Building a Successful Company – With Mathematicians???

Daniel H. Wagner Associates, Inc.
Fifty Years of Excellence

April 24, 2015

Dr. Allen Butler
President & CEO
Daniel H. Wagner Associates
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Allen.Butler@va.wagner.com

Daniel H. Wagner Associates, Inc.

- Consulting services in operations research, mathematics and software development since 1963
- Technical staff of 25 includes 12 PhDs in mathematical sciences
- Primary client base – DoD and financial community
- Offices in Exton PA (HQ), Hampton VA and Vienna VA

Daniel H. Wagner Associates, Inc.

- Missile Defense Agency: Tracking, Registration, and Data Fusion
- Air Force: AWACS Multi-Sensor Fusion; Tracking ground targets
- Army: Combat Identification for IBCS
- Department of Homeland Security (DHS) : Field tested Data Fusion systems for the Mexican (ground) and Canadian (water) borders
- Navy: Torpedo Defense, Data Fusion, Mission Planning, Mine Warfare, Submarine Warfare, Unmanned Vehicles
- NASA: Random Number Generation on GPGPUs
- Financial Community: Retirement Spending Planner, Mean Variance Optimization Library, Statistical Arbitrage, Optimal Coupon selection, Portfolio Optimization

Daniel H. Wagner Associates

Currently Running Data Fusion (World View) on Six Heterogeneous ASVs

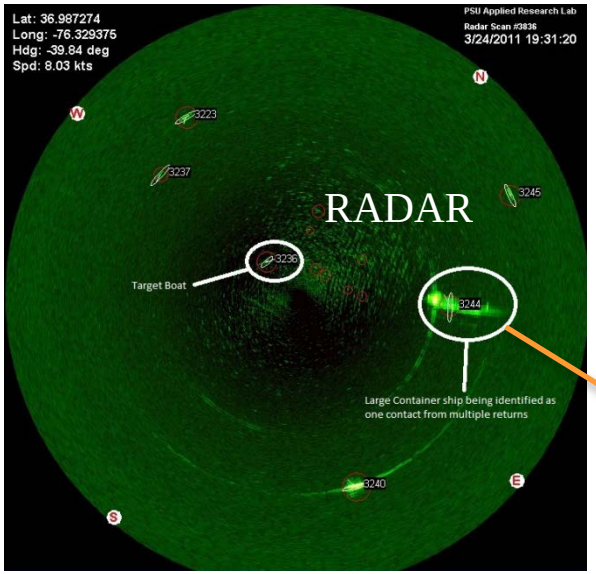
Daniel H. Wagner Associates

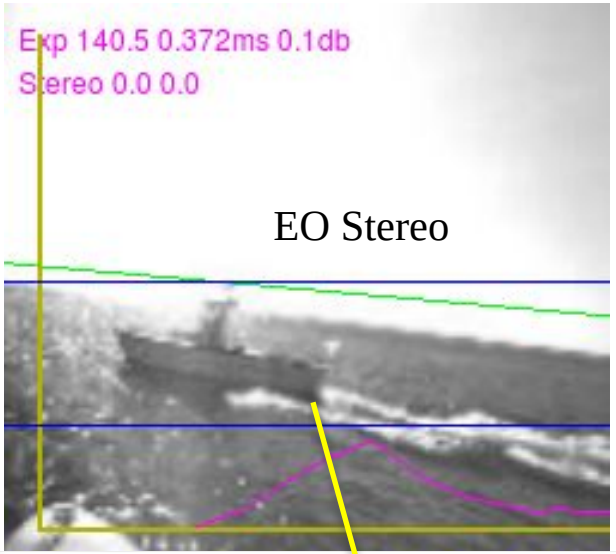
360-Degree Electro-Optical (EO) Imagery

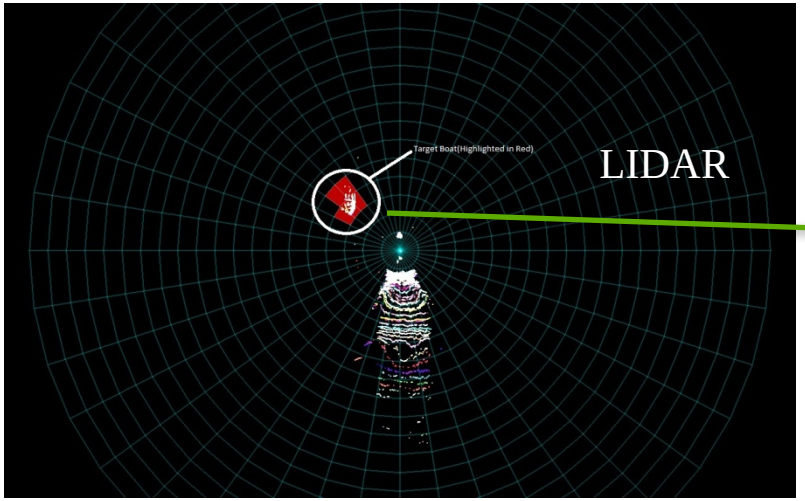
Live, full 360 degree color panorama stitched together from 4 Wide Field of View cameras

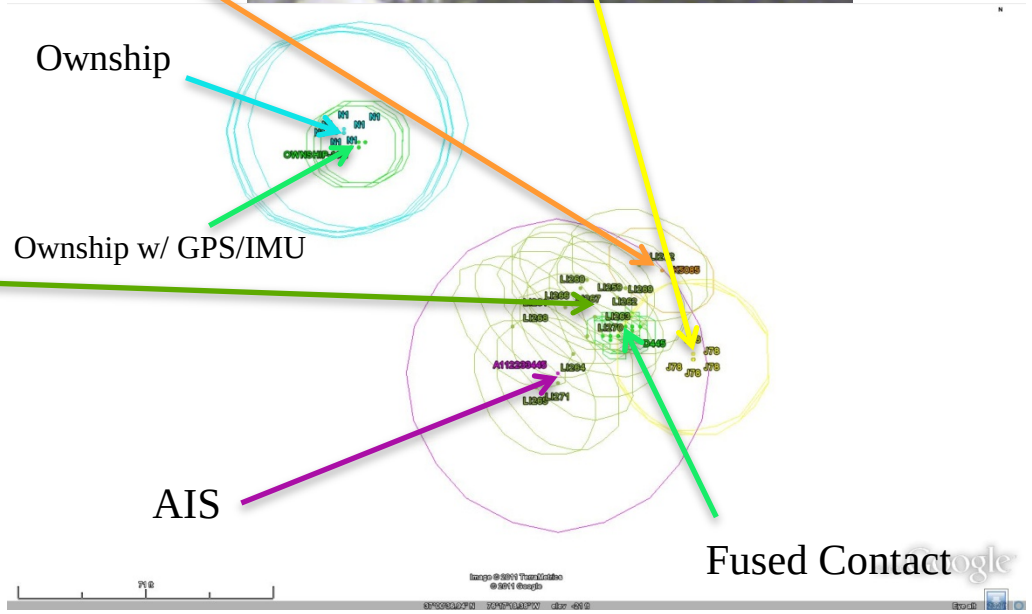
Live image plane subwindowed samples from Narrow Field of View cameras

Fusion of Four Sensors









Logical Progression is Autonomous Use of Non-Lethal and/or Lethal Weapons (as the Navy already does with mines, torpedoes, cruise missiles)

Photo Courtesy of DOD

The Terminator Dilemma:

We are building Skynet now.....

our job is to ensure the robots don't kill us.

Before Wagner Associates

- Daniel H. Wagner, 1925 - 1997
- Dan Wagner at Brown University
  - Real Variables, Banach Spaces, Cohomology – Abstract Math!
- Dan at Navy's Operations Evaluation Group
  - In the vanguard of OR as a discipline

Before Wagner Associates

- Daniel H. Wagner, 1925 - 1997
- Dan Wagner at Brown University
  - Real Variables, Banach Spaces, Cohomology – Abstract Math!
- Dan at Navy's Operations Evaluation Group
  - Origins of OR as a discipline
- **Dan at Burroughs Corporation**
  - **Led a team of Mathematicians designing a new fangled invention!**

Burroughs
CORPORATION

INTER-OFFICE CORRESPONDENCE

FROM July 22, 1957

TO: Dr. Daniel Wagner

FROM: Wynn Etter

SUBJECT: Individual Achievement

Hearty Congratulations on your outstanding performance on the Channel 3 show, "Tic Tac Dough".

As you undoubtedly have heard me say many times--"this is the type of publicity that attracts worthy attention to our Research Activity."

