
Lessons learned from my optical career: what I wish I knew then

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College Did NOT Prepare Me for the Real World

- About 10 years after I graduated, I came to a stark realization:

College did NOT prepare me for the real world!

- Some time later, I mentioned this to Dr. Brian Thompson, my undergraduate advisor, who told me

College is NOT supposed to prepare you for the real world. College is there to teach you how to think in your chosen discipline. YOU are responsible for learning how to succeed in the real world.

- Hmm... What did I wish I knew then that I know now?

It's All Important

- During college, I saw no use for
 - Physical optics
 - Diffraction and coherence theory
 - Polarization
 - Radiometry
 - Lasers
 - Etc
- Heck, I was a lens designer! What possible use did I have for these courses?
- Over time, I learned that I was dead wrong! **It's all important!**
- What was the most useful course I ever took at UR? Amazingly, it was **radiometry!** No one in industry understands radiometry!

Corollary: You're Never Done Learning

- If you think that you're done learning after you graduate, you're gravely mistaken!
- In order to maintain your professional standing, you're going to have to learn new skills continuously in your career.
- What did I have to learn as a lens designer working in industry?
 - Gaussian beam propagation (slept through that course at UR)
 - Fresnel and Fraunhofer diffraction theory (ditto)
 - Partial coherence (ditto, again)
 - Thermal radiometry (had to learn from scratch)
 - How mechanical CAD software works
 - Speckle (had to learn from scratch)
 - C++, .NET programming (didn't exist when I was in college)
 - Tolerancing, component specification for manufacture
 - Stupid business stuff

“Show Me the Money!” – “Jerry Maquire”

- If you graduate and accept a job paying \$100K/year and never get a raise ever during a 30 year career, you're going to earn \$3M. However with raises, you will likely earn \$4-5M or more over your career.
- Do you know how to wisely manage and invest that kind of money?
- I didn't.. .and had to learn! **I believe that this is one of the most significant failings of college programs everywhere!**

“Love of Money is the Root of All Evil” – 1 Timothy 6:10

- Do not be handcuffed to a job that is holding your career back because you are highly paid!
- I have, on 3 occasions, left a comfortable, highly paying job for a new job paying a significantly lesser salary because I believed the new job was in my career interests.
- While this appears to be a simple judgment or values call, I believe in the saying

If you enjoy what you are doing, you'll never work a day in your life!

- Management studies have shown that money is NOT the principal motivator for most employees. It is in fact a distant third to (1) working on a team and (2) being a valued contributor

No Man is an Island...Network!

- Networking is key to a successful career in any professional field **ESPECIALLY** in a small, niche field like optics!
 - You don't know everything but someone else probably knows something that you need to know ... go find him/her!
 - Most of the best job opportunities are NEVER publicized ... they are passed around via "word of mouth"
 - You may need a good recommendation to get that plum job
 - You may need to know why you didn't win that contract, get that job, lose that key employee, etc
 - You may need career guidance
 - You might be faced with a layoff situation
 - ...

Corollary: There are No Secrets in Optics

- In a small, niche field like optics, it is nearly impossible to keep a secret!
- Algorithms, processes, capabilities, technology, etc become public knowledge very quickly.
- Side note: If you're cheating on your significant other, everyone in optics already knows!

Learn to Communicate!

- Are you a wiz at PowerPoint? **If not, become one!**
- Do you panic when you have to give a presentation? **Get over it! Get professional help/training!**
- Can you write a coherent sentence? **Learn to write!**
- Does it take you 2 days to write a paragraph? **If so, you'll never get ahead!**
- Can you explain <pick a topic: coherence theory, thermal radiometry, gradient index optics, etc> to a manager, investor, advertising agent, supervisor or other lesser intellect? **Stop sniveling! Your career may depend on it!**

