

Cultivating Emerging & Black Swan Technologies

November 15, 2012

IMECE, Houston

- **Definitions**
 - **Converging, Emerging & Black Swan Technologies**
- **How do we cultivate them?**
 - **Example –ICTAS**
- **Concluding Remarks**

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- **Collaborators**

Prof. Naren Ramakrishnan, CS: Big Data

Prof. Chris Williams , ME, Additive Manufacturing

Prof. Tom Campbell, ICTAS, Additive Manufacturing

Prof. Jeff Reed, ECE, Wireless Communication

Prof. Rolf Muller, ME, Bio-inspiration

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Converging Technologies

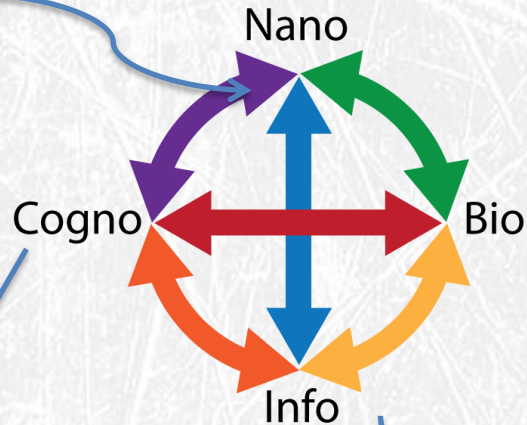
U.S. View NBIC

Manipulation of matter at the nano and molecular scale

- Next industrial revolution
- New phenomena, materials
- Environmental issues
- \$3.3 Trillion global market

Interactive study of mind and its processes

- Brain: the next frontier
- Learning and decision making
- Reverse engineering the brain



How living systems develop, function, and interact with each other and with nonliving systems at the molecular and microscopic levels

- DNA, RNA
- Cell growth
- Cell differentiation
- Cellular behavior

Computer based information systems

- Computers and telecommunications equipment to store, retrieve, transmit and manipulate data.
- Networks

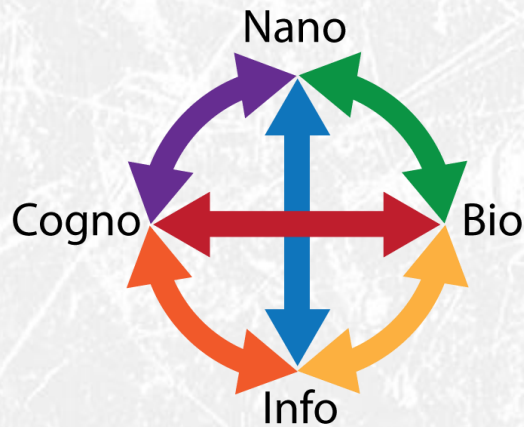
BANG (ETC Group)

- Bits
- Atoms
- Neurons
- Genes

Converging Technologies

U.S. View

NBIC



BANG (ETC Group)

- Bits
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THINK OF THESE AS FOUNDATIONAL TECHNOLOGIES



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Emerging Technologies

New technologies that are currently developing or will be developed over the next 5 to 10 years, and which will substantially alter the business and social environment.



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Emerging Technologies

- *A more comprehensive definition (the World Economic Forum's Global Agenda Council, 2010)*

***Emerging technologies** are ones that*

- *Arise from new knowledge, or the innovative application of existing knowledge;*
- *Lead to the rapid development of new capabilities;*
- *Are projected to have significant systemic and long-lasting economic, social and political impacts;*
- *Create new opportunities for and challenges to addressing global issues; and*
- *Have the potential to disrupt or create entire industries.*

Typical Emerging Technologies

(October 2011 meeting of the WEF's Global Agenda Council)

- Nano-scale design of materials
- Rapid/inexpensive DNA sequencing (\$100 human genome)
- Personalized medicine, therapy, nutrition, and disease prevention
- Brain-machine interface
- Wireless (ubiquitous yet energy-saving) power transmission system



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Another List: Dr. Alexander Van de Putte; Madrid, March 2010

Strategic Foresight: Navigating Uncertainty: Potential Game Changer Technologies

Biotechnology

- Biodegradable electronics, bio-gerontology, biological machines, biomimetics.....

