



**Joseph Priestley Society Lecture
Science History Institute
Philadelphia**

**Restoring an American Industrial Legend:
TIAX and the Arthur D. Little Company**

Kenan E. Sahin, PhD

January 18, 2024

TIAX LLC. & CAMX Power LLC
35 Hartwell Avenue
Lexington, MA
02421-3102

www.TIAXLLC.com

(The original slide deck presented alongside the lecture on January 18, 2024 has been modified to be self-explanatory and some of the slides have been edited for more clarity)

- I thank the Science History Institute for inviting me to deliver the Joseph Priestley Society Lecture
- This Institute is the premier entity that preserves the consequential documents in the evolution of chemistry, chemical engineering and health sciences in the US and also the history of some of the key companies in these fields
- One of those companies was Arthur D. Little, Inc, founded in 1886 as Griffin & Little. That second founder Arthur D. Little was at MIT as an undergraduate in chemistry. Upon Griffin's tragic death in a lab accident, the company became Little & Walker and upon Walker's return to MIT as an instructor, in 1909 the company was incorporated as Arthur D. Little, Inc. (ADL)
- Under Little's direction, ADL became one of the cornerstone companies in the US in the development of technologies especially in chemicals, food, and pharma and a go to company in technology consulting for the giants of industry like DuPont, General Motors, and Batelle.

- After Mr. Little's death in 1935, ADL continued its impact first under the majority ownership of no other than MIT, and then as an independent company growing into a 3,000 person company with branches in 30 countries, even advising governments
- The «classical» ADL remained as Technology & Innovation (T&I), operating over 50 labs and with a staff of 300, primarily in Cambridge, Massachusetts
- In 2002, in an unusual twist of events, ADL was broken up into five parts and sold at an auction, T&I being one of the parts sold
- T&I was purchased by TIAX. I am the founder and president of TIAX and an MIT alum
- It is a privilege for me to have this key forum to tell the history of this storied company, ADL. It is also a personal story.

THE BEGINNINGS

- Arthur D. Little in his own words: attached to his lab notebook 6/4/1932

B. Laboratory Note Book No. 1054 ✓

Assigned to Arthur D. Little Date 6/4/32

Filed 6-28-32

Client E. I. du Pont de Nemours & Co Case No. 46955

This note book is the property of Arthur D. Little, Inc. The Assignee is responsible for its return to the permanent records of this company.

advis. ed. 10

I studied chemistry at the Massachusetts Institute of Technology, and after two years in plant operation opened a laboratory in Boston as an analytical and consulting chemist. The business was ultimately incorporated and developed into a large organization of chemists and engineers specializing in industrial research. The style of the corporation is Arthur D. Little, Inc., and I am its president and general manager.

We have served several thousands of clients in the most varied lines of industry, developing for many of them new processes and products, and reporting to bankers and investors on going concerns and new propositions. I have taken out a number of patents and have testified as expert in important patent cases.

The following are listed by way of record:

President, American Chemical Society (1912-14)
President, American Institute of Chemical Engineers (1919)
President, (British) Society of Chemical Industry (1928-29)

Founder, School of Chemical Engineering Practice,
Massachusetts Institute of Technology

Honorary Ch.D., University of Pittsburgh
Honorary D.Sc., Tufts, Columbia, University of Manchester
(England)

Honorary Associate, Manchester College of Technology

Perkin Medalist for 1931

Vice-Chairman, Engineering Foundation Board (1927-30)

Cyrus Fogg Brackett lecturer, Princeton University
Alfred lecturer, Massachusetts Institute of Technology
Dohme lecturer, Johns Hopkins University.

Below are some of my present connections:

Life Member, Corporation of
Massachusetts Institute of Technology
Chairman, Committee on Chemistry for
the 1933 Chicago World's Fair
Member, Visiting Committee of the
Departments of Chemistry and Chemical Engineering,
Massachusetts Institute of Technology
Member, Committee of Division of Chemistry,
Harvard University
Member, Chemical Engineering Department Senate,
Columbia University
Chairman, Advisory Committee of
the National Exposition of Chemical Industries
Consultant, Chemical Warfare Service.

