

# **Physics Careers in Industry**

**Student Career Panel and Networking Reception  
2011 April APS Meeting, Anaheim, CA**

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General Atomics  
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[www.ga.com](http://www.ga.com)  
[www.sci-ed-ga.org](http://www.sci-ed-ga.org)**

# My Brief History



14-MW TRIGA® Reactor  
in Romania



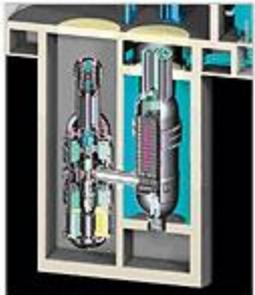
Inside DII-D Fusion Device



LYNX™ Radar System



High-speed Railroad Catenary  
Maintenance Vehicle



Modular Helium-cooled Reactor

- ❖ PhD UCSD Low temperature heat capacity of magnetic superconductors – many publications, 1980
- ❖ Disappointing/unproductive post-doc at Exxon Research, 1980-1982
- ❖ Hired as solid state physicist at General Atomics (GA) in 1982 to help develop non-nuclear programs. At GA for 29 years – mostly materials R&D.

*Every story and perspective of life in industry is unique and changes depending on the stage of one's career*



Aerial View of General Atomics'  
San Diego Facility



Predator® Unmanned Aerial  
Vehicle (UAV)



Maglev Transportation



Electromagnetic Aircraft Launch  
System (EMALS)