“Do or do not.. there is no ‘try’” – Yoda

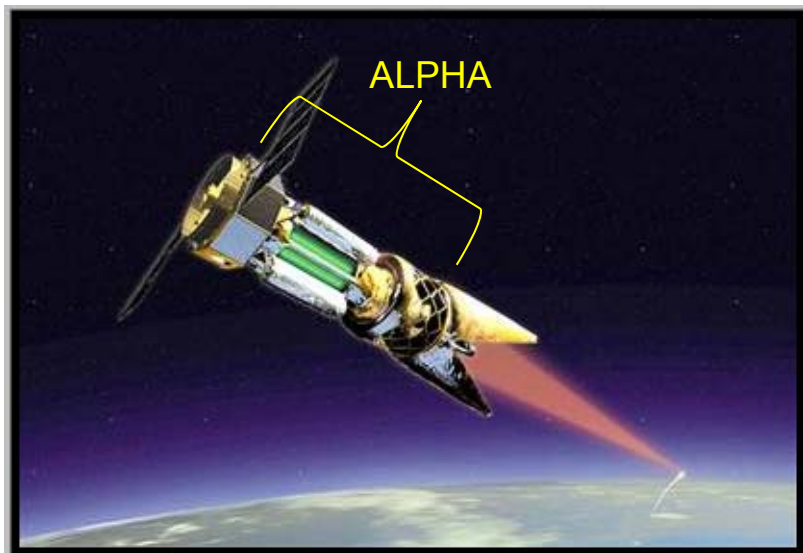
- You will never get ahead in industry if you “try”! However you will get ahead of you “do”!
- Unlike college where you can get an “A” for effort, in the real world, you get an “A” for succeeding; you get an “F” for failing.
- **It's that simple!**

“Trust Your Instincts” – Obi-Wan Kenobi

- Very often, no one knows the answer... that's why they hired you!
- You will be responsible to
 - know the answer
 - find someone who knows the answer
 - know where to look in the literature to find the answer
 - run an experiment to find the answer
 - write a piece of software to find the answer
- “**Failure is not an option**” - attributed to Gene Kranz but he really didn't say it - it was coined by Bill Broyles, one of the screenwriters of *Apollo 13*, based on a similar statement made not by Kranz, but another member of the Apollo 13 mission control crew, FDO flight controller Jerry Bostick.
- How do you know if you have the right answer? **Use the Force** (i.e., everything you've learned)

ALPHA Laser Project

- ALPHA is (was) a high-energy (megawatt) HF-DF chemical laser developed by TRW (now Northrup-Grumman) first fired in 1989 at the Capistrano Test Site in Southern CA.