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- Little's accomplishments are even more remarkable
 - He did not finish high school but was admitted to MIT
 - He did not complete his MIT undergraduate in chemistry either, leaving after his junior year because his family did not have the funds.

- After leaving MIT the summer of 1885 he joined Richmond Paper Company in Rumford, Rhode Island where he met Roger B. Griffin
- The next year, 1886, launched a company, Griffin & Little
- He penned a 12-page letter to his father in Portland, Maine announcing the launch and posted the letter on August 30, 1886, from Canton, Massachusetts.

Griffin & Little is considered the first technology consulting and transfer company in the US and this letter marks a historic moment.

➤ My dear Father,

Canton, Mass

• Aug. 29th '86

•

➤ "Griffin + I are to open a laboratory in Boston. We shall probably have...little to do the first six months but are reasonably sure of a fair amount of work."

➤ My comment: appeal to the ultimate angel funders, Dad or Mom.



Canton - Mass.
Aug. 29th '86.

My dear Father ;
I am glad to be able to write you something definite about my business plan for the future. As I told you in my postal I hoped to do, I was able Friday to have matters decided and in a way which I think will be much to my advantage.

Griffin + I are to open a laboratory in Boston Oct. 1st. We shall probably have comparatively little to do during the first six months but are reasonably sure of a fair amount of work. We are going to make a specialty of paper mill work and I think are the only chemists in the country who have been employed by

- In 1893, disaster struck: Griffin died in a lab accident.
- In 1895, Little teamed up with Dr. William Hultz Walker, a chemistry instructor at MIT, to form Little & Walker
- Little & Walker had only seven employees in 1895 but to give the impression of a larger company they created seven departments (Kahn, p.33): Analytical, Coal and Derivatives, Lubrication, Biology, Textiles, Engineering, Forest Products.

- In 1901, Little married Henrietta Rogers Anthony. They did not have any children but adopted Little's nephew, Royal, as their son
- Royal Little went on to Harvard, played a key role in the later years of ADL, and in his own right was a giant having ushered in the era of conglomerates with Textron
- In 1909, 23 years after its founding, the company was incorporated as Arthur D. Little, Inc. The lawyer was Brandeis who later became a US Supreme Court justice.

FIRST TRANSITION

- Little died in 1935. In his will he left his controlling share to MIT
- At his death ADL had about 50 employees.

Miss Eula Lee Scott.

M. I. T. TO SHARE STOCK IN RESEARCH CONCERN

Will of Dr. Arthur D. Little Gives Controlling Interest After Death of His Wife.

Special to THE NEW YORK TIMES.

CAMBRIDGE, Mass., Aug. 13.—Controlling interest in Arthur D. Little, Inc., an industrial research firm, has been left in trust for the benefit of the Massachusetts Institute of Technology, under Dr. Little's will, filed for probate today.

The trustees, Francis R. Hart, president of the United Fruit Company; Horace S. Ford, treasurer of M. I. T., and Royal Little of Providence, a nephew of Dr. Little, are directed to develop a plan whereby the corporation may be administered to insure its continuance as an independent agency to benefit both industry and the institute.

Dr. Little, who died Aug. 1, had been chairman of the board of the corporation. His will provides further that his widow, Mrs. Henrietta Little, and M. I. T. are to share in the income from the stock held by the trust, with the ownership of the controlling interest ultimately going to M. I. T. Aside from this bequest, his entire estate is left to his widow.

Dr. Little was widely known in his profession and in the business world. He was a former president of the American Chemical Society, the American Institute of Chemical Engineers and the Society of Chemical Industry of London. He was active in alumni and administrative affairs of M. I. T., and had been a life member of its corporation since 1923.

SECOND TRANSITION AND TRANSFORMATION

- With Royal Little's initiative, ADL was purchased from MIT in 1953, the Memorial Drive Trust was created, and ADL became an ESOP
- The "classical" ADL eventually became the Technology & Innovation unit embedded in the rapidly growing global ADL now emerging as a management consulting company competing with Boston Consulting Group and McKinsey
- While ADL would grow to 3,000 with 46 offices in 30 countries, T&I (the "classical" ADL) would remain small, growing from 150 in 1953 to about 300 by 2002 with more than 50 laboratories and primarily in Cambridge, MA.