Before Wagner Associates

- Daniel H. Wagner, 1925 - 1997
- Dan Wagner at Brown University
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  - Origins of OR as a discipline
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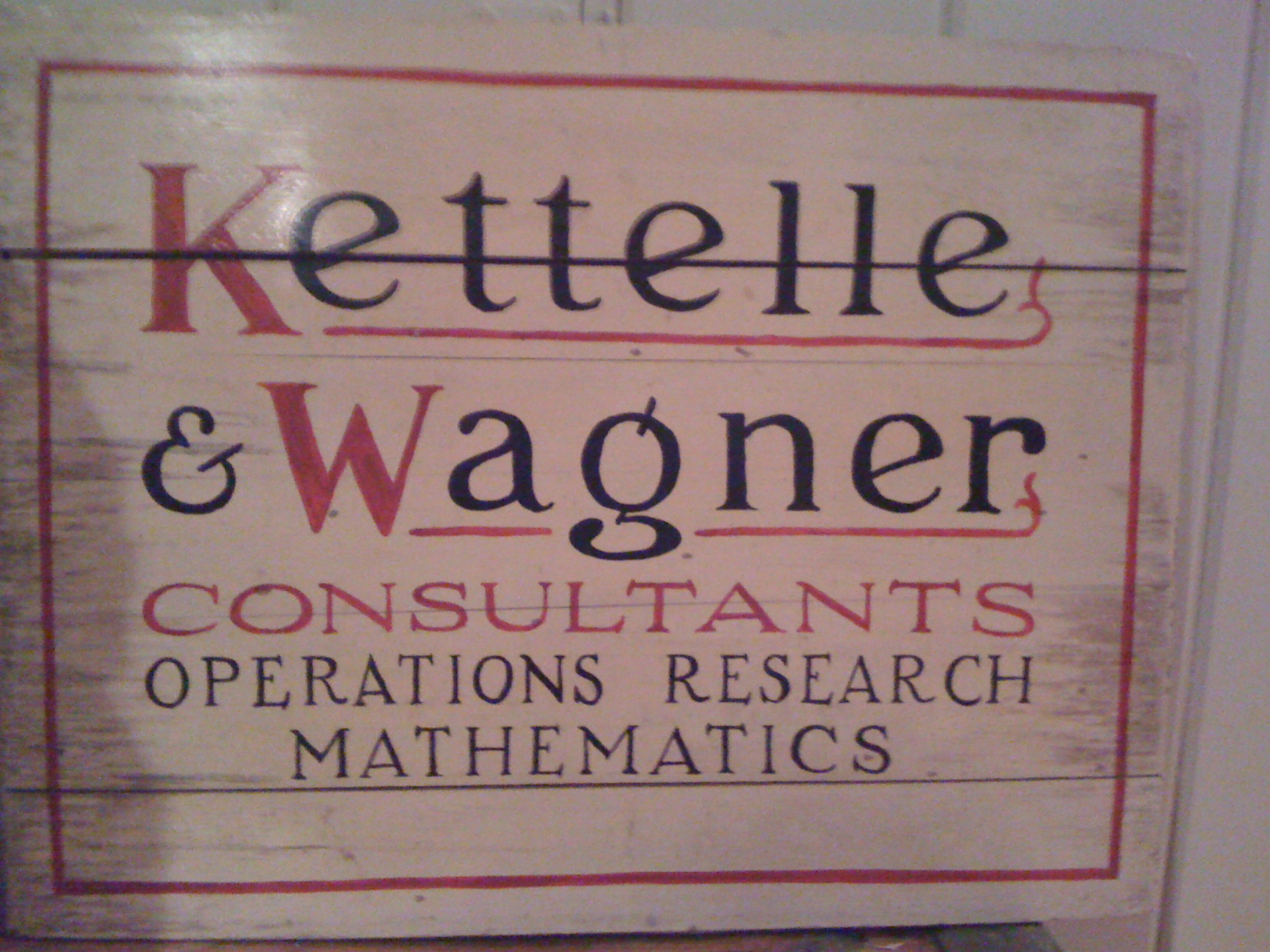
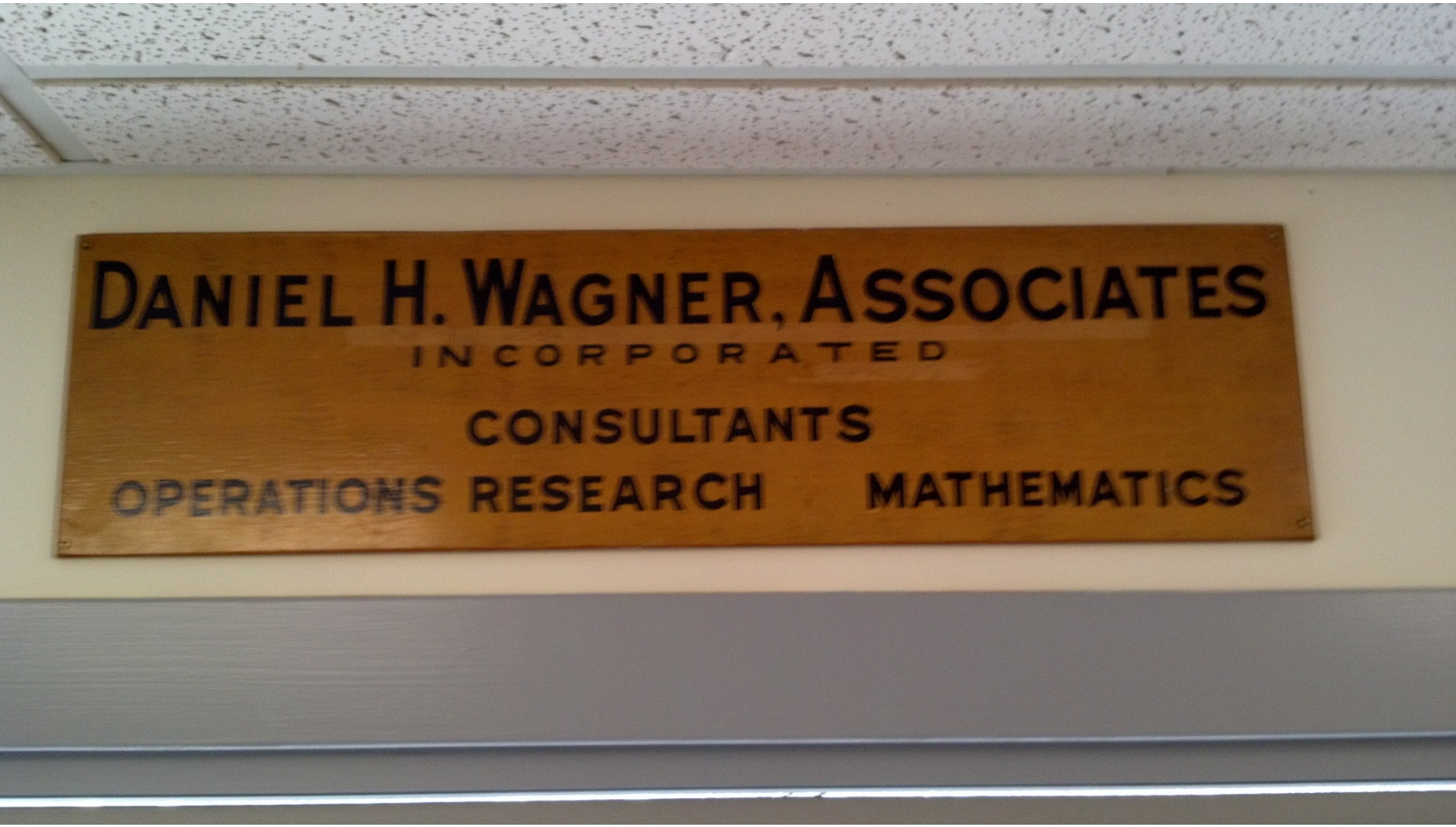
  - Led a team of Mathematicians designing a new fangled invention!
- **Dan's First Entrepreneurial Adventure**
  - **Kettelle & Wagner (1958 – 1963)**
    - **John D. Kettelle**
    - **Ballistic Missile Early Warning System (False Alarm Rules: 1 per 100 years FAR)**


Kettelle
& Wagner
CONSULTANTS
OPERATIONS RESEARCH
MATHEMATICS


DANIEL H. WAGNER, ASSOCIATES
INCORPORATED
CONSULTANTS
OPERATIONS RESEARCH MATHEMATICS

Wagner Associates – The Beginning

- Business started on May 1, 1963
- Incorporation on December 20, 1966
- Hire “pure” mathematicians
  - Maintain Strong Academic Connections
  - Hire Interns
  - Encourage Prof Development; Publish Papers; Attend Conferences
- On the job training
  - “Field Assignments” for the Navy
- Excellence in Written Documentation and Oral Presentation

  Dan writes “High quality in report preparation is obviously of fundamental importance to an organization whose only output is on paper.”

  “In the 1960’s and early 1970’s I reviewed editorially and technically almost all of our technical output”

CUMULATIVE DETECTION PROBABILITY FOR PASSIVE SONOBUOY FIELDS

Report to

U. S. Naval Air Development Center

December 14, 1967

Under Contract No. N62269-67-C-0136

by

DANIEL H. WAGNER, ASSOCIATES
Paoli, Pennsylvania

By: Leslie K. Arnold
Leslie K. Arnold

Henry R. Richardson
Henry R. Richardson

Approved: Daniel H. Wagner
Daniel H. Wagner

August 1963--CAPT D. H. Guinn, USN, new skipper of the attack carrier FORRESTAL, on the bridge with his guest, Dr. Daniel H. Wagner, mathematician from Paoli. The FORRESTAL was conducting carrier landing qualifications off the Virginia Capes. CAPT Guinn holds the Navy Cross, the Nation's second highest decoration for valor.

Naval Field Assignments

- Summer of 1967: Dave Bossard goes to Groton, CT to support Commander Submarine Development Group Two
- Commander Second Fleet – Norfolk, VA
- Commander Submarine Forces Pacific Fleet – Pearl Harbor, HI
- Commander Patrol Wings Atlantic Fleet – Brunswick, ME
- Commander Patrol Wings Pacific Fleet – Moffet Field, CA
- Commander Task Forces 69 & 66 – Naples, Italy
- September 1987: Reynolds Monach returns from CSP, Pearl Harbor
- Thirty eight Field Representatives over a twenty year span

Dave Bossard At Sea
August 1968

A Few Famous (Wagner) Searches

- January 17, 1966 – USAF loses an H-Bomb
- May 22, 1968, the nuclear attack submarine USS Scorpion (SSN-589) sinks
- September of 1857, the 2100 ton SS Central America (carrying three tons of gold) sinks off the Carolinas
- The search and recovery operation following the 1986 Challenger disaster
- Clearance of mines from the Suez Canal

The H-Bomb Search

- January 17, 1966 over Palomares, a small Spanish fishing village
- B-52 Bomber carrying four H-Bombs collides mid-air with SAC KC-135 refueling tanker
- Three H-Bombs hit the land, but one is lost (presumably at sea)
- No existing search methodology (doctrine) to apply

The H-Bomb Search References

- Lewis, Flora (1967). *One of Our H Bombs is Missing.* McGraw Hill
- Bush, Julie and Maydew, Randall C. (1966). *America's Lost H-Bomb: Palomares, Spain.*
- Moran, Barbara (2009). *The Day We Lost the H-Bomb: Cold War, Hot Nukes, and the Worst Nuclear Weapons Disaster in History*. Random House, Inc.

- Craven, John Piña (2001). *The Silent War*. Simon and Schuster.
- McGrayne, Sharon Bertsch (2011). *The Theory That Would Not Die: How Bayes' Rule Cracked the Enigma Code, Hunted Down Russian Submarines, and Emerged Triumphant from Two Centuries of Controversy.* Yale University Press

The H-Bomb Search

- Dr. John Piña Craven, Chief Scientist Navy Special Projects Office 1958 - 1970
  - Divide the Search Area into small grid cells
  - Combine possible scenarios into prior probability distribution
  - Hire Wagner Associates to do on-site analysis
- Daniel H. Wagner Associates
  - Ashore: work on developing a better prior distribution and a search plan
  - Dan Wagner sends a young PhD, Henry R. (Tony) Richardson to Spain
  - Expecting an august authority, Admiral “Bull Dog” Guest assigns the eminent mathematician a Captain’s stateroom and steward.

“When he met Richardson, who looked even younger than his 26 years, Bull Dog harrumphed ‘I didn’t think we were getting a teenager.’ ”

The H-Bomb Search

- Search Assets
  - 125 Swimmers and Scuba Divers
  - 25 Navy Ships with 3,000 Navy personnel
  - 4 Research Submersibles
  - A host of civilian researchers and contractors (including Tony)
- Each day Tony computes “Search Effectiveness Probability”
  - The probability that the bomb would have been detected if it were in a given cell
  - Overlaying bits of paper to superimpose curves
  - Use a slide rule and an adding machine that could also multiply!

Richardson: “My recollection of my marching orders was to statistically document the search and … to be able to certify to the President and to Congress that everything possible was done and that it was done in a scientifically accurate and careful way. ”

The H-Bomb Search

The H-Bomb Search

The H-Bomb Search

- On March 15, 1966 the H-Bomb is located
- From Craven's Book

"By this time, Wagner Associates, [Dan] Wagner's firm, had constructed a mathematical model whose complexity defied understanding by mere mortals."

The H-Bomb Search

March 1966--Aboard Flagship of H-Bomb Search off Palomares.

Paoli Mathematician Assists Navy In Underwater H-Bomb Recovery

Dr. Henry R. Richardson, Paoli mathematician, worked directly with the Naval task force which conducted the underwater search for the recently missing H-bomb off Palomares, Spain. As the civilian mathematician on the analysis team formed by the Navy, Dr. Richardson has provided on-scene assistance to Rear Admiral William S. Guest, the task force commander. Since February, Dr. Richardson has been stationed aboard the force flagship, successively the guided missile cruisers USS Boston and USS Albany, anchored off Palomares.

Dr. Richardson, 27, is an Associate in the mathematical consulting firm, Daniel H. Wagner, Associates, Paoli, which had been retained to provide probability and operation research analysis in connection with the search. His firm's partcipation s on a subcontract with the ocean engineering company, Ocean Systems, Inc., New York City.

Dr. Richardson recevied his Ph.D. in mathematics from Brown University in June 1965; his thesis was in probabilty theory. He was a Fellow under the National Defense Education

(Continued on page 2)

(Continued from page 1)

Act. His M.S. was from Brown in 1962 and he had previously graduated Magna Cum Laude from the University of Pittsburgh, where he was elected to Phi Beta Kappa.

Dr. Richardson has been with his present firm since August, 1964, where he has performed extensive operations research in anti-submarine warfare. Prior to going to Palomares, he had just completed six months work on a major strategic anti-submarine study, as a part of a high-level team in Washington.

Dr. Richardson, his wife Judy and their infant son John reside at 266 West Wendy Way, King of Prussia. He is a native of Pittsburgh. Mrs. Richardson has just left to join her husband in London for two weeks vacation in Europe, now that his arduous work with the search force has been completed.

DR. HENRY R. RICHARDSON studies H-bomb search data on board USS Albany, flagship of Rear Admiral William S. Guest. Dr. Richardson is a mathematician in the Paoli firm of Daniel H. Wagner, Associates.