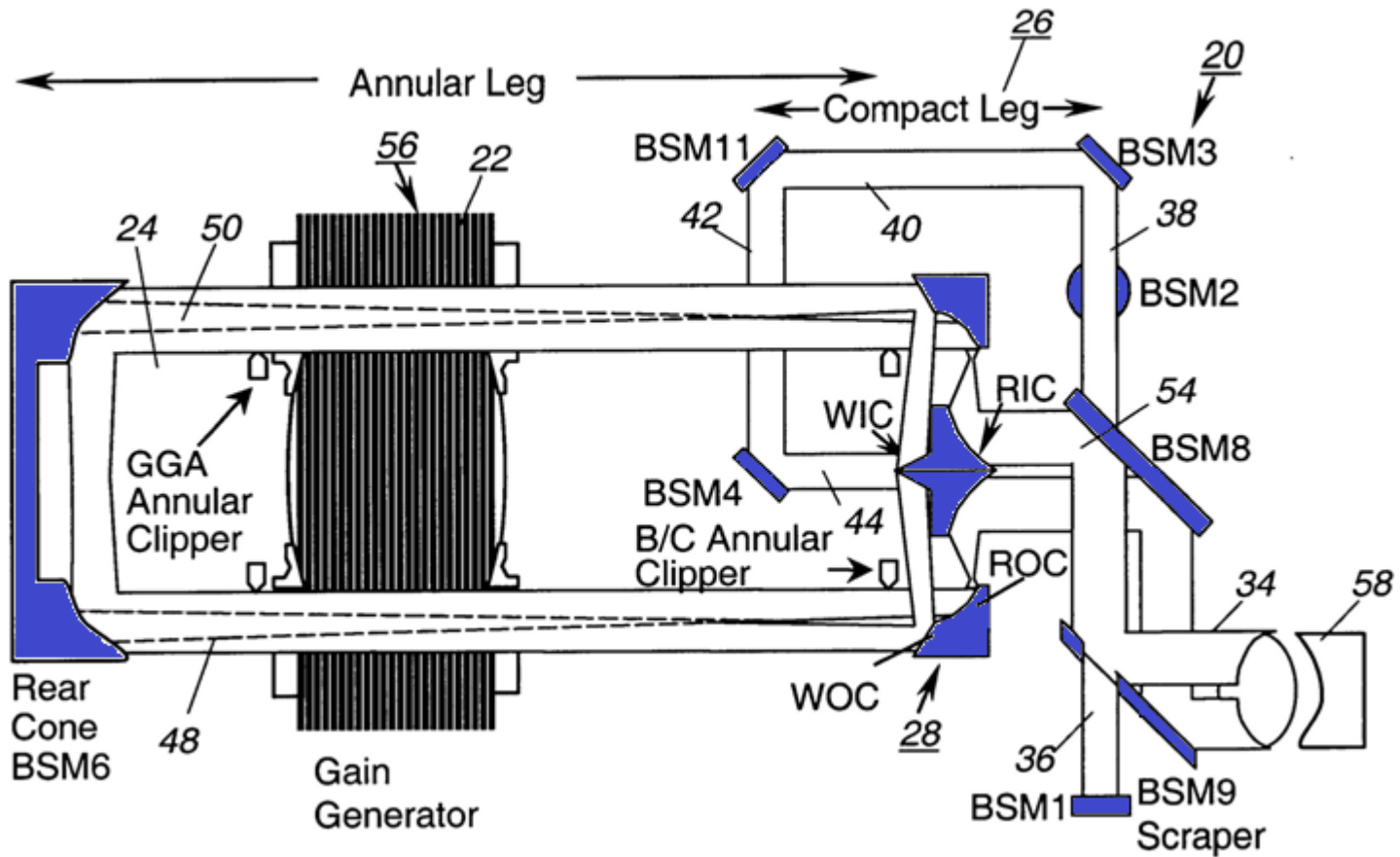


ALPHA as a SBL



Capistrano Test Site

Optical Schematic of ALPHA Laser



Ref: US Patent 6,519,035

Steering the Ship Towards the Iceberg

- Optical design completed in early 1980's using proprietary resonator design code "CROQ" (Cylindrical Resonator Optical Quality)
 - Physical optics model; no geometrical rays were traced
 - All propagation accomplished through Hankel Transforms
 - Limited ability to model perturbations, misalignments, etc
- The prescription of one of the mirrors was slightly changed after CDR ("hardly worth mentioning", "insignificant", "not to worry", "no one will notice", etc)
- Mirrors fabricated in early 1980's after successful CDR
- Laser was constructed through the mid 1980's
- Inevitable delays regularly postponed the 1st firing

Looking at the Problem with a New Tool

- Question of alignment tolerances came up in 1985: what happens to the beam trajectory if the rear cone BSM6 were to decenter?
- How to address this question?
 - CROQ could not evaluate a decentered (perturbed) system
 - TRW has just purchased the 1st commercial copy of Breault Research Organization's ASAP program
 - ASAP was primitive by today's standards but functional
 - Hybrid single/double precision raytrace
 - Geometry stored in single precision
 - Limited to 6th order surfaces
 - **Unproven software**
- Project management was skeptical that a mere geometrical optics program could be useful modeling a high-energy laser designed by a custom physical optics code!

“Houston, We (May) Have a Problem!”

- Since ASAP stored geometry in single precision and no higher than 6th order surfaces could be modeled, constructing the model was a nightmare and we had to be clever!
 - Higher order surfaces had to be broken up into a series of lower order surfaces and then “stitched” together
 - Wavefront calculations were very noisy and looked nothing like the smooth, refined wavefronts produced by CROQ
 - High degree of support from ASAP’s author Al Greynolds throughout!
- It was quickly apparent that something wasn’t right!