• Energy Technologies

- Wireless power transmission, CNT fibers, liquid battery, nanowire electrodes

• Information & Communication Technologies

- Neural super-computer, holographic data storage, machine-augmented cognition...

• Kinematics & Robotics

- Swarm robotics, molecular nanotechnology, nanorobotics, spintronics...

• Materials Science

- Programmable matter, self-healing materials, paper diagnostics, nanopiezoelectronics..

• Transportation/Mobility Technologies

- Non-rocket space launch and flight, personal rapid transit



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Emerging Technologies on the Horizon

(Mills & Ottino, WSJ January 30, 2012)

The Coming Tech-led Boom

In January 1912,

Emerging technologies circa 1912—*electrification, telephony*, the dawn of **the automobile age**, the invention of *stainless steel* and the *radio amplifier*

In January 2012,

we sit again on the cusp of three grand technological transformations with the potential to rival that of the past century.

- Big Data,
- **Smart Manufacturing**
- **Wireless Revolution.**

All find their epicenters in America



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Agencies Rally to Tackle Big Data

V. 336, Science , 6 April 2012

- *“ Big data is indeed a big Deal” John Holdren, the President’s Science Advisor*
- *1.2 zettabytes of electronic are generated each year*
 - *Manage, understand and act upon the deluge of data*
 - *Applications in health, energy, intelligent analysis, and education*
 - Mining Massive Passive Data e.g., tweets, search queries
 - Data mining for intelligence analysis
 - Modeling population level movements/changes
 - Data center chiller management
 - Mining electronic health records



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Smart Manufacturing

- Additive Manufacturing

- Digital sharing

- Global sharing; Local manufacturing
 - Reduced transport, packaging, and distribution costs
 - Democratization of manufacturing

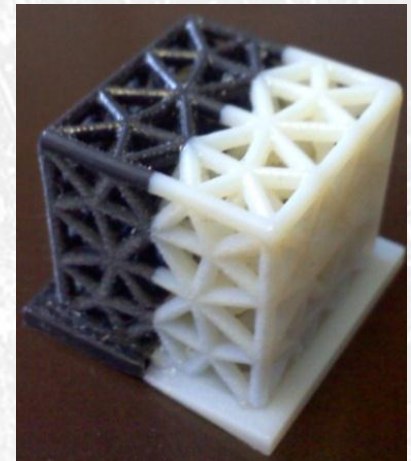
- Desk top printing of body parts

- Emerging Materials Science

- Design and build from the molecular level
 - New materials—graphene; new alloys
 - Meta materials



www.makerbot.com



www.dreams.me.vt.edu

Wireless Revolution

- Coupled with the cloud, the wireless world provides cheap connectivity, information and processing power to nearly everyone, 'any time and any place'
 - Rapid change—e.g., the Arab Spring—and great opportunity.

- **Augmented reality and “just in time” learning**

- **"situated visualizations"** that are related to and displayed in their environment.

White, S. and Feiner, S. SiteLens, 2009

- Shift the locus of computation into the physical environments in which we live and interact.
- The physical world can be digitally augmented, e.g., through embedding the environment with information contextually relevant to an ongoing activity.

Y. Rogers, S. Price, 2006



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I would add Bio-Inspiration to this list

Global **Biomimicry** Efforts An Economic Game Changer

- > Commissioned by San Diego Zoo Global
- > Researched and produced by the Fermanian Business & Economic Institute.