IMPACT

- Unquestionably Arthur D. Little is still a towering figure, his impact on applied chemistry, chemical engineering and food sciences still felt
- Unquestionably ADL has been a cornerstone company, its impact far, far greater than its actual size
- It was the launch pad for many other companies
- For example, Bruce Henderson was hired from ADL by Boston Safe Deposit and Trust Company to found a division called Boston Consulting Group (BCG) which eventually became independent through a management buyout
- William Bain left BCG in 1970 to found Bain and Company
- BCG and Bain are two of the largest management consulting firms alongside McKinsey
- The industrialist Gordon Batelle was so impressed by the contract research ADL had provided in the early '20s that in his will he left funds for a similar company to be founded. That company became Batelle Memorial (1929) (a non-profit) now managing many of the National Labs for the Department of Energy.

IMPACT

- And Dr. Little's knack for promotion embedded the company and the man in the public mindset, e.g. debunking "you cannot make a silk purse out of sows' ears."
- One of the two such "silk purses" made is at the Smithsonian. Here is the other.



IMPACT ON MIT

- While a student at MIT, Little co-founded
 - Tech, the main MIT newspaper still running
 - The MIT Technology Review, now a major magazine
- He chaired the MIT Visiting Committee for the Department of Chemistry which in 1915 recommended MIT have a Department of Chemical Engineering and so it was
- Ultimate impact: the bequest of ADL to MIT.

- Financially, though, the company was not a stellar success until the 60's and even then success would come crashing down (unlike Textron which was to become one of the top 100 US companies by 1960)
- I mention this not to in any way diminish this great company, but to underscore that even then contract R&D was tough. And provide some explanation for the collapse
- Dr. Little was more keen on IMPACT than on financial gain
 - In 1909, when it was incorporated after 23 years of operations, it only had 22 employees, \$2,178.16 in cash, \$7,496.40 in receivables and fixed assets of \$11,565. (Kahn)
 - It took 25 years to reach profitability, not six months as he had announced to his father.
 - ***“In the last five years before Dr. Little's death, the average earnings of his company had come to a meager \$6,230.”*** (Kahn p.101)
 - In 1953, when ADL became independent, MIT's 55% share of ADL was valued at \$1.3 million, thus the company's total worth was \$2.3 million. It had about 150 employees. Profitability was still poor.

BANKRUPTCY/LIQUIDATION

ADL - January 2001 as described in a company presentation

Arthur D. Little pioneered the contract research and consulting businesses. Today, we are one of the world's leading consulting firms.



Dr. Arthur D. Little (1863–1935)

- **Founded in 1886**
- **World's first consulting firm**
- **Headquarters in Cambridge, Massachusetts**
- **Revenues: ~\$600 million/year**
- **>3,000 employees worldwide**

Business Overview Global Presence

We provide consulting services worldwide from 46 offices in 30 countries.



We conduct over 2,000 assignments annually for clients in more than 60 countries.