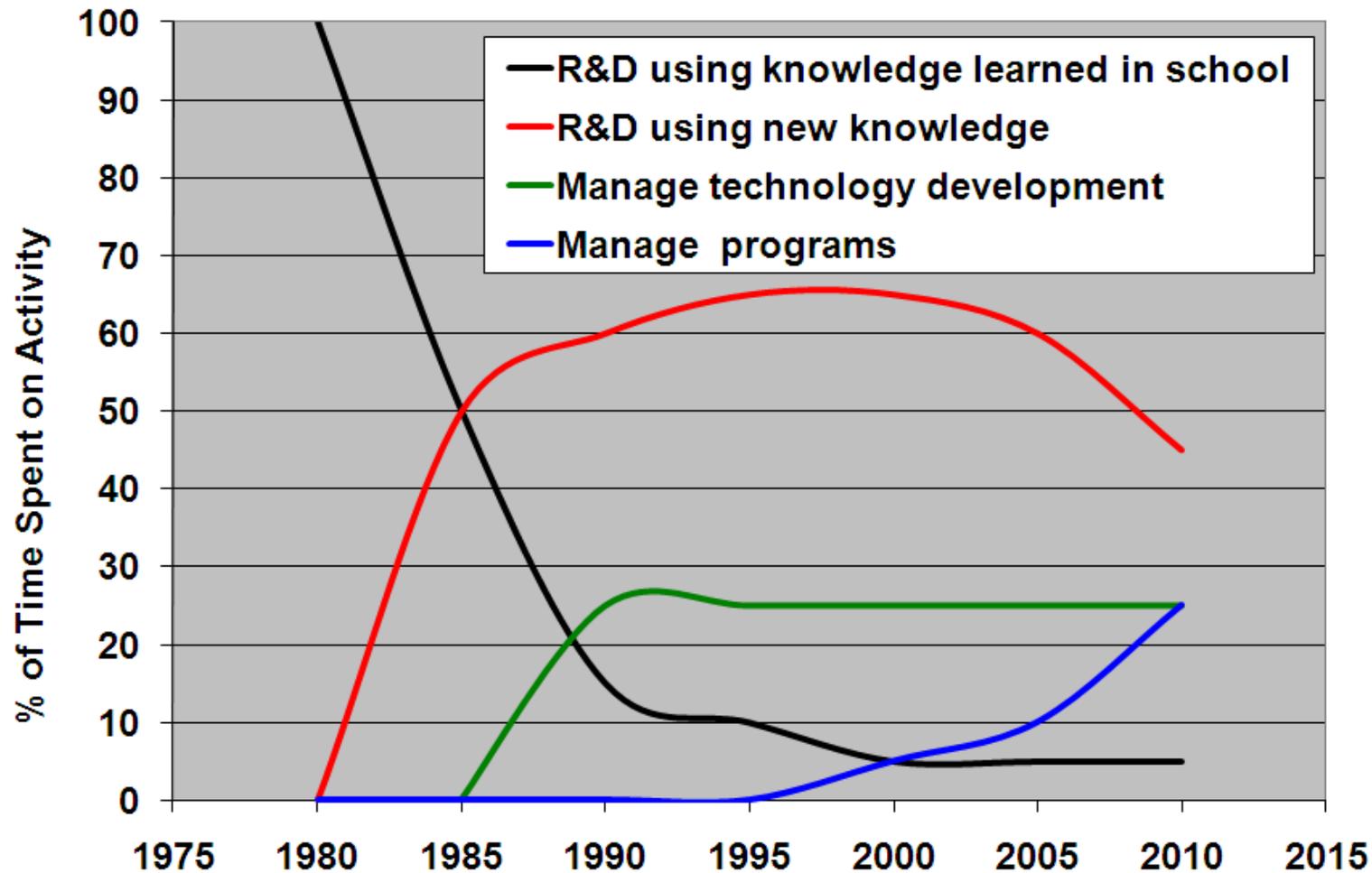
High-power AC Propulsion System

# Industrial careers are varied – and often unrelated to PhD thesis

- ❖ Neutron doping of silicon: '82-'83 (GA funding)
- ❖ Graphite fiber physics and materials science: '83-'85 (GA funding)
- ❖ Thermophotovoltaics: '86-'87 (Gov. funding)
- ❖ High temperature insulators, thermionic energy conversion for space nuclear power: '88-91 (Gov. funding)
- ❖ High temperature superconductors; ceramic processing; wire fabrication: '91-'98 (Japanese Venture Capital funding)
- ❖ High temperature insulators for conductors for aircraft: '98-'00 (Gov. funding)
- ❖ Thin film designs and coatings: '01-'11 (Gov. funding)
- ❖ Program management, government contracting, intellectual property/patents, budgeting, proposal writing, internal and external reports, personnel management: '87-'10

*Punctuated Equilibrium Theory of Job Evolution*

# Evolution of my job over time



# What do I do all day?

- ❖ **New ideas/solution to problems**
  - **Internal R&D proposals to management**
    - Sell concept to management, considering technical risk, core competency, existing equipment, schedule, costs, competition
  - **Respond to Requests for Proposals(RFP) or Broad Agency Announcements (BAA)**
    - Write/manage technical and cost proposal, including schedule, milestones
- ❖ **Develop/optimize designs/concepts (physics)**
- ❖ **Develop overall experimental approach (manufacturable)**
- ❖ **Initial development**
  - **Initiate development/analyze data**
  - **Use analysis to design next experiment**
  - **Iterate until initial development is complete**

# What else do I do all day?

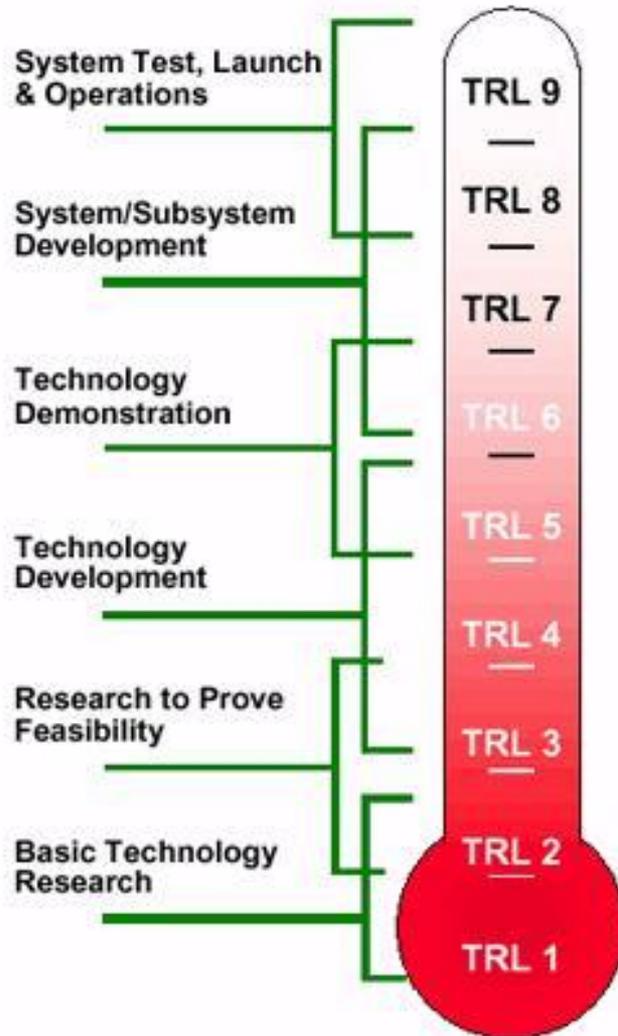
- ❖ **Transition from initial development to pilot scale production**
- ❖ **Assist transition from pilot scale production to full scale production**
- ❖ **Write reports: technical, cost, contractual issues**
  - Monthly reports
  - Final report
  - Task/technical reports
- ❖ **Write and give presentations to internal management and funding agency, neither of whom may be experts in the technology (importance of explaining technology to non-experts!)**
- ❖ **Discuss issues with technicians, engineers, scientists, managers both informally and in formal meetings**