SAN DIEGO ZOO



POINT LOMA
NAZARENE UNIVERSITY

November 2010

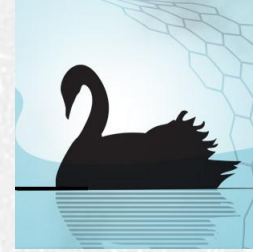
**Estimated Impact on US GDP by 2025
in billions of 2010 dollars: 350**



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Black Swan Technologies



A Black Swan is an event that has three characteristics;

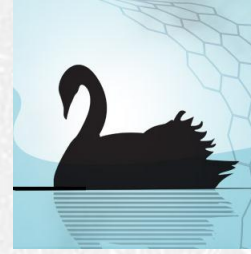
- it is an outlier
- it carries an **extreme** impact
- it has retrospective predictability.

"The Black Swan", by Nassim Nicholas Taleb

In history, science, finance and technology

- The real estate melt down/collapse of the stock market in late 2008
- "Arab Spring", January 2011
- Earthquake/tsunami/ and nuclear accident in Japan, March 2011

Black Swan Technologies



In Technology, Nassim Nicholas Taleb cites the following Black Swans

- the internet
- the computer
- the laser

All three were unplanned, unpredicted, and unappreciated upon their discovery, and remained unappreciated well after initial use.



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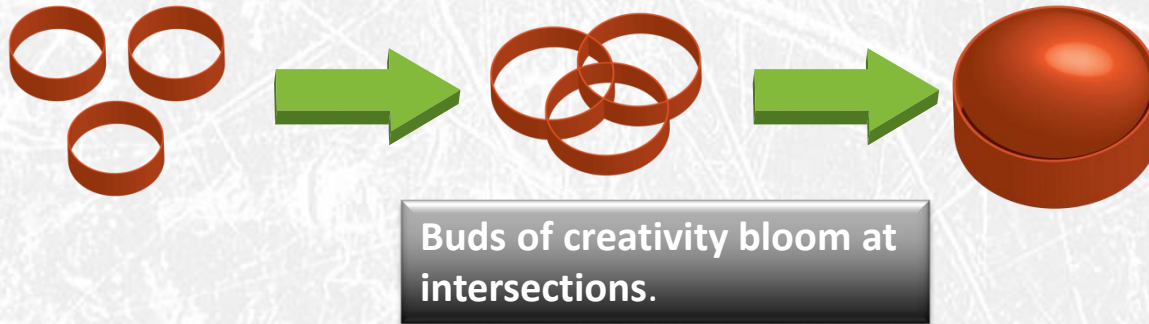
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Cultivating Emerging and Black Swan Technologies

- **Promote interdisciplinary research**



- **Create a culture of risk-taking**
 - **A good dose of blue sky component**
 - **Provide support**
- **Provide a breeding ground for next Black Swans**



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In Praise of Interdisciplinary Research

“... one of the most *productive and inspiring* of human pursuits – one that provides a format for conversations and connections that lead to new knowledge.”

“As a mode of discovery and education, *it has delivered much already and promises more* – a sustainable environment, healthier and more prosperous lives, new discoveries and technologies to inspire young minds and a deeper understanding of our place in space and time.”

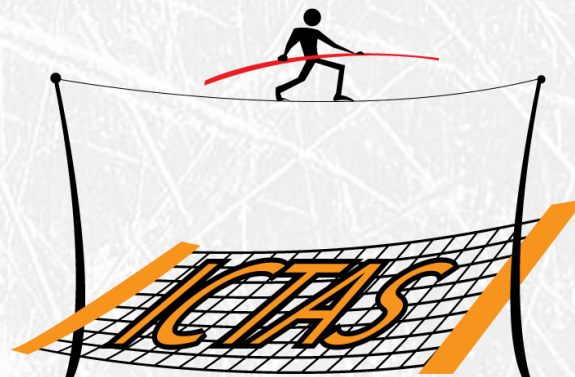
*“Facilitating Interdisciplinary Research
National Academies Press, 2005.”*

Institute for Critical Technology & Applied Science at VT

➤ Acts as a catalyst for Interdisciplinary Research (IDR)