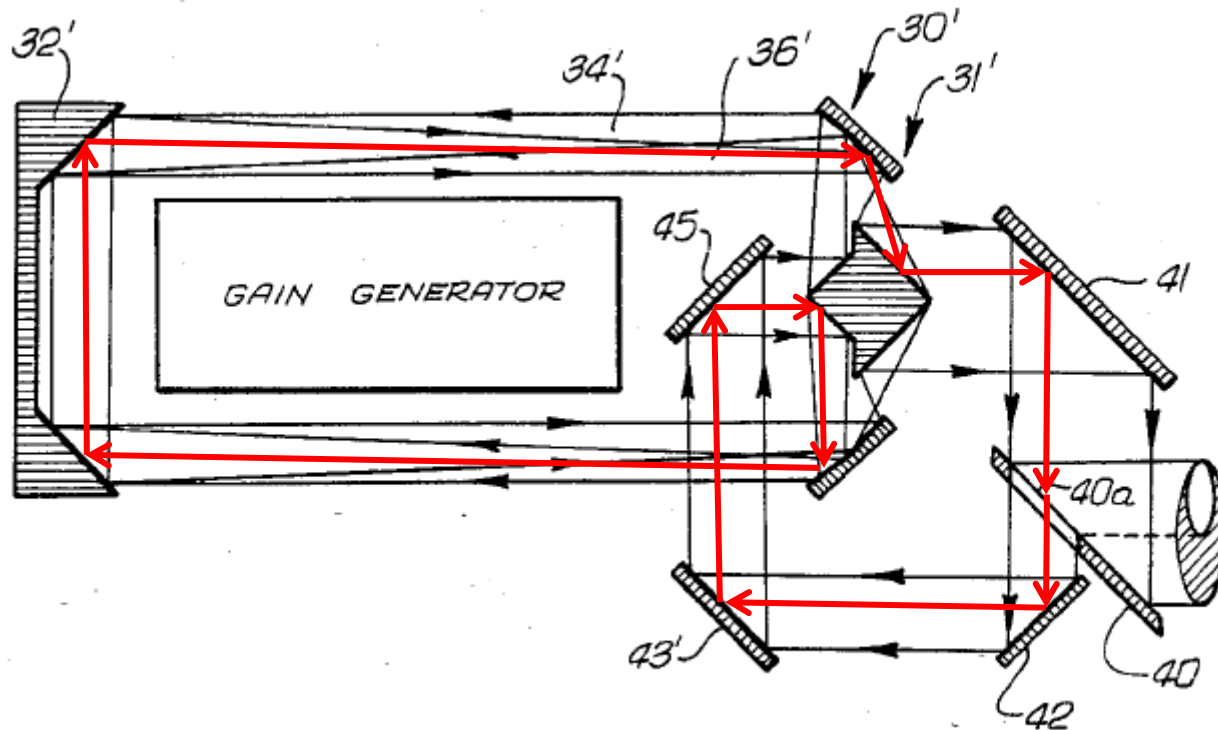
Kill the Messenger (Because He's Wrong!)

- After 3 months of modeling work, we had reached a crossroads:
 - ASAP was hopelessly unable to model the geometric properties of the resonator!

OR

- **The resonator did not resonate!**
 - **Self-replicating ray did not replicate.**
 - **Exiting wavefront was not a plane wave.**
- Project management took the following actions:
 - Canceled my job number
 - Told me how disappointed they were that I couldn't get the job done
 - Decided that ASAP was a worthless tool

