documentation Project, Special Collections Research Center. Raleigh, NC: North Carolina State University Libraries, 2004b.
[47] Meszaros, 2004b: 4
[48] Meszaros, 2004b: 4
[49] Meszaros, 2004: 9-10
[50] North Carolina Board of Science and Technology. Tracking Innovation: North Carolina Innovation Index 2000. Raleigh, NC: North Carolina Board of Science and Technology, 2000a.
[51] Board of Science and Technology, 2000: 17-18
[52] North Carolina Board of Science and Technology. Vision 2030: Science and Technology Driving North Carolina's New Economy. Raleigh, NC: North Carolina Board of Science and Technology, 1999.
[53] North Carolina Board of Science and Technology. Mapping the Vision 2. Raleigh, NC: North Carolina Board of Science and Technology, 2000b.
[54] Nalebuff, B. "Co-opetition." New Haven Connecticut: Yale University School of Management, http://users.uoa.gr/~atsaoussi/Nalebuff.pdf. Retrieved, December 23, 2009.
[55] Silva, J., A. York, and K. Whelan, "North Carolina Faces Difficult Road to Recovery," Charlotte, NC: Wells Fargo Securities, November 13, 2009.
[56] Lang, Robert E. and Dhavale, Dawn. "America's Megapolitan Areas." *Land Lines*. Vol. 17, No. 3. July 2005.
[57] Florida, R., T. Gulden, and C. Mellander, "The Rise of the Mega-Region," Toronto, Canada: University of Toronto, October, 2007.
[58] Dordal, P. R. BRAC: A Regional Opportunity, *Economic Development Journal*, 8, Winter 2009, 49-54.

[59] Porter, M.E. & Kramer, M.R. (2006) "Strategy and Society: The Link Between Competitive Advantage and Corporate Social Responsibility", *Harvard Business Review*, December 2006, pp. 78–92.
[60] Berkley, D. L., M. S. Henry, and S. Nair, "Regional Innovation Systems: Implications for Nonmetropolitan Areas and Workers in the South," *Growth and Change*, 37, 2, 2006, 278-306.
[61] Ostergaard, 2008
[62] McMahan, R. K., "One North Carolina Program Status," presentation to the North Carolina Board of Science and Technology, Raleigh, NC, September, 2007.
[63] National Science Foundation, Science and Engineering State Profiles: 2006-2008, Washington, DC: National Science Foundation, November 2009.
[64] National Science Foundation, 2009.
[65] McMahan, 2007
[66] Audretsch, D. B., Erik E. Lehmann, and Susanne Warning. University Spillovers and New Firm Location. *Research Policy*, 34, 2005, 1113-1122.
[67] Bardo and Evans, 2006
[68] Bardo and Evans, 2006
[69] Feldman, M. P. and J. Francis. Fortune Favors the Prepared Region: The Case of Entrepreneurship and the Capitol Region Biotechnology Cluster. *European Planning Studies*, 11, 2003, 765-788.
[70] McMahan, 2007
[71] Ostergaard, 2008
[72] Bardo and Evans, 2006
[73] NSF, 2009
[74] Adams, J. D. Fundamental Stocks of Knowledge and Productivity Growth, *Journal of Political Economy*, 98, 1990, 673-702.
[75] Adams, J. D. Science, R&D and Invention Potential Recharge: US Evidence, *American Economic Review*, 83, 1993, 458-462.
[76] Adams, J. D. Learning, Internal Research, and Spillovers: Evidence from a Sample of Industrial R&D Laboratories. Rensselaer Working Papers in Economics, Troy, NY: Rensselaer Polytechnic Institute, March 2004.
[77] Paytas, J. et al. *Universities and the Development of Industry Clusters*. Pittsburgh: Carnegie Mellon Center for Economic Development. 2004
[78] National Governors Association, Innovative State Policy Options to Promote Rural Economic Development, Washington, D.C.: National Governors Association, 2003.
[79] Goldstein H. A. and Renault C. S. "Contributions of Universities to Regional Economic Development: A Quasi-experimental Approach." *Regional Studies.* Vol. 38, Issue 7. Pages: 733-746. 2004.
[80] Small Business Administration [prepared by BJK Associates]. The Influence of R&D Expenditures on New Firm Formation and Economic Growth. Washington, D.C.: Small Business Administration, 2002.
[81] Link and Scott, 2005.
[82] Anselin, L., Varga A. and Acs, Z. Geographical Spillovers and University Research: A Spatial Econometric Perspective. *Growth and Change*, 31, 2000, 501-515.
[83] Fischer, M. M. & Varga, A."Production of Knowledge and Geographically Mediated Spillovers from Universities: Spatial Econometric Perspective and Evidence from Austria," ERSA conference papers ersa01p182, European Regional Science Association. 2001.
[84] Anselin, L., Varga, A. and Acs, Z., 2000. Anselin, L., A. Varga and Z. Acs. Local Geographic Spillovers between University Research and High Technology Innovations. *Journal of Urban Economics*, 24, 1997, 422-448.
[85] Co, C. "Evolution of the Geography of Innovation: Evidence from Patent Data." *Growth and Change*, 33, 4, 2002, 393-423.
[86] O hUallachain, 1999.

[87] Verspagen, B. and Schoenmakers, W. "The Spatial Dimension of Knowledge Spillovers in Europe: Evidence From Firm Patenting Data." 2000-016. (working paper)
[88] Doring, T. and J. Schnellenbach. What Do We Know About Geographic Knowledge Spillovers and Regional Growth?—A Survey of the Literature. Deutsche Bank Research Working Paper Series, October 12, 2004, www.dbresearch.com.
[89] Link and Scott, 2005.
[90] Popper, S. W. and Wagner, C.S., New Foundations for Growth: The U.S. Innovation System Today and Tomorrow.Santa Monica, CA: The RAND Corporation, 2001. http://www.rand.org/pubs/monograph_reports/MR1338.0/MR1338.0.pdf (Popper and Wagner).
[91] National Governors Association, Innovation America: A Compact with Postsecondary Education. Washington, D.C.: National Governors Association, 2007.
[92] National Governors Association, 2003.
[93] National Governors Association, A Governor's Guide to Creating a 21st- Century Workforce. Washington, D.C.: National Governors' Association, 2002a.
[94] National Governors Association, A Governor's Guide to Cluster-Based Economic Development. Washington, D.C.: National Governors Association, 2002b.
[95] National Governors Association, 2007.
[96] National Governors Association, 2007: 1
[97] Berglund, D. and Clark, M. "Using Research and Development to Grow State Economies." Washington, D.C.: National Governor's Association, 2000.
[98] National Governors Association, State Strategies for the New Economy. Washington, D.C.: National Governors' Association, 2000.
[99] National Governors Association, 2002a.
[100] National Governors Association, 2002b.
[101] National Governors Association, 2003.
[102] Kao, 2008.
[103] McMahan, 2009.
[104] McMahan, 2009.