➤ Serves as an Agent of Innovation

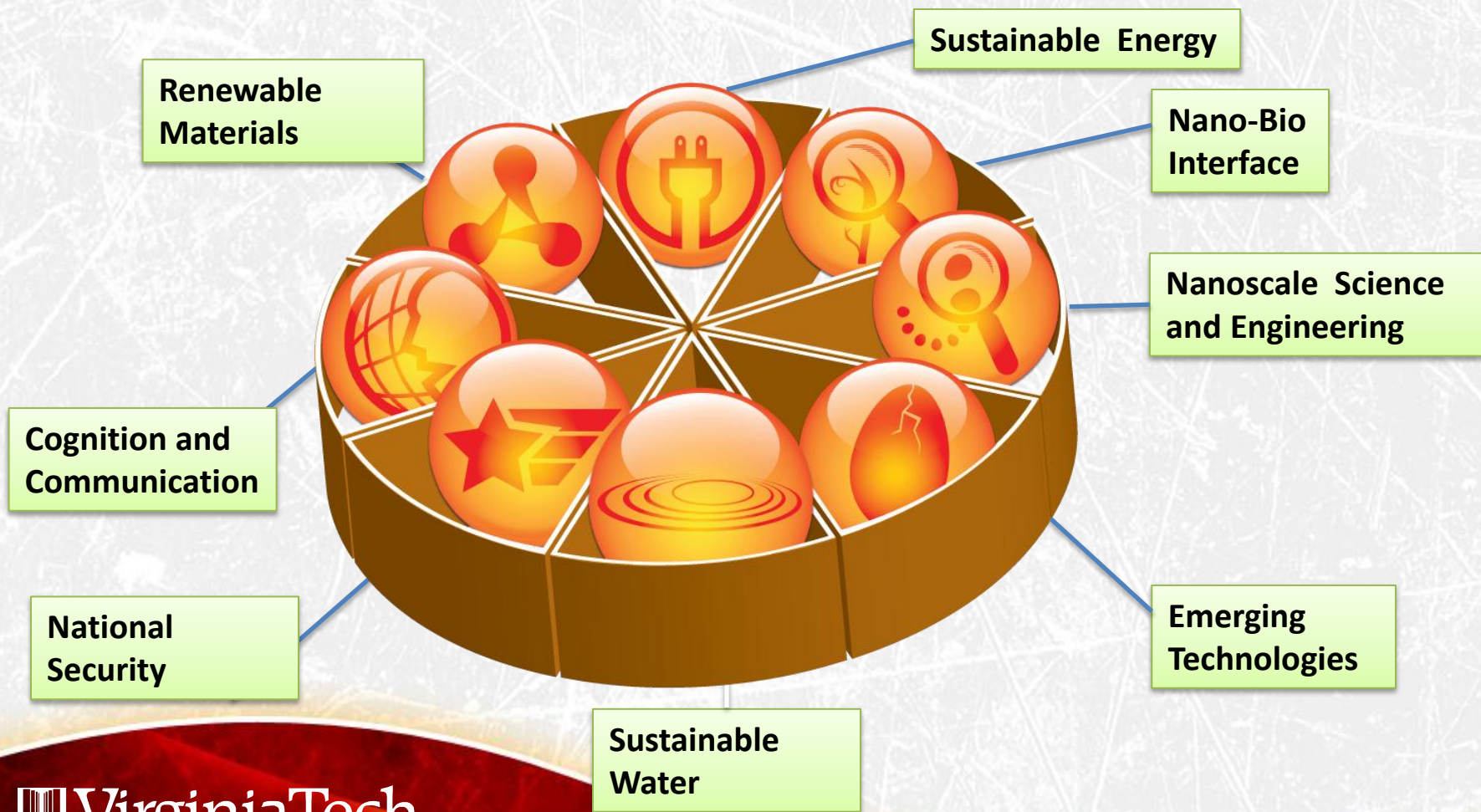


➤ Enhances educational experience of students in IDR



➤ Promotes economic development and enhance quality of life in the COV, USA and the world