The USS Scorpion Search

Photo # NH 70305 USS Scorpion comes alongside USS Tallahatchie County, April 1968

The USS Scorpion Search

- Declared lost at sea June 5, 1968
  - A nuclear submarine (SSN-589)
  - Between Azores and base in Norfolk, VA
  - 99 Crewmen perished
  - Remains at depth of 11,220 feet
- Implosion event was detected acoustically
  - Triangulation reduced search area to 10 mile radius circle
  - Dr. Craven et. al. came up with nine possible scenarios
  - Each scenario produces a location uncertainty (probability distribution)
  - Each scenario is given a weight
  - Monte Carlo simulation produces a priori target distribution

Daniel H. Wagner Associates

The USS Scorpion Search Probability Map

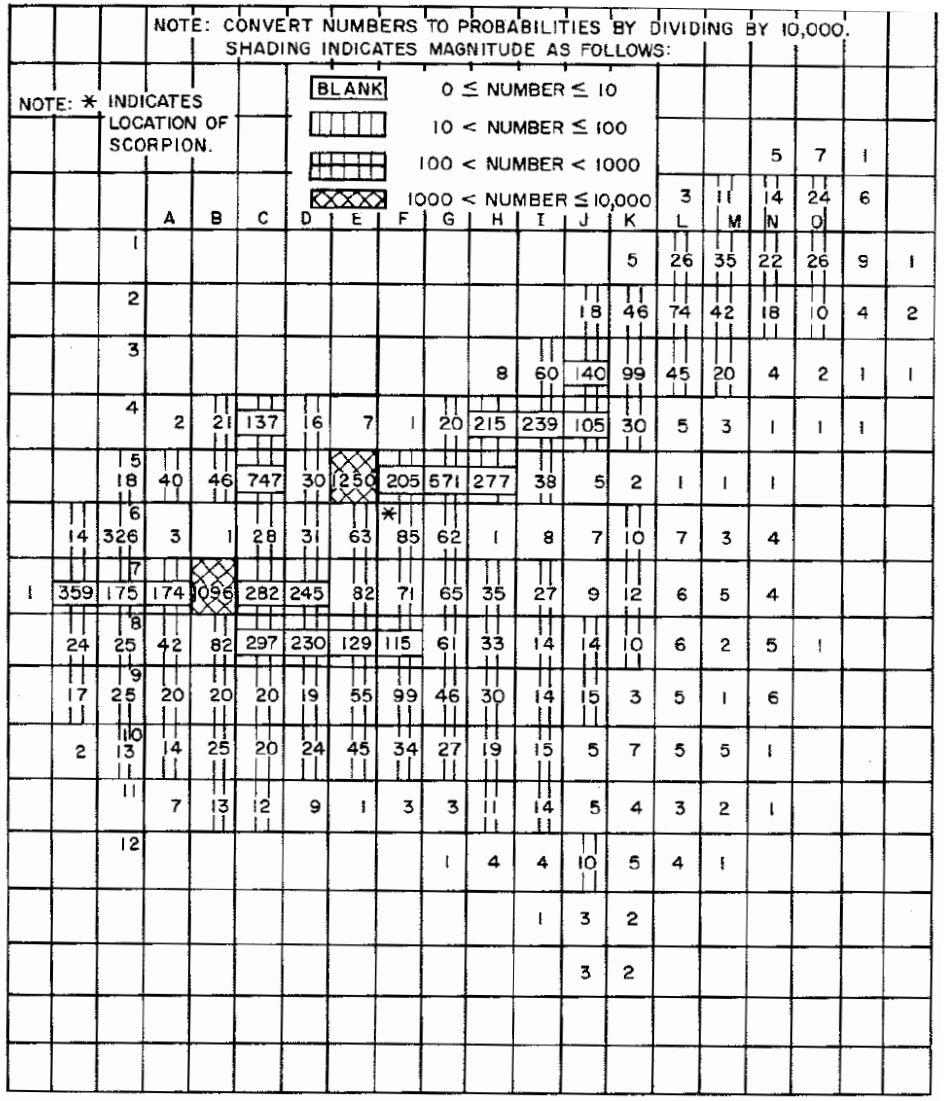


FIGURE 2. Overall A Priori distribution for *Scorpion* search

- 10,000 Monte Carlo samples.
- Count number in each grid cell and divide by 10000 to get probability.
- Highest Probability Cell: 0.125
- Now update probabilities using Bayes Rule as you search
- Scorpion found 260 yards from the highest probability cell

SS Central America

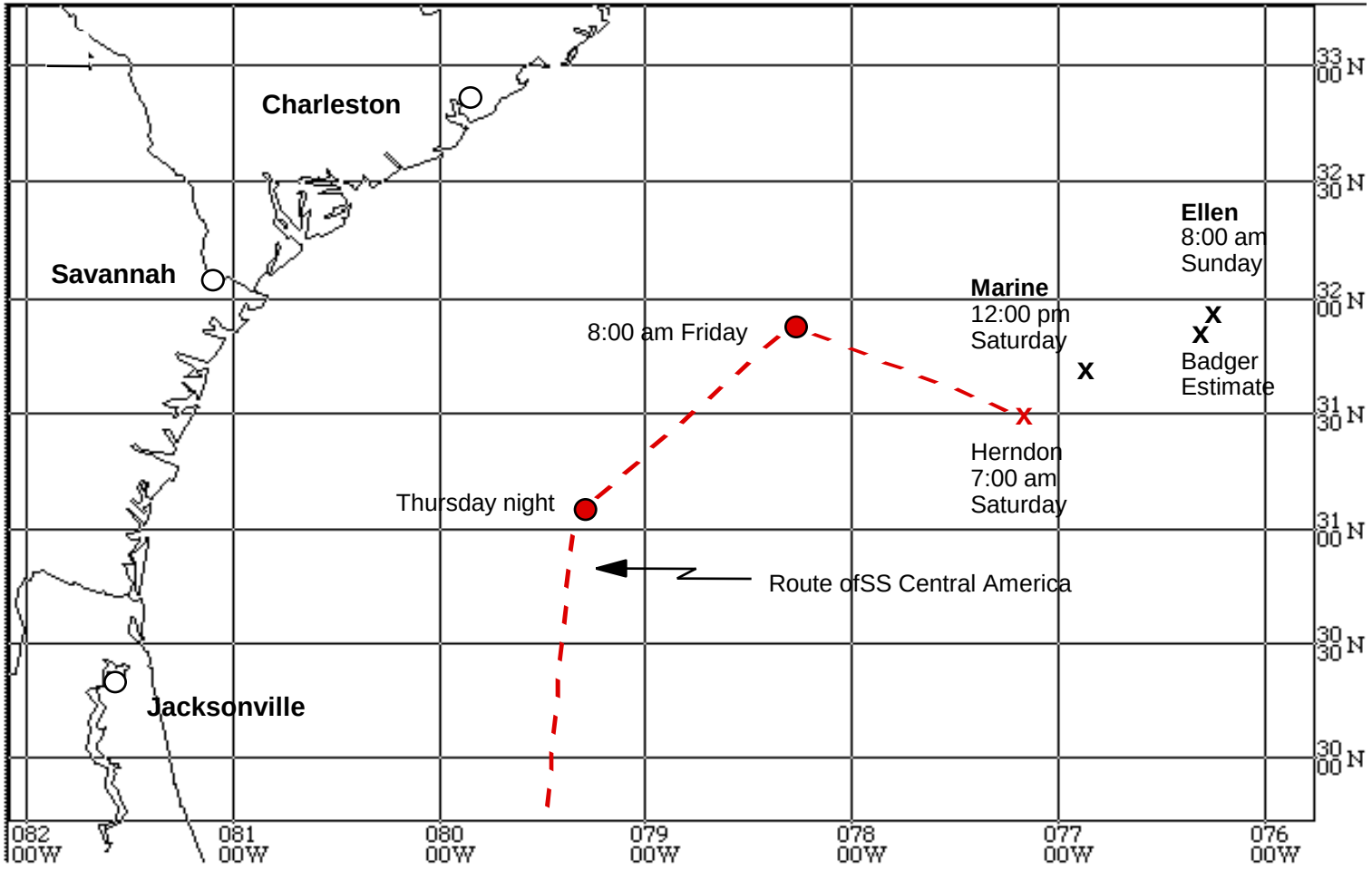
- In 1857, while carrying passengers and gold from California to New York, the *SS Central America* sank in a September hurricane taking tons of gold bars and coins to the ocean bottom 8,000 feet below.
- Some 425 people lost their lives, including the Captain of the ship.
- A financial panic ensued in New York, and the Navy was directed to investigate the loss.
- The *Central America* was the most famous shipwreck of its time, comparable to the loss of the *Titanic* in the 20th Century.