And the reality - just one year later

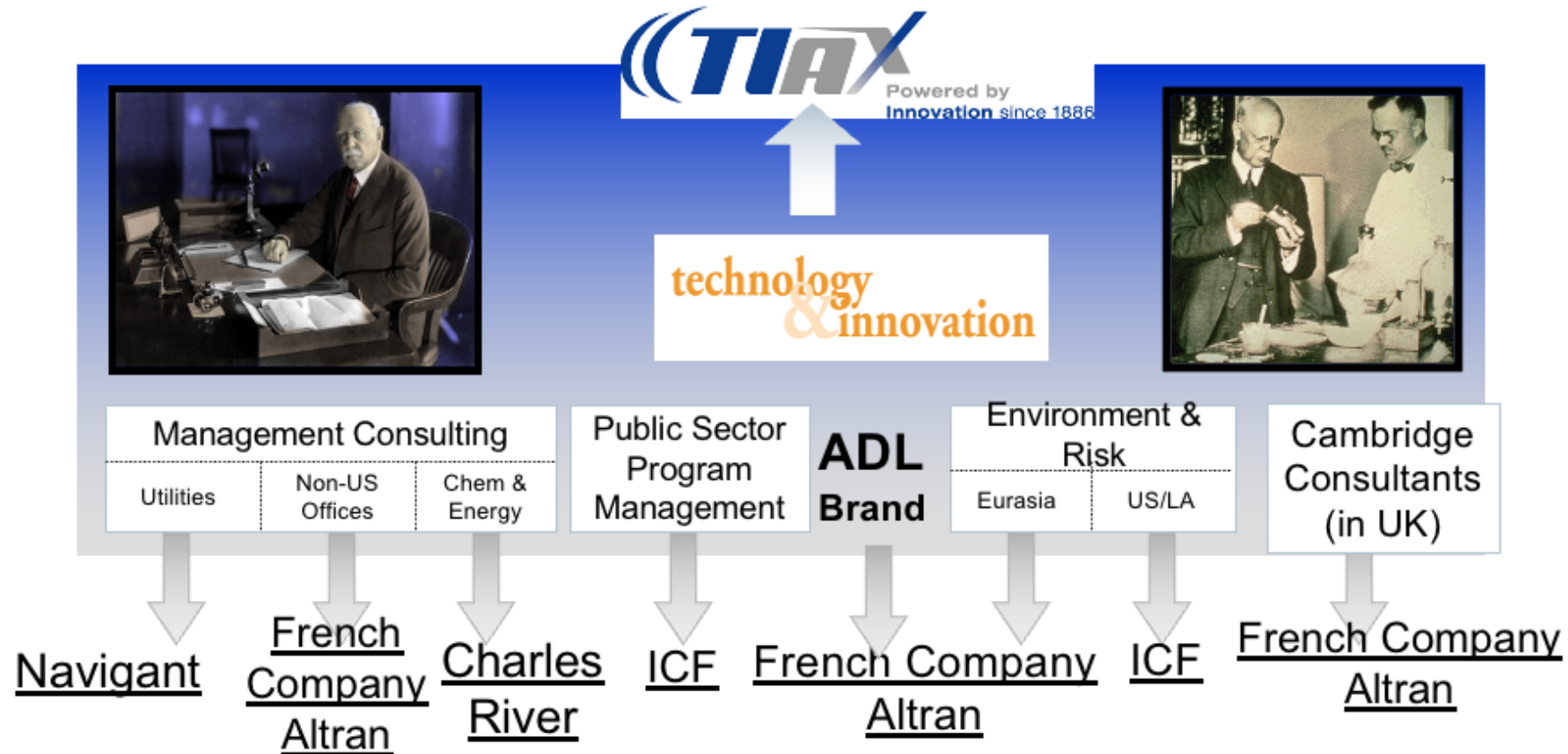
New York Times,

February 6, 2002, Section C, Page 4: *Arthur D. Little, the oldest consulting firm in the country, announced yesterday that it would file for bankruptcy protection as a precursor to its acquisition by...Cerberus Capital Management of New York... [for] \$71 million.*

- When other creditors and some European employees objected, the court ordered that ADL be divided into five “lots” and the lots be sold at an auction to be held on April 4, 2002 in Boston
- The “stalking horse” amount was \$71 million. If the bids received for the five lots did not reach that level, then the auction would not proceed
- The auction did proceed partly because of the “unexpected” bid by TIAX.

- Arthur D Little, Inc. was splintered into multiple entities and assets sold at auction on April 4, 2002. A 3,000 person 116 year old company was liquidated in just two months!

The Technology & Innovation business, representing the company's 116 year technology heritage and achievements emerged intact as TIAX.