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ICTAS HQ



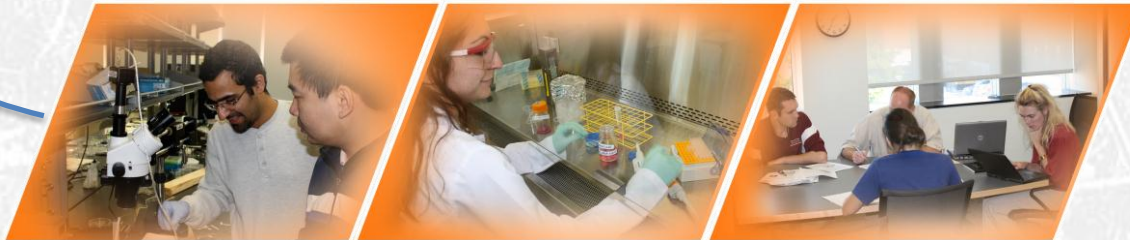
ICTAS CRC



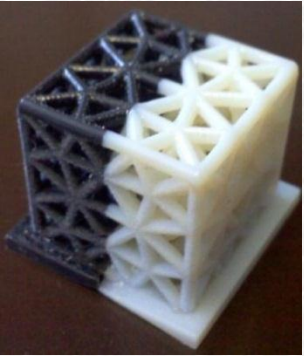
ICTAS LSC



ICTAS NCR



Emerging Technologies



3-D Printing



VT in Space...

Sick Humanoids make us well

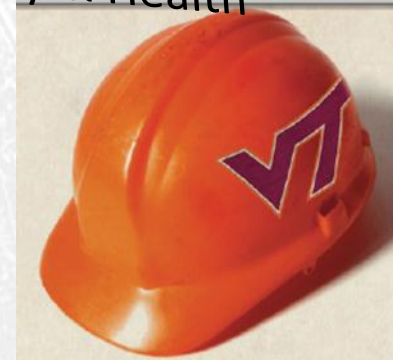
Deep Dives



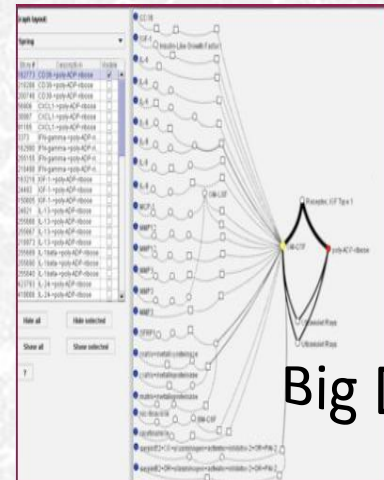
Bats, Beetles, Flying Snakes



Safety & Health



Nuclear beyond energy



Big Data

“The Black Swan and Disruptive Technology”:

An informal discussion of the future

Where ? Café X located in the main ICTAS building.

Objective

- Create an environment for engineers, scientists, and humanists to come together to move **beyond the predictable and incremental advances** in the current technologies to the **disruptive technologies** of the future.

Features:

- No tyranny of power point
- Focus on one general area with invitees from outside the field

Black Swan Seminar Series



Concluding remarks

Grand Challenges facing humanity

• *Emerging Technologies*

- Help solve important economic and societal problems;
- Serve as a “North Star” for high-impact, multi-disciplinary collaborations among government, industry, universities, non-profits, and philanthropists;
- Create a foundation for industries and jobs of the future;
- Capture public imagination and increase support for
- Public policies that foster science, technology, and innovation;
- Inspire the next generation of scientists, engineers, and entrepreneurs.

21st Century Grand Challenges, The White House OSTP; April 20, 2012

1. Energy
2. Water
3. Food
4. Environment
5. Poverty
6. Terrorism & War
7. Disease
8. Education
9. Democracy
10. Population

Richard Smalley
Energy & Nanotechnology
Conference, Rice U.,
May 3, 2003

Watch out for