- For the full story, see *Ship Of Gold In The Deep Blue Sea* by Gary Kinder

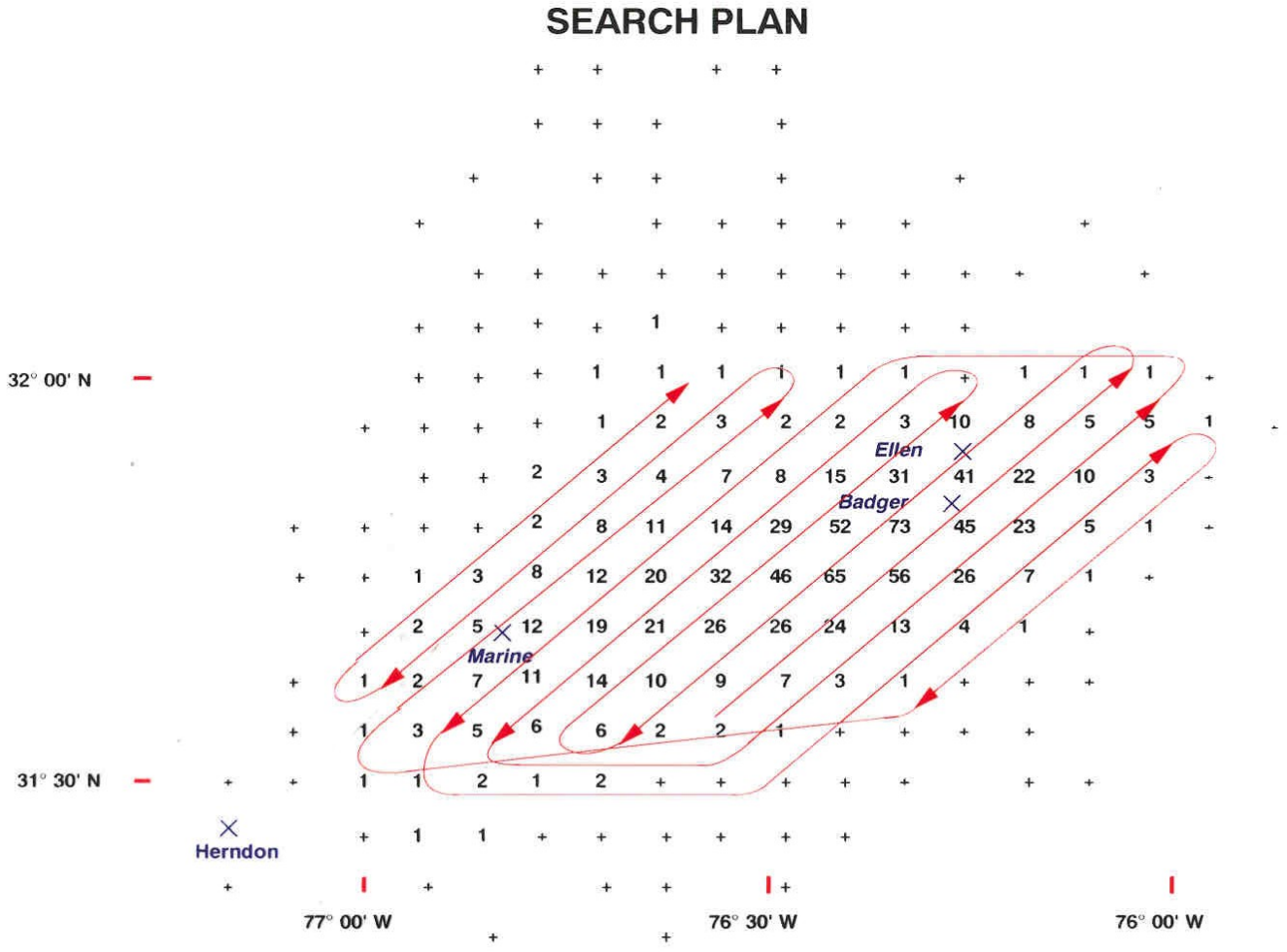
Route of the SS Central America

SS Central America Encounters Hurricane

ROUTE OF THE SS CENTRAL AMERICA September 1857



Probability Distribution and Search Plan



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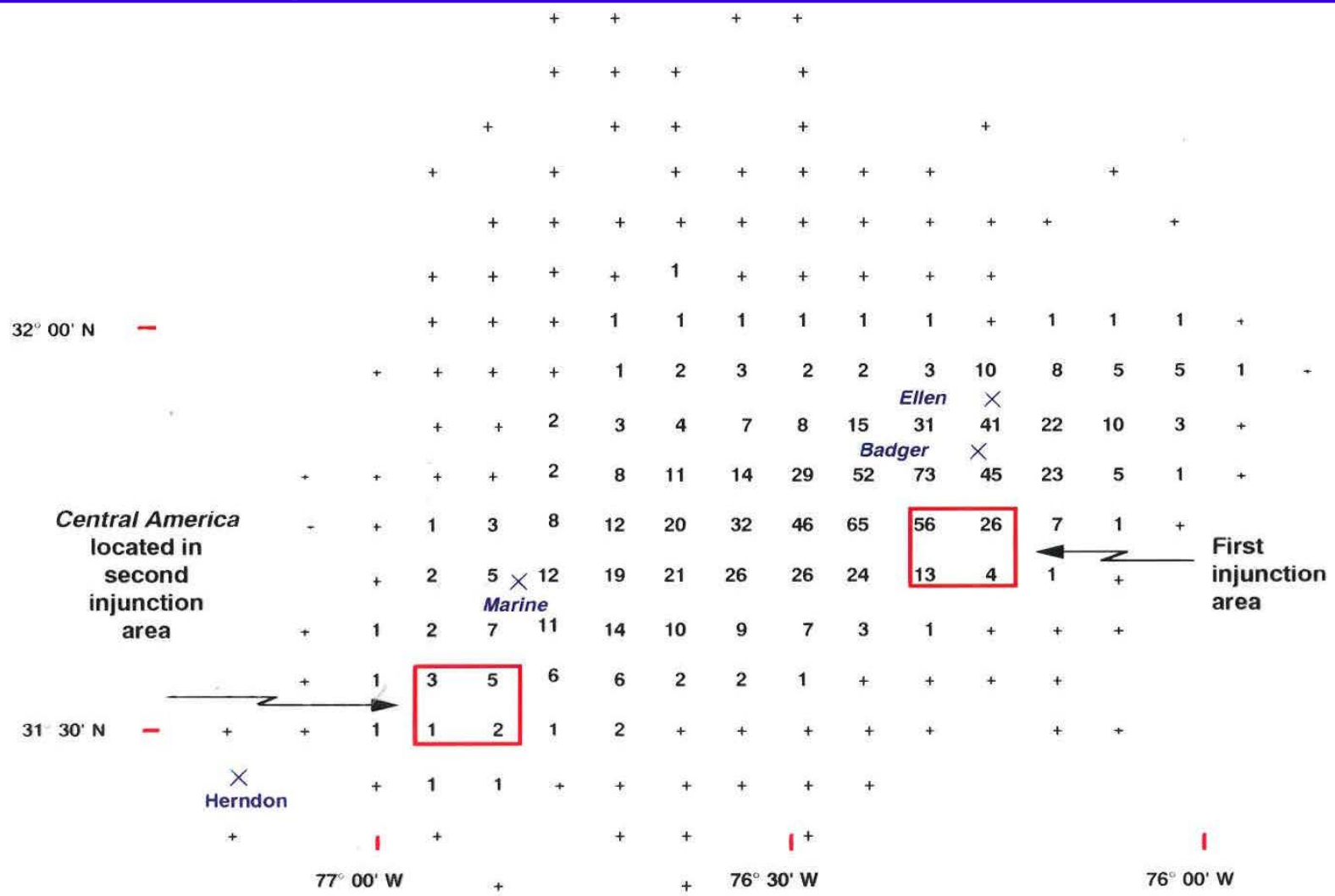
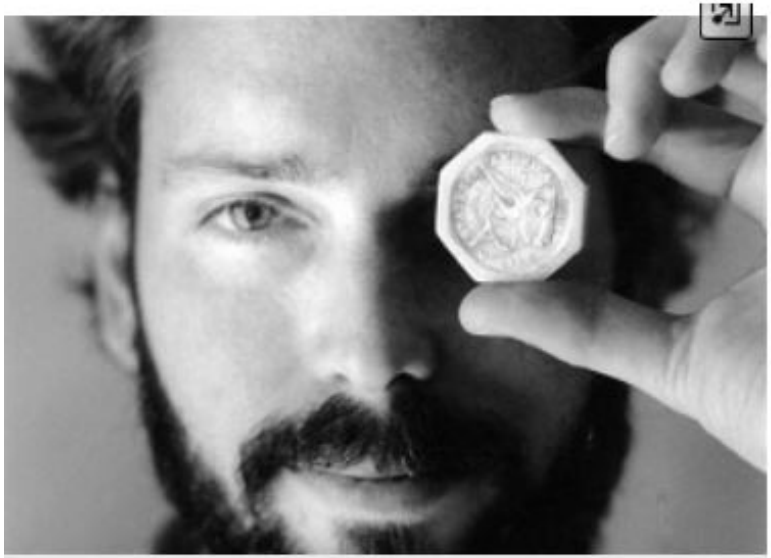
Daniel H. Wagner Associates

Location of SS Central America



Some Gold from the SS Central America

Fugitive treasure hunter charged with contempt due in court



In this November 1989 file photo, Tommy Thompson holds a $50 pioneer gold piece retrieved earlier in 1989 from the wreck of the gold ship Central America. According to the US Marshals Service, Thompson, a fugitive treasure hunter wanted for more than 2 years was arrested in Florida. (AP Photo | The Columbus Dispatch, Lon Horwedel)

View full-size photo | Buy Pilot photos

The Associated Press
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COLUMBUS, Ohio

A deep-sea treasure hunter charged with contempt of court after refusing to testify about gold he discovered from a historic shipwreck is expected to appear in court Wednesday.

A federal prosecutor's office spokeswoman said 62-year-old Tommy Thompson is expected to enter a plea during a hearing Wednesday afternoon in federal court in Columbus. A plea agreement was filed with the court last week along with a criminal information, a document used by prosecutors when a deal has been reached and a defendant agrees to plead guilty.

Thompson went missing three years ago amid demands he appear in court. He and his longtime female companion, Alison Antekeier, were apprehended in January at a hotel where he was living near Boca Raton, Florida. He has been in custody in Ohio for several weeks following his extradition from Florida.

Challenger Search

6 DAILY LOCAL NEWS, West Chester, Pa., Thurs., March 27, 1986

Paoli firm has a hand in search for shuttle debris

By MICHAEL GIBBONS
(Local News Correspondent)

Every day, thanks to a small company in Paoli, divers off Cape Canaveral find more pieces of the tragic puzzle named Challenger.

For the past seven weeks, Daniel H. Wagner Associates, a think tank of mathematicians and computer specialists in the Station Square One office complex off Central Avenue, has orchestrated the ongoing search for fragments of the ill-fated shuttle along Florida's coast.

"We are honored to be asked to participate in something of such grave national importance," said Bernard J. McCabe, who works out of the Paoli office.

HE AND HIS ASSOCIATES use advanced mathematics and computer analysis to generate large-scale mathematical descriptions of the ocean floor that help direct the nine U.S. Navy search and recovery vessels combing a 400-square mile area of the Atlantic.

Although forbidden by NASA to reveal details of the mission, McCabe, who received his Ph.D. in mathematics from Catholic University in 1968, said the shuttle search has been easier than previous assignments the company has undertaken, notably the 1963 search for a lost hydrogen bomb off Palomares, Spain, and the search for the lost submarine Scorpion in 1968.

Before contacting Wagner Associates, NASA officials "knew where the big pieces were already" by studying extensive film footage of the craft before and after it exploded and noting the trajectory of the falling debris, he said.

AND BECAUSE THE search area is so close to land, personnel can quickly travel to and from the site.

"We can rotate people around," McCabe said. "The conditions are ideal. They're continually finding stuff, thousands of pieces ... The more they recover, the more information they get."

"There is value in recovering the debris," agreed Dr. Barry Belkin, a Wagner associate who also received his mathematics doctorate from Cornell University.

He confirmed the shuttle search has been easier than most because the submerged remnants remain relatively stationary. Much harder to find are floating objects like a disabled cabin cruiser because the wind and ocean currents move the object around and complicate matters.

IN THE EARLY 1970s, the company developed a software program called Computer Assisted Research Planning (CASP) to assist the Coast Guard in search and rescue missions.

PROFILES

Last November, the Coast Guard used the program to locate a family of four who sent out a distress signal from their sinking cabin cruiser two hours out of West Palm Beach. After seaching more than 2,000 square miles, the Coast Guard fed what information they knew into CASP.

The group was found clinging to an ice chest 80 miles north of the route suggested by the computer, according to an article in the Miami News.

To find the lost submarine Scorpion, which took five months and consumed the energy of scientists working in two shifts 12 hours a day, CASP had to produce 10,000 possible scenarios of an area approximately 400 miles southwest of the Azores before eventually locating the craft on Oct. 28, 1968.

SEARCHING, ACCORDING to Belkin, means asking oneself, "If (the object) was there, would you have found it by now?" as well as figuring out "where to look ... when to look elsewhere, when to give up."

It employs what Belkin termed "Monte Carlo simulation," postulating thousands of slightly different hypothetical situations by computer to determine the probability of a certain event.

A simple example of simulation, not involving computers, would be to deal out hundreds of poker hands, count the number of times a full house comes up, then divide that number by the total number of hands dealt. The resulting percentage indicates the probability of dealinga full house.

WAGNER ASSOCIATES helps the Navy plot the probable movements of enemy submarines, as well as develop strategies for surface warfare, by calculating "how we react in a certain situation and how the other side will react," said Belkin.

He said the company also assists the Air Force in tracking and cataloguing satellites in space, and even has a hand in another project off-limits to prying questions — President Reagan's Strategic Defense Initiative.

As for peaceful applications, the company created a software program for Children's Hospital in Philadelphia that generates "in a few hours an annual staffing calendar which formerly demanded up to a month of the chief resident's time," according to a company brochure.

BECAUSE THE COMPANY is listed under mathematics in the yellow pages, people sometimes call with more mundane requests.

A man building his own lobster tank once asked Belkin how much salt to add to the tank's water supply. And McCabe has gotten several calls from high school students baffled by logarithms.

Wagner Associates employs a staff of 20 — 16 men and four women — in four locations: Paoli; Washington, D.C.; Sunnyvale, Calif., and Yorktown, Va. The company became employee-owned two months ago, Belkin said; 12 or 13 employees now own shares and no one employee owns more than a 15 percent of the shares.

"We're all quite optimistic about the future," he said. "We're now beginning to, I think, accelerate upward."

For McCabe, the immediate future means working on his newest problem, which he sketched on a note pad. Given nine U.S. missiles and five enemy ships in more or less known positions, in what pattern would one aim the missiles to have the greatest probability of hitting a ship?

Belkin (left), senior software analyst Carol Hopkins and McCabe in their Paoli office

Clearing Ordnance from the Suez Canal

Paoli Math Wizards Help Clear Suez Canal

Human Side of Business

Peter H. Binzen

For the first time in at least 15 years an Israel-bound cargo ship passed through the Egyptian-operated Suez Canal last week. The ship, Olympus, owed its smooth transit, in part, to a team of mathematicians based in an office near the Paoli, Pa., railroad station.

The local math wizards helped clear the canal of old beer cans, bombs, bedsprings and other junk — including several sunken tanks, trucks and boats — that had made Suez navigation hazardous.

Their on-the-scene calculations by portable computer were used to pinpoint the location of the underwater debris, which was then removed by Egyptian divers.

Under contract to the U.S. Navy, Daniel H. Wagner Associates, 1 Station Square, Paoli, had at least one mathematician at the canal for 6½ months last year while the entire 100-mile length was swept by sonar and magnetic sensors.

'High Probability'

It was the Wagner firm's job to plot the sweeps needed to provide a "high probability" of finding most of the junk on the 200-foot deep canal bottom. And when the detection devices made contact with "objects," the mathematician-in-charge plotted their location so that Egyptian divers could recover them.

Silt and mud limit underwater visibility in the canal to 10 feet or less. Hence the need for sonar and sensors. But these devices can't distinguish between rocks and bombs. Hence the need for divers.

U.S. navy sonars swept the southern half of the canal, British units the northern half. Then they reswept each other's area to provide double coverage.

Ten "major hazards to navigation" were removed from the canal, according to Daniel H. Wagner, the firm's founder-president. The U.S. and Britain agreed to help the Egyptians reopen Suez after the Arab-Israeli war of October 1973.