At the conclusion of the auction, the winners lined up as follows:

- **Altran of France, \$56 million for**
 - Global Management and Consulting that was ADL's worldwide management consulting practice
 - **Rights to the Arthur. D. Little name**
 - Cambridge Consultants, a technology consulting company located in Cambridge, U.K.
- ICF Consulting Group, \$10 million for
 - Public Sector Program Management business that concentrated on Government contracts
 - Global Environment & Risk Americas business
- Navigant Consulting, \$6 million for
 - Advanced Energy Systems business that worked on strategic decision-making
- Charles River Associates, \$7 million for
 - Chemical Energy Vertical business that emphasized energy consulting for the petrochemical industries
- **TIAX LLC, \$17 million for**
 - **Technology and Innovation.**

“Mercer was interested in ADL's management consulting and not technology business. In retrospect, it would have been wise to sell off the management consultants and use any proceeds to build up the traditional [“classical”] ADL technology business.” Avots, p.31

In a sense that is what happened with T&I emerging as an independent company-

TIAX *Technology and Innovation Applications (X)accelerated LLC*

But the investment came from TIAX not from the sale of the other assets.

Why TIAX? Why me? Why my interest?

- I have been at or affiliated with MIT since 1961, BS and PhD and also on the faculty for some years
- Like Little, I have been a life member of the MIT Board and on many visiting committees
- I would often walk by the Arthur D. Little building on East Campus. ADL and Arthur D. Little were legends on campus
- I was (and am) keenly interested in innovation and implementation
- My beacons were ADL (classical) and Bell Labs.

- In 1982, while on the MIT faculty, I started a company with \$1,000 of my money to field-test my ideas, my pontifications
- Later it was named by the Board as Kenan Systems
- Board chair was Howard Johnson and a key member was Jerome Wiesner, both former MIT presidents. Dr. Wiesner was the science advisor to Presidents Kennedy and Johnson
- The company grew to nearly 1,000, with me the sole shareholder. It was acquired by Lucent/Bell Labs in 1999
- A key condition for the sale was that my 750 technical colleagues be made Members of Bell Labs Staff, and they were, as they were that good
- I became a VP at Bell Labs and Group President of Lucent Communications Software
- I saw how this legendary R&D group was operating **nestled inside a mothership**
- **And that is more or less how T&I was operating.**

- In 2001 I returned to Boston to finally have a quiet life
- Pondered about the dotcom bust that had begun in 2001
- And noted a huge innovation backlog emerging
- I wrote about it in MIT Technology Review:
<https://www.technologyreview.com/s/402429/our-innovation-backlog/>
- As I was watching Lucent/Bell Labs implode, I read in the Boston Globe about the troubles of my second beacon, ADL
- I wrote a letter in January 2002 to the ADL president Pam McNamara offering to share my perspectives. No response
- On February 6, 2002, I read in the Boston Globe about the bankruptcy and understood why there was no response and I moved on with my newly found quiet life
- And sketching out my planned book on the innovation-to-implementation chain and startups, with Kenan Systems as a case study
- By the way I finally wrote the book. Forbes published it and the book will come out March 27, 2024.

KENAN E. SAHIN, PhD

LEAN STARTUP, TO LEAN COMPANY, TO RICH EXIT

Forbes | Books

KENAN E. SAHIN, PhD

LEAN STARTUP, TO LEAN COMPANY, TO RICH EXIT

HOW TO APPLY KENAN SYSTEMS'

\$1,000 IN, \$1.5 BILLION OUT PRINCIPLES

TO TODAY'S STARTUPS



Forbes | Books

"Kenan Sahin is a legend. I remember hearing about the Kenan Systems exit and being shocked.
It still is the gold standard."

Dr. Bill Aulet, author, entrepreneur, distinguished professor MIT

"Kenan Sahin built a remarkable company following the mantra of a good teacher, 'by your students you'll be taught.' Using striking parables to illuminate innovative management solutions, he shows how talent can be recruited, organized, and engaged in building a successful business while working hard and having what they describe as the best times of their lives."

Joseph L. Bower, author, distinguished professor Harvard Business School

"Few entrepreneurs go from bootstrap to success on the scale that Kenan Sahin has. Even fewer are also teachers who can mine the insights applicable to virtually any venture . . . an incredible journey that is not to be missed."

Robert Buderer, author, founder, and editor in chief MIT Technology Review

"An intellectual, a professor, an entrepreneur, wealth creator, philanthropist, and a turn around professional, Kenan's life story has many useful stories for anyone who wants to impact the world with their entrepreneurial zeal."