***Note: Most of this does not involve solving physics problems!***

# Similarity of work in government contracting and university research

- ❖ **Professor receives funding from government for basic research and manages all aspects of the program**
- ❖ **Program manager in industry receives funding from government for applied R&D and manages all aspects of the program**

# But major differences between industry and university



## Technology Readiness Levels (TRL)

- **University Research: TRL 1**
- **Industry: TRL 1 to 9**

# Physicists in industry should know something about process and manufacturing engineering

- ❖ **Process and manufacturing engineers often do not understand the basic physics enough to understand how best to process and manufacture the material/device; physicists need to understand relevant process and manufacturing techniques to efficiently transition basic technology into production**
- ❖ ***Perform R&D with final goal informing selection of design, materials, processes***

# Levels of employment in industry: Level ~\$ (physics)

(Aviation Week and Space Technology 2009 Workforce Study)

- Level 1. Individual contributor working under direction of technical leadership, beginning to understand internal processes and tools for systems development (\$66K)
- Level 2. Improved knowledge of product, some self-direction, understands internal processes, and contributes to engineering estimates (\$80K)
- Level 3. Significant knowledge of products, decisions may have significant impact on costs, schedule, and performance. Mentor to more junior engineers (\$99K)
- Level 4. Serves as system architect, recommend tools and techniques for continuous improvement, lead preparation of proposals and presentations, estimates and tracks costs and schedules while managing scope (\$120K)
- Level 5. Develops product and technical roadmaps and competitive assessments, leads or reviews proposals, cross functional teams in a project engineering roles (\$138K)
- Level 6. Industry expert in knowledge of products and systems, directs sophisticated design, analysis and testing of complex systems, provides direction on strategic technology plans for company (\$177K)

## My 15 Point Guide to Success

1. **Be responsive – return phone calls and emails promptly. When asked to do something, do it on time – be sure to ask when it should be done. Document requests and responses in writing.**
2. **Become the world expert in your particular area.**
3. **Continually expand the depth and breadth of your knowledge and skills.**
4. **Utilize all information resources available - books, science magazines, web sites, search engines, search services, colleagues, patents, trade magazines, catalogs, sales reps, conferences.**
5. **Get involved with or develop projects that have a high probability of contributing to the company's success.**

## My 15 Point Guide to Success

6. Understand and be aware of project constraints such as your personnel and company capabilities, competitor's strengths, and customer needs.
7. **Innovate continuously. Always push your envelope as well as the science and technology envelope. Stay uncomfortable with what your skills and knowledge are.**
8. Document your work in manner that can be easily understood by a co-worker a year from now. Use spreadsheets, tables and charts to convey your results in a concise, visual, and easy-to-understand manner.
9. Make sure that you learn something useful from any tests or experiments that you perform. These results should form the basis for future tests.
10. Learn from your mistakes. Don't repeat them.

## My 15 Point Guide to Success

11. Don't believe everything you are told, even if it is company lore or told to you by an expert. Be skeptical.
12. Enjoy your work.
13. Treat everyone you work with (above and below you) with respect. Thank them for their work. Acknowledge their contributions whenever possible. Keep them informed as to what you are doing and why you are doing it.
14. Have a sense of humor.
15. **Develop a unique and necessary skill and knowledge set that complements those of your co-workers and greatly increases the value of your project/team. Be indispensable.**

## Expanding on these points ...

- ❖ **“... you need to be very good at whatever you are hired to do. One aspect of communication is to let your colleagues know that you are being productive.”**
- ❖ **“Being good at what you are hired to do will help you keep your job today. Constantly learning and growing in your abilities will help you remain competent tomorrow. Taking on project management responsibilities will broaden your experience and build your reputation and network of contacts. What you learn in the process will keep you employable, not to mention being more valuable to your company.”**

Milton Chang in the Business Forum feature of Laser Focus World magazine, October 2009, p.33.