Helped Find Submarine

The U.S. Navy called in Wagner as one of the world's leading firms in mathematical searches. Dr. Henry (Tony) Richardson, 37, senior vice president and one of 14 staffers with PhDs in math, assisted in the successful 1966 search for an H-bomb lost in the crash of a bomber off Palomares, Spain.

He and another Wagner vice president and Suez team member, Lawrence D. Stone, 33, helped the Navy find the sunken submarine Scorpion off the Azores in 1968. The sub was located two miles down on the ocean floor after a five-month search by sonar, sensor and TV cameras (it was not raised and the cause of its sinking remains a mystery).

When the Suez search was ordered, the Navy called Richardson. He and Dr. Thomas L. Gorwin flew over with a portable computer and lived in a Suez Canal Authority building. They were spelled by four other Wagner mathematicians during the course of the work.

"Living conditions were primitive," said Richardson.

When the computer broke down, emergency calls were made to Paoli. There Dr. Wagner, 50, called the manufacturer in Massachusetts and got the names of two European repairmen. One was in Tel Aviv, the other in Brussels.

Dr. Wagner reached the Israeli who declined to visit Egyptian territory. The Belgian made the trip and fixed the computer.

At least 90 percent of the Wagner firm's work is with the U.S. Navy. At present, one of its mathematicians is on field assignment with the submarine force at Pearl Harbor, another is with the 2d Fleet at Norfolk, Va., a third is with a submarine development group at New London, Conn., while a fourth is assigned to the Atlantic Fleet patrol wing at Brunswick, Me.

Led by Dr. Richardson, the Paoli firm has developed for the Coast Guard a computer assisted search planning system called CASP.

"When a ship or plane is lost," said Dr. Wagner, "our system produces a probability map for the target's location based on clues available. The map indicates the best places to look. As time passes, a computer moves the target area to take account of drift resulting from ocean currents and wind."

Sunk Tuna Boat

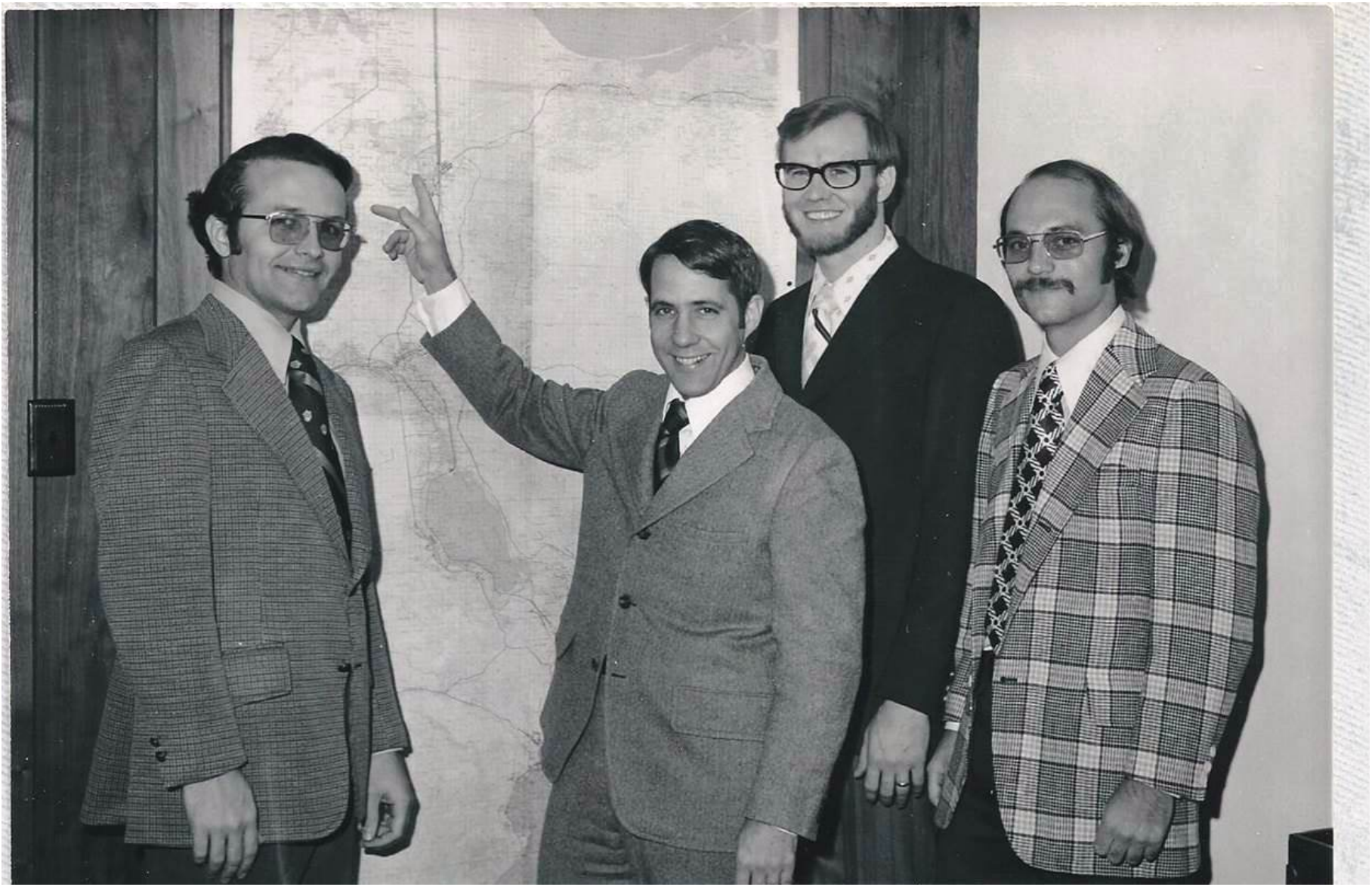
From its location in Washington, D.C., the computer can feed search information anywhere on the East and West coasts and in Hawaii.

Dr. Wagner and his associates all have top security clearances. Much of their work in the Pentagon has been for the Chief of Naval Operations. They ran a high-level study of antisubmarine warfare and they have advised the Navy on the inventories of ordnance thate might be needed in case of war.

"The Secretary of Defense outlines the (military) threat you must be ready to meet," Dr. Wagner said, speaking in the second person. "You calculate how much ordnance is needed to meet the threat."

Dr. Wagner, son of a former superintendent of schools in Tredyffrin-Easttown, Chester County, started his company with another mathematician and a secretary in 1963. Now it has 24 fulltime employes and four parttimers.

Clearing Ordnance from the Suez Canal



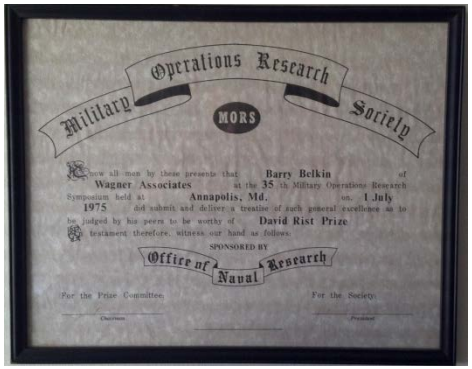
Awards & Recognition

Operations Research Society of America *Lanchester Prize* - recognizing *Theory of Optimal Search* by Lawrence D. Stone as the best English language publication in operations research for 1975

Rist Prize - to Barry Belkin, Joseph Bolmarcich, and Lambros Hatzilambrou recognizing "A Methodology for Estimating Quantities of Threat-oriented Ordnance Needed for Combat" as the best paper in military operations research in 1975

Military Operations Research Society (MORS) *MOR Journal Award (2004)* - to David P. Kierstead and Donald R. Del Balzo for their published technical article, "A Genetic Algorithm Applied to Planning Search Paths in Complicated Environments," Volume 8, Number 2

United States Army *1997 Army SBIR Phase II Quality Award* - for work on "Continuous Speech Recognition with Speaker Verification for Secure, Real-Time Voice Control"



Awards & Recognition

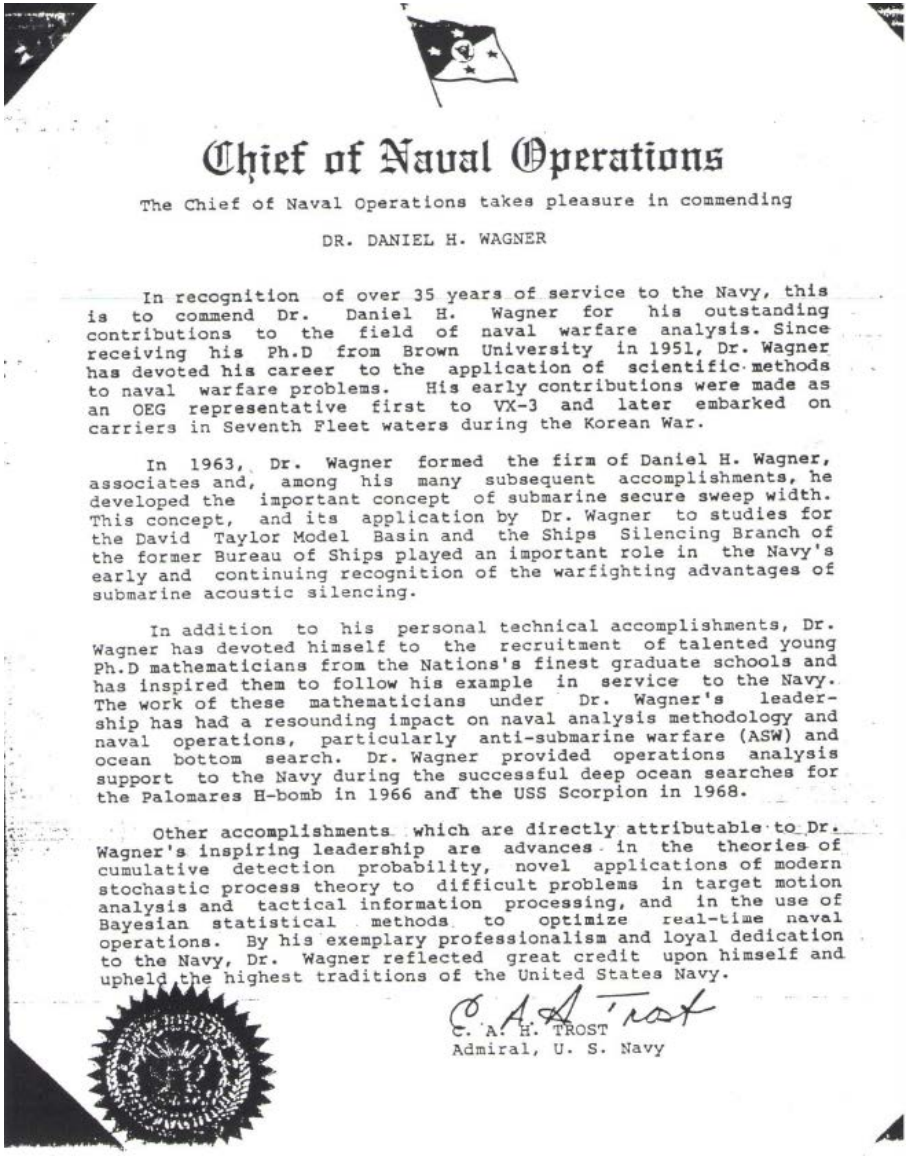
Defense Logistics Agency *James S. Cogswell Award (1979)* - in recognition of sustained outstanding achievement in implementation of the Department of Defense Industrial Security Program

United States Navy *Distinguished Public Service Award* - to Thomas L. Corwin

United States Navy *Meritorious Public Service Citation* - to Reynolds Monach for meritorious scientific achievements in the field of operational anti-submarine warfare

United States Navy *Commendation from the Chief of Naval Operation* - to Daniel H. Wagner for his outstanding contributions to the field of naval warfare analysis

Awards & Recognition



Chief of Naval Operations

The Chief of Naval Operations takes pleasure in commending

DR. DANIEL H. WAGNER

In recognition of over 35 years of service to the Navy, this is to commend Dr. Daniel H. Wagner for his outstanding contributions to the field of naval warfare analysis. Since receiving his Ph.D from Brown University in 1951, Dr. Wagner has devoted his career to the application of scientific methods to naval warfare problems. His early contributions were made as an OEG representative first to VX-3 and later embarked on carriers in Seventh Fleet waters during the Korean War.