Dr. Gururaj "Desh" Deshpande, distinguished professor MIT, founder Sycamore Networks

"What successful scientific entrepreneurship is all about . . . of great value to any entrepreneur."

Dr. Robert S. Langer, biotechnician, businessman, distinguished professor MIT

"An unusual, and unusually compelling, contribution to the literature on innovation, leadership, and strategy . . . a heartfelt human story of courage, invention, growth, learning and reflection, and extraordinary impact."

Dr. David Schmittlein, Dean and Professor of Marketing MIT Sloan School of Management

"This thoughtful book is a testament to Kenan's commitment to technology and innovation. He has garnered valuable experiences in entrepreneurship and what it takes to succeed!"

Larry Weber, businessman, author of Authentic Marketing:

How to Capture Hearts and Minds Through the Power of Purpose

On Dr. Sahin's Rich Exit, "Only the beginning of a wave of stock-market-fueled philanthropy bigger than any since the days of the Carnegies, Vanderbilts, and Rockefellers."

The Wall Street Journal

- A side note as it is relevant to chemistry, chemical engineering and life sciences, the three pillars of the Science History Institute: Dr. Langer, who is quoted on the jacket (see above) has a ScD in chemical engineering from MIT, is the most cited engineer in history, second most cited scientist, holds 400 patents, founded over 40 companies, elected to all three academies, and has received honorary degrees from 41 universities.

- Another side note: Arbor/BP the telecommunications platform developed at Kenan Systems based on Natural Language Processing and Expert Systems and renamed by Lucent as Kenan/BP now processes over one billion telecom subscribers in the world or about 30% of the global total. As the book describes, that story, too, is an MIT story, from its very beginning and continuing on.

- Apparently, the letter I had written to ADL's president was not forgotten and ended up in the hands of the investment banking firm tasked with the auctioning off of ADL in lots, Houlihan Lokey
- One evening early March 2002 they called me on my cell phone and asked if I would be interested in bidding on one of the five "lots"
- I was shocked. Of course I would NOT be interested
- But wait - I asked why liquidation and not reorganization. Come to New York and we will tell you
- In New York I learned why there was to be an auction, and that the Technology&Innovation or T&I (the "classical ADL") had 30+ interested companies as potential buyers
- If I wanted to learn more (which I very much wanted to do for my book and curiosity) I would need to be an interested party to gain access to the confidential data room
- It was T&I that was my object of interest and with 30+ potential parties, why not put in a bid, gain access to the data room and at the auction learn from the potential bidders
- My chances of winning: ZERO (or so I said to my legal counsel at Hale & Dorr, now WilmerHale, and hence no need for onsite due diligence. Just one visit.)
- I quickly formed a single member company TIAX LLC to submit the bid.

- In the end, TIAX enabled the auction because its pre-auction high dollar bid allowed the total bids to exceed \$71 million, the threshold or the “stalking horse” as others had done the logical thing, submit pre-auction bids with very low values, some starting as low as \$2 million
- On April 4, I showed up early to interview the potential bidders for T&I which I assumed would be many
- The corridors were eerily quiet
- At 7 PM the auctioneer came, announced he would start with T&I and that there was **ONLY ONE BIDDER: TIAX LLC**
 - Going once, going twice, **SOLD!**
- The shock is still with me.

- An innocent letter, answering a call at off hours on my cell phone, curiosity, and now my plans for a quiet life and writing books had evaporated
- Instead, I would be showing up on April 8 at the HQ of now “former” ADL where T&I and its 50+ labs were, to cordon it off, declare it to be TIAX and run it. WOW. Unreal. Must be a jarring dream. It was all too real and very very jarring
- And here I am nearly 22 years later to tell you the sequel. Clearly, we made it but how?
- Is there a framework that can be used for other heritage companies that have failed or are faltering?
- I am working on a second book to tell that story and describe the framework
- First though the story from April 8, 2002 to now, 22 years later.