# Advantages of Careers in Industry

- **Goal is development of a product**
- **Satisfaction of seeing your efforts make a difference to people**
- **Opportunities for patents, business development**
- **Challenge of not just doing science, but applying science to technology, then figuring out how to commercialize it. Challenges include science, technology, manufacturing, costs, schedule, competition, a dynamic marketplace.**
- **Challenge of learning how to perform R&D and scale-up under time, cost, equipment, personnel, facilities constraints**
- **Varied career opportunities: science, technology, manufacturing, program management, group management**
- **Many different projects; constant learning needed**
- **Pay, bonus pool**

# Disadvantages of Careers in Industry

- Often minimal publications or presentations due to proprietary or security issues
- Focus on a defined goal
- Limited freedom to pursue your personal interests
- Reduced likelihood of being recognized for your achievements from an academic perspective, e.g. awards, fellowships, etc
- No sabbaticals, no tenure
- Reduced interactions with peers due to proprietary or security issues
- Need to rapidly reinvent yourself as technologies and business areas change

# Recommendations to enhance preparedness for physics related careers in industry

- ❖ **Have grad students participate in proposal writing and in determining the direction of future research – similar to determining the strategic direction of a business unit**
  - **Evaluate core competencies vs. competitors**
  - **Evaluate opportunities for major discoveries (academic) or businesses (industry)**
- ❖ **Have grad students locate, discuss and evaluate proposal opportunities from RFPs and BAAs**
- ❖ **Have grad students schedule and track contractual and financial progress**

# Recommendations to enhance preparedness for physics related careers in industry

- ❖ **Have learning goals in classes more closely mirror industry needs**
  - **Short term memorization and rapid problem solving are not important, yet form the basis for most tests – major disconnect**
  - **Need to be able to develop solutions to new problems based on deep conceptual and quantitative understanding across multiple fields**
  - **Often a focus on mathematical derivations to the exclusion of deep conceptual understanding, especially in graduate classes – isn't this a form of rote learning?**

# Recommendations to enhance preparedness for physics related careers in industry

- ❖ **Have grad students evaluate eventual commercialization of their research**
  - **How could it be mass produced**
  - **What are advantages vs. competition**
  - **Work with grad students in process engineering and manufacturing engineering and learn about these topics**
  - **Evaluate potential material and production costs**

*Could this meet, in part, the NSF broader impacts requirement?*

# Recommendations to enhance preparedness for physics related careers in industry

- ❖ **Include more engineering in physics courses**
  - real-world problems
  - Industrially relevant advanced labs
- ❖ **Bring in industrial physicists for colloquia to talk about their work**
  - Near exclusion of information for undergrads and grads to understand what life is like in industry
- ❖ **Survey your graduates in industry and ask them how their education could have been improved to increase their success at work – see next slide**

# APS Question 1 of 3

## 1. What drew you to physics initially?

- Interest in astronomy in elementary school
- The night sky/telescopes/planetariums/space program

## APS Question 2 of 3

### 2. What aspects of your current career do you find surprising or difficult?

Surprising:

- Longevity at GA
- Ability to innovate
- Good at doing R&D as well as scale-up
- Many patents
- My extensive involvement in many aspects of science education, from K-12 to graduate

Difficult:

- Developing cost proposals
- Inability to discuss work with others or publish
- Need to accomplish many goals at same time

## 3. What advice you would give to students who are interested in pursuing a career in your field?

- See my 15 point guide to success
- Take ownership of your projects – as a PhD, you are responsible for making it a success
  - As a PhD, you will be asked to run programs so learn about program management, budgets, schedules, milestones, engineering, quality – physics is a critical part, but only a part

# Conclusion

## ❖ **Physics careers in industry**

- Varied
- Rewarding
- Dynamic
- Challenging
- Many aspects not included in curriculum

## ❖ **Education opportunities in industry**

- Outreach
- May be more extensive depending on personal motivation and corporate culture