In 1963, Dr. Wagner formed the firm of Daniel H. Wagner, associates and, among his many subsequent accomplishments, he developed the important concept of submarine secure sweep width. This concept, and its application by Dr. Wagner to studies for the David Taylor Model Basin and the Ships Silencing Branch of the former Bureau of Ships played an important role in the Navy's early and continuing recognition of the warfighting advantages of submarine acoustic silencing.

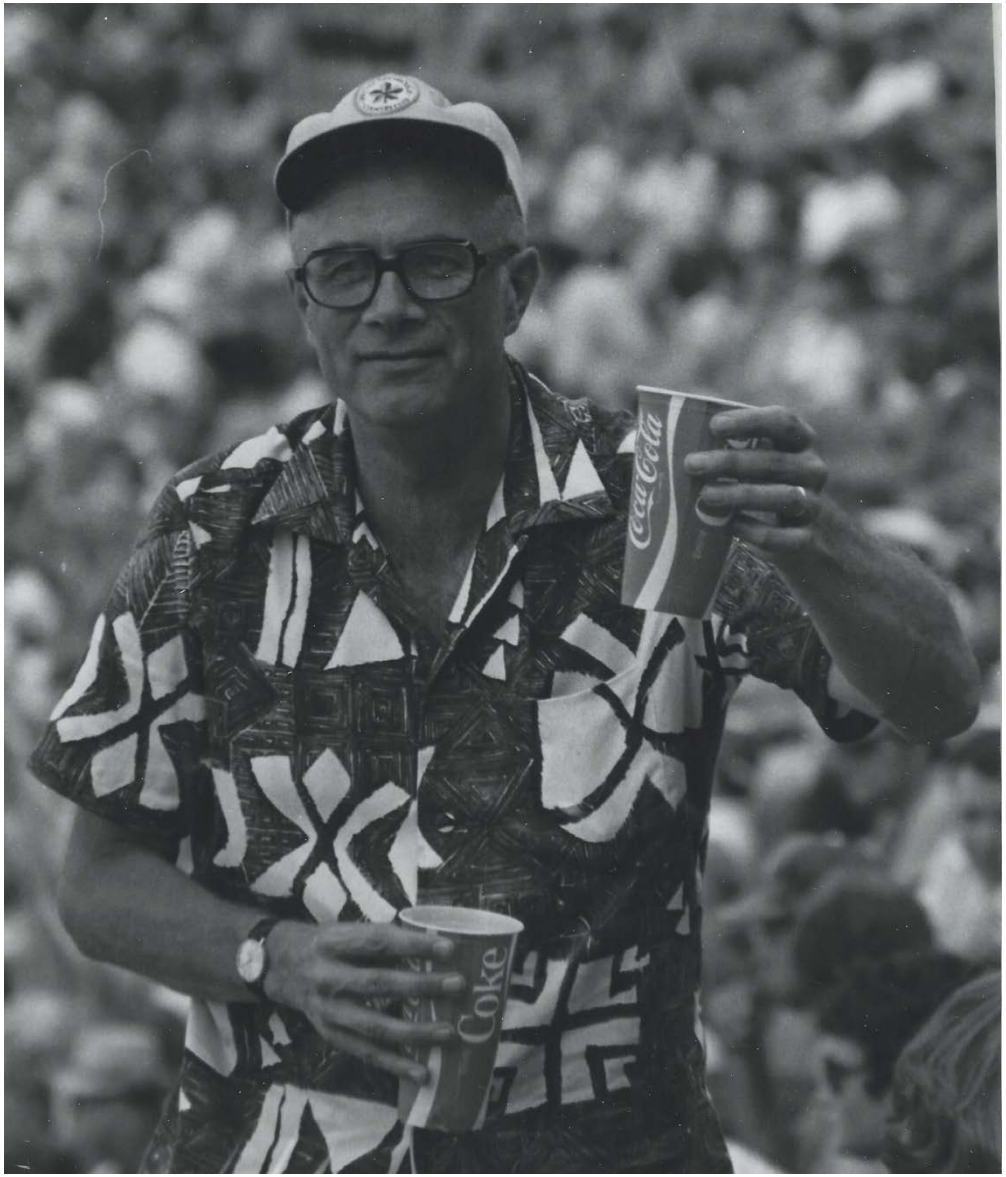
In addition to his personal technical accomplishments, Dr. Wagner has devoted himself to the recruitment of talented young Ph.D mathematicians from the Nations's finest graduate schools and has inspired them to follow his example in service to the Navy. The work of these mathematicians under Dr. Wagner's leadership has had a resounding impact on naval analysis methodology and naval operations, particularly anti-submarine warfare (ASW) and ocean bottom search. Dr. Wagner provided operations analysis support to the Navy during the successful deep ocean searches for the Palomares H-bomb in 1966 and the USS Scorpion in 1968.

Other accomplishments which are directly attributable to Dr. Wagner's inspiring leadership are advances in the theories of cumulative detection probability, novel applications of modern stochastic process theory to difficult problems in target motion analysis and tactical information processing, and in the use of Bayesian statistical methods to optimize real-time naval operations. By his exemplary professionalism and loyal dedication to the Navy, Dr. Wagner reflected great credit upon himself and upheld the highest traditions of the United States Navy.

C. A. H. TROST
Admiral, U. S. Navy

"Other accomplishments which are directly attributable to Dr. Wagner's inspiring leadership are advances in the theories of cumulative detection probability, novel applications of modern analysis and tactical information processing, and in the use of Bayesian statistical methods to optimize real-time naval operations."

Awards & Recognition



THE DANIEL H. WAGNER PRIZE

Excellence in Operations Research Practice

Abstract Deadline May 1, 2015.

Apply to win this prestigious practice prize that rewards professionals who devise innovative analytical methods, utilize those methods is a verifiably successful O.R./analytics project, and describe their work in a clear, well-written paper.

Two-page abstract is due by May 1, 2015.

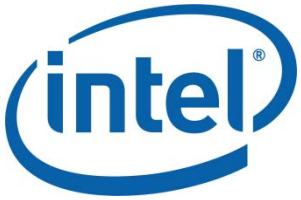
This prestigious INFORMS practice prize spans all O.R. and analytics disciplines and application fields. Any work presented in an INFORMS section or society practice-oriented competition is eligible as long as the work did not result in a published paper.

Wagner Prize competition is high-profile, with its own track at INFORMS Annual Meeting. Presentations are widely distributed via streaming video. Finalist papers are published as a special issue in INFORMS respected practice journal *Interfaces*.

Allen Butler (middle) congratulates members of the 2014 winning team - Oleg Gusikhin, Ford Motor Company (left) and David Simchi-Levi, MIT (right.)

The 2015 competition will be held at the INFORMS Annual Meeting, November 1-4, in Philadelphia, PA. First-place prize of $1,000 will be awarded at the Edelman Gala, during the April 2016 Conference on Business Analytics and O.R.

The Daniel H. Wagner Prize for Excellence in Operations Research Practice



A Few Non-DoD Projects

Computer Assisted Search Planning (CASP)

MAIN LINE TIMES
Thursday, January 23, 1986

Daniel H. Wagner Associates Involved In Dramatic Rescue

Computer software developed by Daniel H. Wagner Associates of Paoli was instrumental to success of a dramatic rescue off Florida recently, according to a Coast Guard source. The software, known as Computer Assisted Search Planning (CASP), was developed by the firm in Paoli in the early 1970's to assist the Coast Guard in search and rescue planning. It was modified in the last three years mainly by the firm's Sunnyvale, Calif., office and partly by its Paoli office.

As recounted by Lieutenant Gordon Garrett of the Coast Guard Rescue Coordination Center in Miami, the incident began Nov. 10 with a "mayday" at 9 a.m. from the cabin cruiser Yorkie Express two hours out of West Palm Beach.

The Coast Guard Cutter Point Barnes received a quick message that they were sinking fast with a family of four onboard and flares but no life raft. The Coast Guard quickly confirmed the validity of the information to eliminate hoax possibilities and promptly launched a search by aircraft. All the remaining hours of daylight were utilized because of the distress proximity to the fast moving Gulf Stream.

During the night, planners at the Coast Guard Rescue Coordination Center in Miami employed the Computer Assisted Search Planning program to develop a map showing at each grid cell location the possi- probability that the family adrift would be at that location the next day. Drift data and an estimate of the mayday position surrounded by a 20 mile radius of uncertainty were fed into the program for this purpose. The next morning, the search was renewed with a helicopter, a Falcon reconnaisance aircraft, and a large C-130 transport configured for search and rescue.

The helicopter was assigned the grid cell with the highest probability and flew to the four people adrift in the water on one of the legs of the search pattern. They were hypothermic and in dangerous condition after 24 hours adrift. The holicopter took them aboard through basket hoists, and ashore they were released from medical treatment after brief hospitalization of one of them.

According to Lieutenant Garrett, the computation was remarkably accurate. Such accuracy and additionally good luck, he said, were needed because high seas at the time made visibility difficult, which considerably narrowed the path effectively searched by the holicopter and other aircraft. To this observation, Daniel H. Wagner, president of Wagner Associates, added praise for the skill and dedication of those who planned and executed the search, noting that the search planning program is no better than the capabilities of the professionals who use it.

Lieutenant Garrett further observed that they use the computer assisted search planning program routinely on multi-day, multi-unit search operations, which occur about once per three days. He credits the program with having made a crucial difference in saving numerous lives through successful rescues in recent years. The Coast Guard has 16 such rescue coordination centers using the program, and the Miami center has the heaviest volume of this usage.

"Computer software developed by Daniel H. Wagner Associates of Paoli was instrumental to success of a dramatic rescue off Florida recently, according to a Coast Guard source."

"During the night, planners at the Coast Guard Rescue Coordination Center in Miami employed CASP to develop a map showing at each grid cell location the probability that the family adrift would be at that location the next day."

Hospital Resident Scheduling

USER'S GUIDE FOR THE
RESIDENT SCHEDULING PROGRAM

Memorandum Report to

THE CHILDREN'S HOSPITAL
Philadelphia, Pennsylvania

August 17, 1981

by

DANIEL H. WAGNER, ASSOCIATES
Paoli, Pennsylvania

By: Stephen J. Bloom
Stephen J. Bloom

Reviewed by: Barry Belkin
Barry Belkin

Approved by: Henry R. Richardson
Henry R. Richardson
Technical Director

Hospital Resident Scheduling

MEMORANDUM REPORT

To: The Children's Hospital of Philadelphia
Attn: Robert Doughty, M. D.

From: Stephen J. Bloom

Subject: Computer Program User Guide for Scheduling Pediatric Residents

This memorandum report describes the use of the computer software package by which schedules are computed for pediatric residents at the Children's Hospital of Philadelphia (CHOP). This package was successfully used to produce the resident schedules for the 1981-1982 teaching year.

There were several considerations motivating this project for Children's Hospital. One important factor was the considerable time and effort, mostly on the part of the chief pediatric resident, that had been required to generate these schedules manually by trial and error. We are advised that in the past it was not uncommon for the chief resident to spend as long as two or three months working out the scheduling details. In addition, there was considerable secretarial work involved in editing and typing several revisions. Human error in schedule preparation frequently

"…considerable time and effort … to generate these schedules manually by trial and error."

"… not uncommon for the chief (pediatric) resident to spend as long as two or three months working out the scheduling details."

"…considerable secretarial work involved in editing and typing revisions."