- On April 8, 2002, I showed up bright and early at Alewife
- Unpleasant surprise: the receptionist would not let me in. A secure facility and she had no idea who I was or who TIAX was. I had arrived ahead of the word
- Dr. Collins (an MIT PhD, one of many MIT grads at now TIAX) who was running T&I and who would be our VP, signed me in as a “Visitor”
- Other unpleasant surprises I learned that day:
 - “TIAX” as a new company had no lease. ADL estate held it
 - Suddenly TIAX had 300 employees with no health care coverage or other benefits
 - The book of business was enough for 150 vs 300 on the payroll, now TIAX responsibility
 - And a good chunk of those contracts were government contracts that needed to be “novated” - a lengthy process
 - And part of those contracts were top secret and I could not even access them. Since I had not done any due diligence, I did not know of their existence
 - The liquidation had happened so fast, most of the customers did not know about it and would need to be educated on TIAX as the new entity
 - Many many more unpleasant surprises were to follow.



“CLASSICAL ADL” NOW AS TIAX:
RESTORATION NOT TURNAROUND AS OBJECTIVE

The night of April 8 was a long but inspirational one:

- It was clear I had to act fast
- I had to address the intangibles: morale, trust, confidence, commitment...
- I had to address the tangibles: money, lease, benefits, accounting, rates, IT...
- I accepted that this would not be an investment but a GREAT OPPORTUNITY TO CONTINUE WITH MY VALIDATION EXPERIMENTS
- Why not turn this shocking outcome and do R&D on the R&D process itself
- I should aim to RESTORE rather than attempt a business TURNAROUND
- That meant no layoffs, no salary cuts, and letting attrition achieve equilibrium
- A new business model was imperative
- And why not a business model based on INNOVATION BACKLOG
- And bring in the time-tested principles of Kenan Systems experiment to the T&I-to-TIAX transformation with a LEXICON.

- Met with the staff on April 10, my third day at work
- And announced that TIAX
 - Would provide medical benefit plans ASAP
 - No layoffs
 - No salary cuts
 - On the contrary 401K match
 - A new business model
 - And that I am coming in NOT as an investor but to work alongside them and just by myself, NO TEAM from the outside.

- Their take (so I surmised)
 - Is this real?
 - This unknown guy is like a solo cowboy on a mule riding into Dodge City carrying two rusty pistols and saying “all will be fine”. Really?
 - And he says this is not an investment. Who does that? He must have an ulterior motive
 - Once he realizes how bad the situation is, he will back off or flip or worse.
- My take
 - 300 pairs of puzzled eyes of highly trained and accomplished staff on me
 - I can work with them. Pick up from where I left at Bell Labs
 - Yes I was blindsided, unprepared, no plans, no management team coming with me but I had experience as an academic, Kenan Systems founder/president, Lucent Group President and Bell Labs VP, and extensive contacts
 - And I had the resolve to push on. So will figure things out day at a time
 - But my words will not do it. I had to act and very quickly.

- Since ADL had so many connections to MIT as I did too and since so many of the staff were MIT grads, why not see if Dr. Chuck Vest, then the president of MIT, would be willing to chair an advisory Board much like I had turned to Howard Johnson at Kenan Systems to head the Board and managed to convince him
- I approached him. Very reluctant. He wanted to see my plans, the new business model, roadmaps, etc.
- I promptly provided all that and articulated RESTORATION as my objective and that I would provide the funding (which eventually topped \$100 million)
- He joined and I had instant credibility, gained the confidence of the staff and TIAX became legitimate as opposed to a “hobby” by an eccentric MIT guy.

- Dr. Charles Vest (left),
President of MIT and
Chairman of the TIAX
Advisory Board.