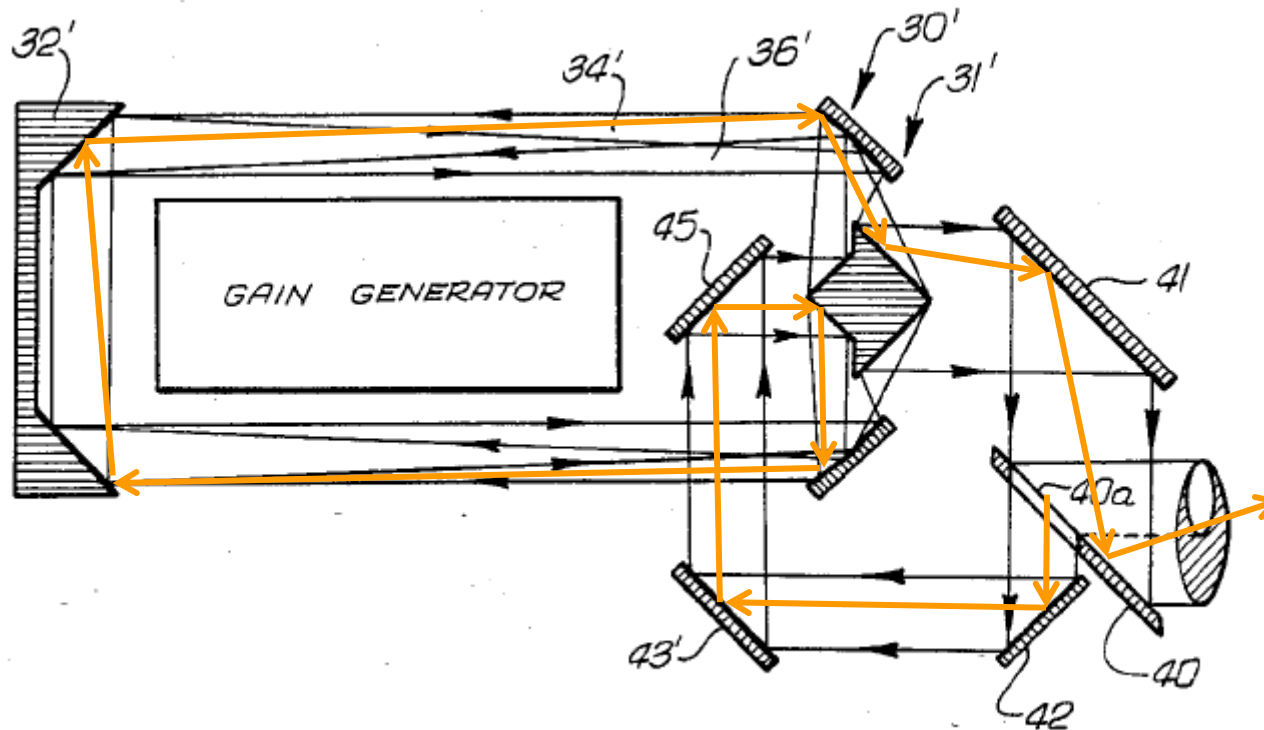
Ideal Behavior of the Self-Replicating Ray



The “self-replicating ray” is that ray that continuously retraces its path through the resonator. Needless to say, it never exits!

Ref: US Patent 4,598,408

What the ASAP Model Predicted



The “self-replicating ray” did not self-replicate... it left the system after a single pass through the optics. Oh, and the exiting wavefront was not planar!

A Second Chance and a Breakthrough

- Three months later with increasing programmatic urgency, project management asked me to take another crack at the calculations
 - One SPM told me “Try to get it right this time!”
- ALPHA model was reconstructed from scratch, all analyses were rerun, and I got the same results → **the resonator did not resonate!**
- This time I decided that ASAP was, in fact, correct and with the help of a fellow engineer started snooping through the old CROQ runs
- Late one night we found the error: the trajectory of the self-replicating ray in the gain-medium according to the ASAP model **did not match** the resonator specifications

The End of the Mystery

- The next morning we tracked the ray trajectory error to the waxicon outer surface (“WOC”); the surface prescription was just plain wrong! (go back 7 charts, 2nd bullet)
- Problem identified, the same analysts that designed ALPHA reanalyzed the CROQ results and declared that the ASAP results were correct: the “as built” resonator didn’t work!
- I designed a corrector mirror using ASAP and that design was also checked against CROQ
- ALPHA was successfully fired in 1989

Ultimately Life is What You Make of It

- During college, all I could think about is the next homework assignment, the next lab writeup, the next hourly exam, the next computer project, the next ...
- When I got out of school and first started working, I'd
 - leave work
 - drive home
 - make dinner and ... sit around watching TV until the next day
- Something was missing! Was this all there was in life?
- I learned that I had to make my life “happen”
 - Joined a kung fu school
 - Joined a music group
 - Started voice lessons
 - Taught guitar
 - And.. ultimately started Photon Engineering, LLC