"Human error in schedule preparation …"

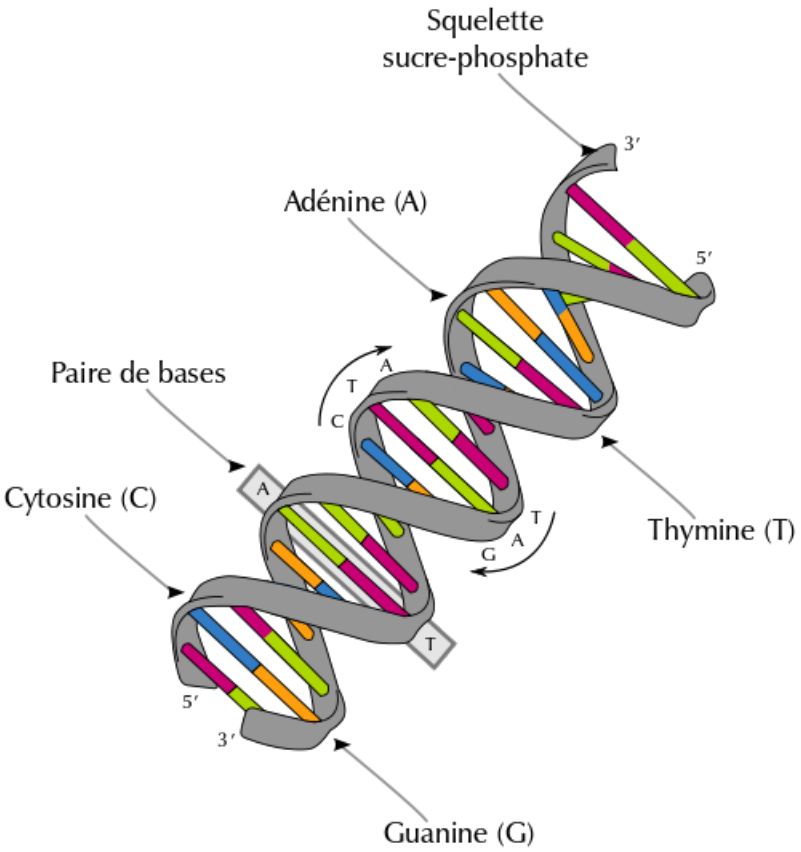
AND THE AWARDS GO TO….

POLLY MITCHELL-GUTHRIE · GENERAL · COMMENTS OFF

I posted earlier on the competitions sponsored by the Analytics Section, and since the final decisions were made by this evening now I'll announce the winners.

Winning first prize in the Innovative Applications in Analytics competition is the Mayo Clinic for their work on Intelligent Surgical Scheduling. Congratulations to them for winning, as well as to the teams from American Airlines and from the MIT Operations Research Center and Rue La La for their excellent work as finalists.

DNA Sequencing



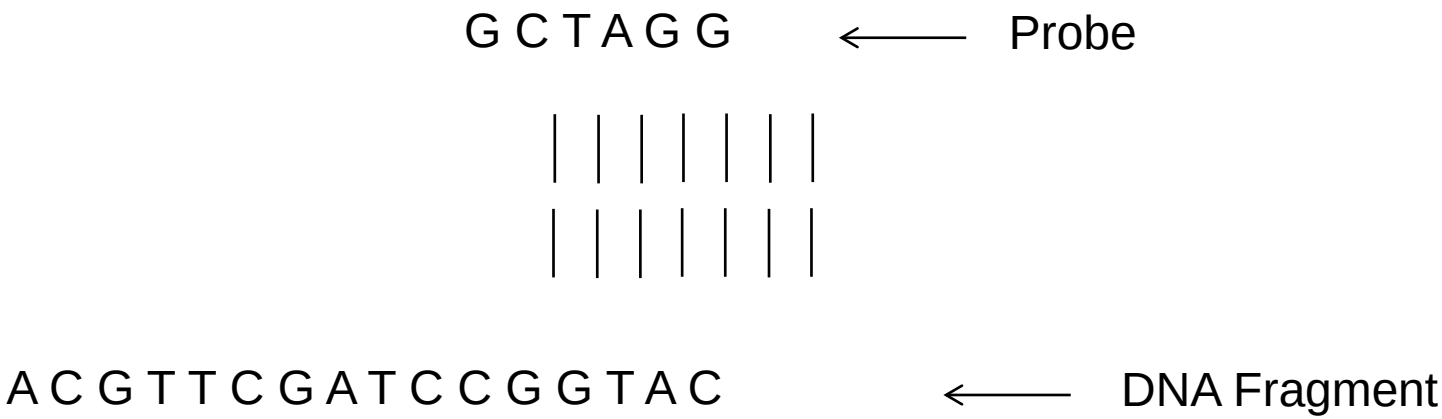
Human Genome Project

- Map all human genetic material
  - Determine location of all genes within chromosomes
- Sequence all human genetic material
  - Determine sequence of DNA bases in chromosomes
  - Given a fragment of DNA, find sequence of bases
  - Human Genome has ≈ 3 billion bases
- Leads to
  - Diagnosis and cure of human genetic disease
  - Understanding of human physiology
  - Application of technology to other species
- Prominent Methods in late 80s
  - Maxam Gilbert
  - Sanger

Problems With Maxam-Gilbert or Sanger Methods

- Tedious
- Error Prone
  - Repeat several times for accuracy
- Slow
  - 100,000 Bases/Persons/Year (1988)
  - 30,000 MY for Human Genome
- Costly
  - $.75/base
- Goal: 1 million bases per day (project wide)
  - $.10/base

Hybridization



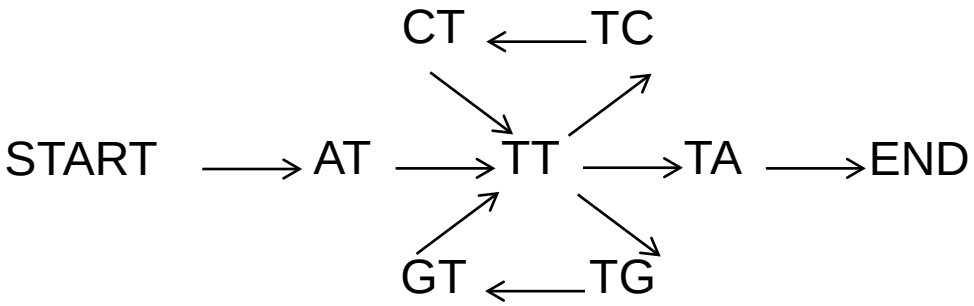
- Probe hybridizes with (binds to) complementary subsequence of DNA fragment
- Insight: Use probes to learn about subsequences of fragment

Sequencing by Hybridization

DNA Fragment
ATTCTTGTTA

All Length 3 Probes								All Length 3 Sequences	Reconstructed Sequence
AAA	AAC	ACA	ACC	CAA	CAC	CCA	CCC	ATT CTT	
AAG	AAT	ACG	ACT	CAG	CAT	CCG	CCT	TCT TTA TTC	ATTCTTGTTA
AGA	ACC	ATA	ATC	CCA	CGC	CTA	CTC	GTT TGT	ATTGTTCTTA
AGG	AGT	ATC	ATT	CGG	CGT	CTC	CTT	TTG	
GAA	GAC	GCA	GCC	TAA	TAC	TCA	TCC		
GAG	GAT	GCG	GCT	TAG	TAT	TCG	TCT		
GGA	GGC	GTA	GTC	TGA	TGC	TTA	TTC		
GGG	GGT	GTG	GTT	TGG	TGT	TTG	TTT		

Reconstruction by Graph



- Probes are Length k
- Vertices are all k – 1 subsequences
- Edges are all k subsequences (directed)
- Reconstruction is a path through all vertices
- Uniqueness (fragment length n)
  - n – k + 1 probes hybridize
  - Graph Eulerian
  - Unique Eulerian Path

Wagner DNA Projects

Topic	Client
Probe based partial sequencing/data base search	NIH/DOE
Gel Image Storage/ Data Compression	Intelligenetics
Signal Detection Flourescent Gel Scanning Film Transfer Image Analysis Mass Spectroscopy Gel Scanning	 ABI Pharmacia/NIH/DOE Intelligenetics/NIH/DOE Genomyx
Multiple Hypothesis Fragment Assembly	ABI/Intelligenetics
Lab Management System (with Intelligenetics)	NIH/DOE

Stochastic Models of Sperm Motility

STOCHASTIC MODELS
OF SPERM MOTILITY

Report to
National Science Foundation

by

Daniel H. Wagner, Associates

September 30, 1987

Prepared Under
Grant No. ISI-8660729

Submitted to:

Dr. Andrzej Manitius
Deputy Division Director
Division of Mathematical Sciences

Mr. Ritchie Coryell
Program Manager
Small Business Innovative Research
Programs

By: Bernard J. McCabe
Bernard J. McCabe
Vice President
Principal Investigator

Barry Belkin
Barry Belkin
President

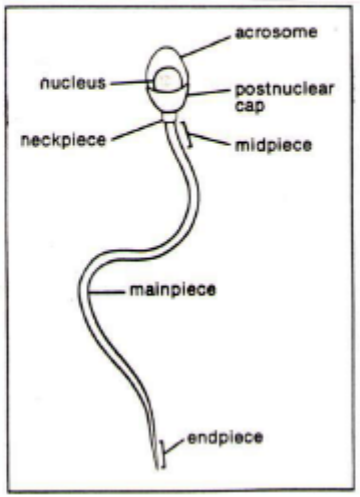
Daniel H. Wagner
Daniel H. Wagner
Consultant

Kathleen M. Sommar
Kathleen M. Sommar
Senior Software Analyst

Stochastic Models of Sperm Motility
Biology Basics

FIGURE I-1

DIAGRAM OF A NORMAL SPERM



Given appropriate menstrual timing, an egg awaits at a well-defined location in the upper section of one of the two oviducts. This location, called the ampulla, has a larger cavity than the lower oviduct. The number of sperm attaining the ampulla range from a few hundred to a few thousand.

As a sperm nears the egg, it emits an enzymatic secretion in what is called the acrosomal reaction. This secretion helps to break down the outer investments of the egg to facilitate penetration. When a sperm penetrates the egg, an action takes place immediately to render the egg impenetrable by further sperm. In a normal fertilization process, this prevents incorporation of excess genetic material, which would lead to an abnormal embryo.

In addition to the foregoing transit, to achieve fertilization sperm must undergo conditioning in the female tract (seven hours in humans) known as capacitation: Protein substances are removed from the acrosomal overlay, which permits the acrosomal reaction. Another change in motility, called hyperactivation, also occurs in this transit.

I-4

Stochastic Models of Sperm Motility
Math Model for Motion

2.1 Stochastic Differential Equation Model

Our principal modeling assumption is that each of the component sperm motion processes $X_B(t)$, $Y_B(t)$, $X_R(t)$, and $Y_R(t)$ satisfies a linear second-order SDE of the general form (here dx, dẋ, and dW are stochastic differentials, e.g., see [b], while ẋ is the ordinary derivative):

$$\begin{cases} dx(t) = \dot{x}(t)dt \\ d\dot{x}(t) = -\alpha^2 x(t)\,dt - \beta\dot{x}(t)\,dt + \sigma dW(t), \end{cases} \qquad (2.1)$$

where

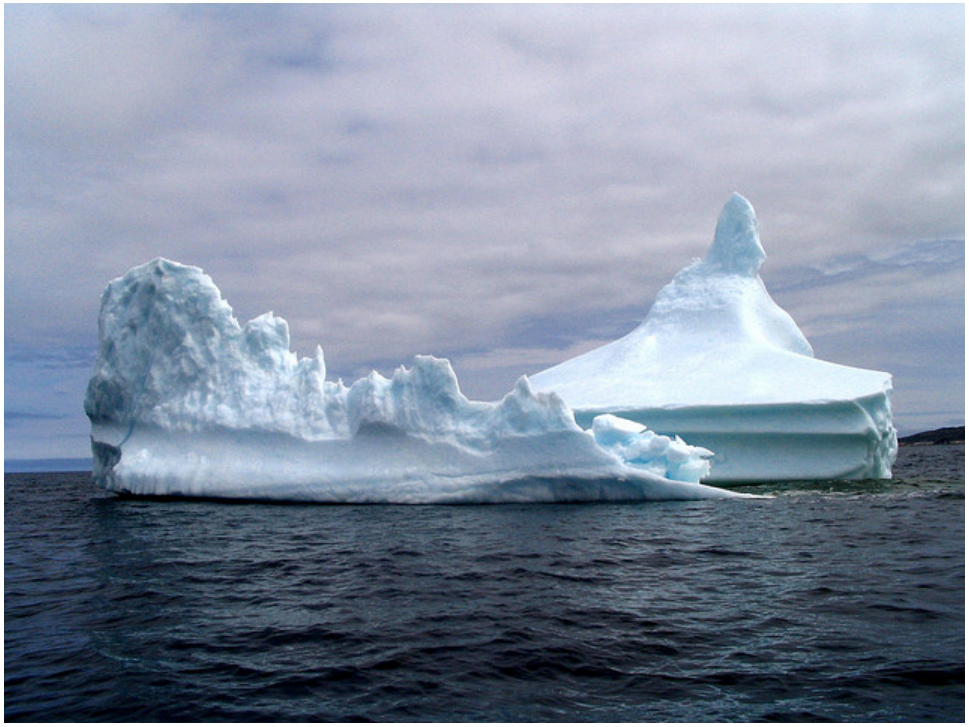
(i) x(t) generically represents the value at time t of one of the component process $X_B(t)$, $Y_B(t)$, $X_R(t)$, or $Y_R(t)$,

(ii) dW(t) is a white noise process, i.e., W is a Wiener process, with unit variance,

(iii) $\alpha \geq 0$, $\beta \geq 0$, and $\sigma > 0$ are model parameters.

Equation (2.1) is in the form of a generalized Langevin equation (see, e.g., [c]). The classical Langevin equation describes the motion of a free particle (no external force) in a medium subject to the dynamical friction of the medium and to random (Brownian) impulses. We refer to the solution to equation (2.1) with an external spring-type force as the frictionally damped harmonic oscillator (FDHO) process. The model parameters have the interpretations:

The Iceberg Project



- Client: Lower Churchill Development Corporation (Canada)

- Problem: Quantify risk of iceberg scour to a proposed power cable across the bed of the Strait of Belle Isle (between Labrador and Newfoundland)

The Iceberg Project
Analytical Approach

- Factors to consider:
  - Number of icebergs flowing through Strait
  - Shapes and sizes of icebergs
  - Geography and bathymetry of Strait
  - Presence of a sill (submerged ridge) acting as a natural barrier
  - Possible rotational instability of icebergs
- Discretize points on cable and floor of Strait
- Calculate probability of scour by given iceberg taking into account
  - sill entry point of iceberg
  - iceberg shape index
  - initial iceberg draft
  - possibility tilting and rollover of iceberg in crossing sill
  - point at which iceberg crosses cable
- Utilize historical data on number of icebergs entering Strait, sill entry points, iceberg shapes, and iceberg drafts to estimate required frequency functions

The Iceberg Project
Main Results

- Investigated the two alternate cable routes under consideration
- Parameterized probability of scour event based on
  - depth of trench in which cable is buried
  - length of time period
- Determined that without a trench the acceptability criterion of one expected scour event every 25 years is not met
- Determined required depth of trench to meet acceptability criterion

Wagner Associates' Offspring

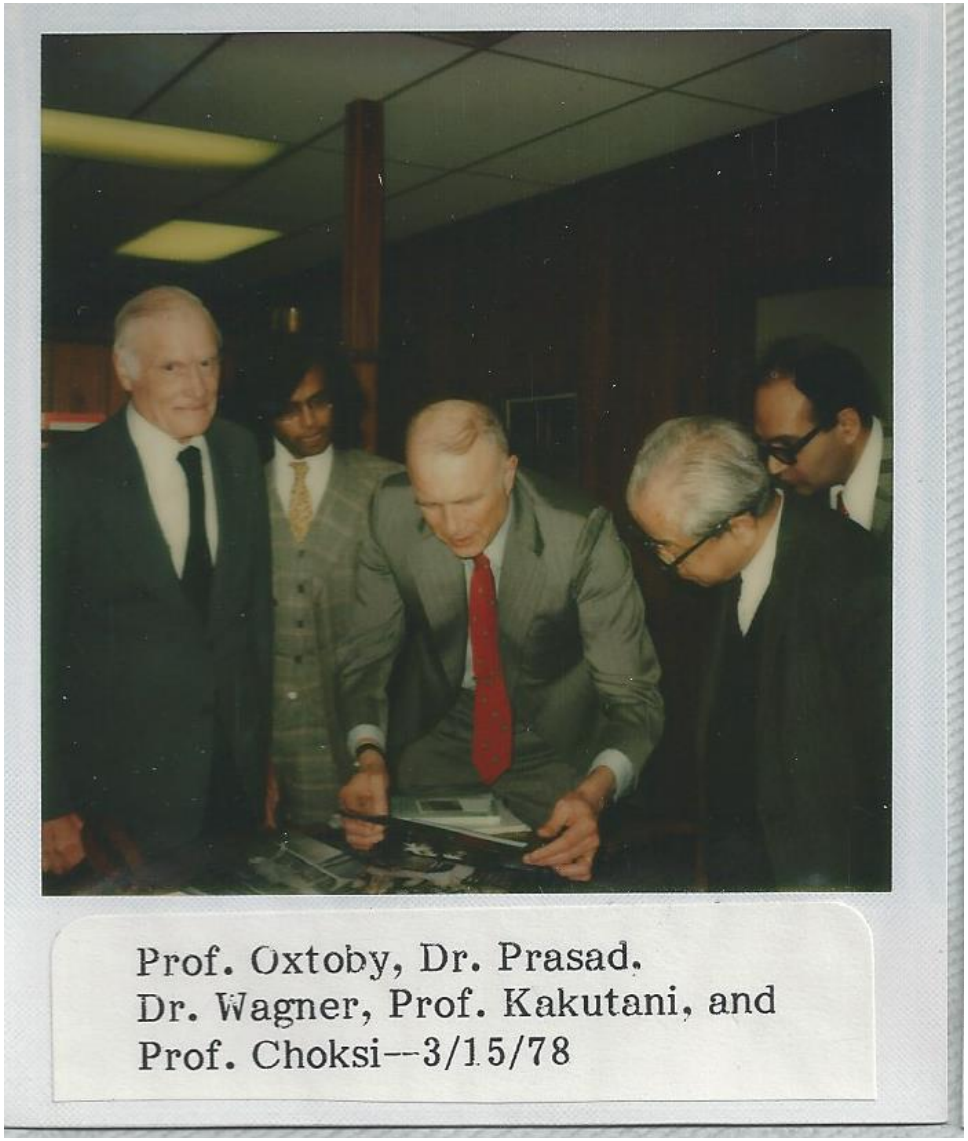
- Bossard Analysis (Dave Bossard)
- EPL Analysis (Ted Loane)
- Quantics, Inc. (Joe Bolmarcich, Robert Higgins)
- Inter-National Research Institute (Frank Engel)
- Applied Mathematics, Inc. (Bill Browning)
- Metron, Inc. (Tom Corwin; Larry Stone)
- SmartCrane, LLC (Joe Discenza)

Maintaining the Academic Connection

Guest Lectures

- Shizuo Kakutani
- Kazimierz Kuratowski
- Paul Halmos
- Paul Erdős

Shizuo Kakutani , et. al. (1978)



Prof. Oxtoby, Dr. Prasad.
Dr. Wagner, Prof. Kakutani, and
Prof. Choksi--3/15/78

Birth and Development of the Polish School of Mathematics Kazimierz Kuratowski (1977)

Today's Post Friday, June 17, 1977 21

Mathematician Talks

Prof. Kazimierz Kuratowski, world-renowned Polish mathematician, recently lectured in Paoli on the "Birth and Development of the Polish School of Mathematics."

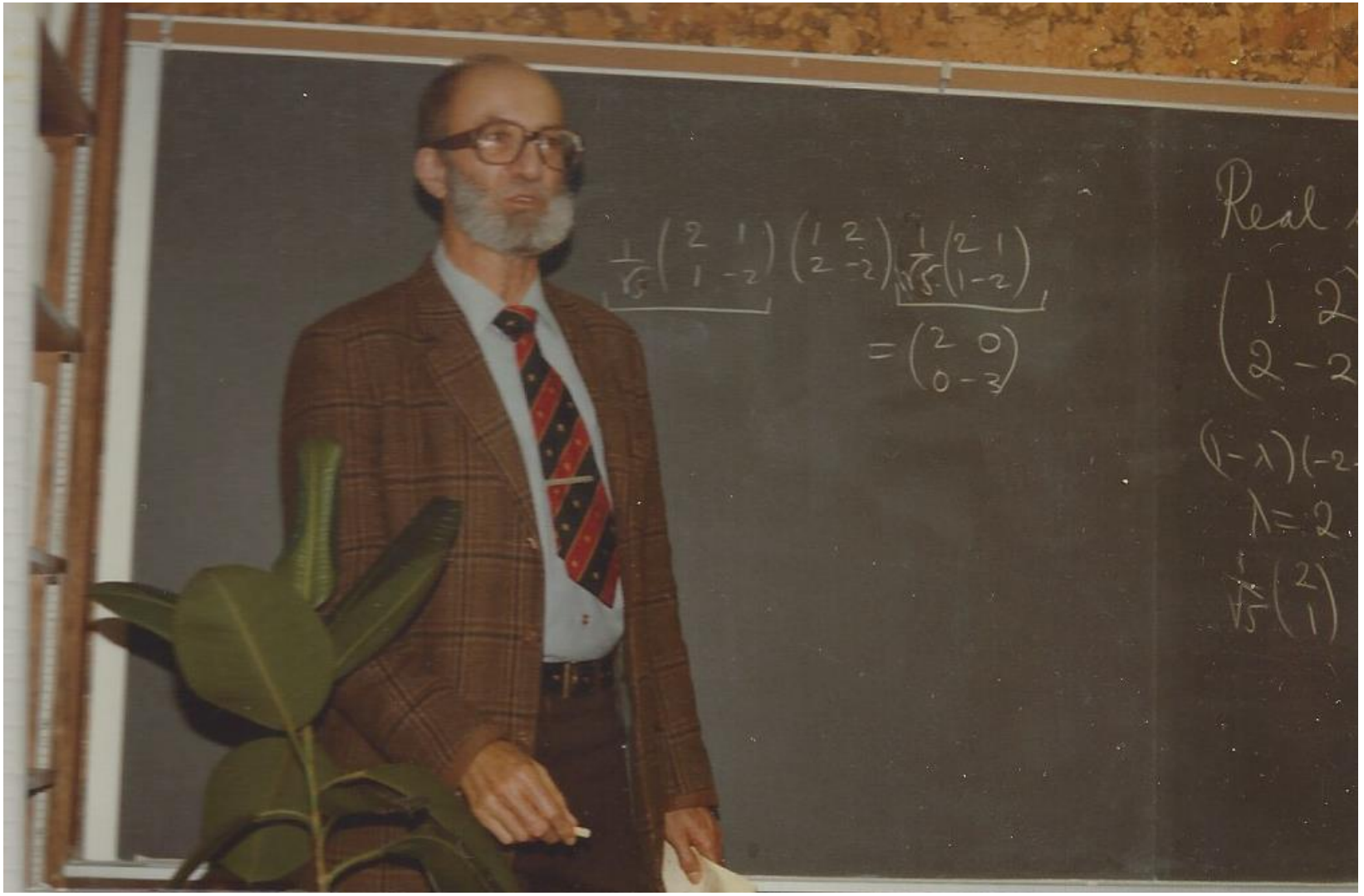
Kuratowski, 81, is one of the few surviving members of a group of Polish mathematicians which had great influence on mathematics during the 1920s and 1930s. He attributed the birth of the school to the Polish desire for national identification in the wake of World War I, and to the leadership and foresight of three mathematicians — S. Janiszewski, S. Mazurkiewicz and S. Sierpinski.

The school was a loosely defined group spread over the universities in Warsaw, Krakow and Lvov until it was somewhat formalized by the founding in 1920 of "Fundamenta Mathematica," a journal devoted to pure mathematics , principally set theory and logic.

Kuratowski's speech, sponsored by the operations research consulting firm, Daniel H. Wagner, Associates of Paoli, attracted an overflow audience of 65 mathematicians, including professors from a dozen colleges and universities.

Applications of Probability Theory to Number Theory and Combinatorics
Paul Erdős (1981)

How to Throw Small Matrices Away
Paul Halmos (1983)



Maintaining the Academic Connection
Return to Academia

- Dr. Bruce Scranton
  - Chair, Mathematics Department
    Emmanuel College
- Dr. Stan Benkoski
  - Instructor, Mathematics Department
    West Valley College
- Dr. Burgess H. Rhodes
  - Visiting Lecturer of Mathematics
    University of Richmond
- Dr. Walt Stromquist
  - Editor, Mathematics Magazine (a Journal of the MAA)
  - Visiting Associate Professor, Mathematics Department
    Swarthmore College
- Dr. Michael Monticino
  - Dean of the College of Arts and Sciences
    University of North Texas

A Wall of Journals

1966 ORSA Journal