The innovation gap

Universities and Similar Entities



Number of Product Introductions



The innovation gap

Universities and Similar Entities

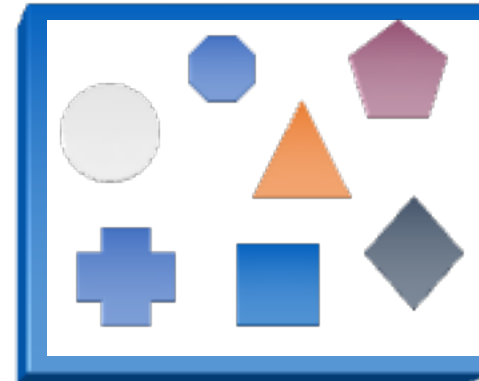


Reach of Universities



End

Number of Product Introductions



Reach of Industries

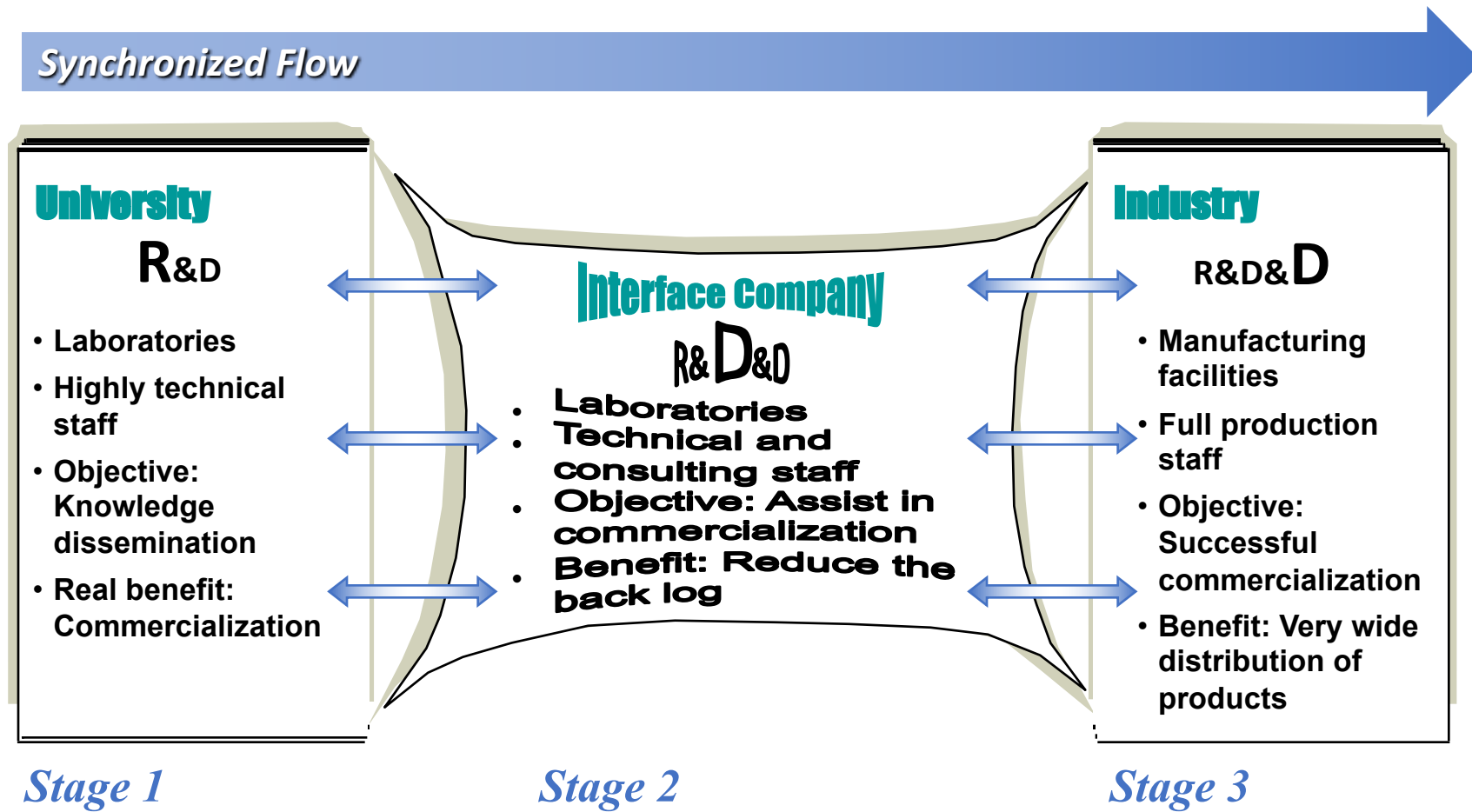


Start

- Incentives define limits
- “Small scale” entrepreneurship lacks market penetration power
- Funding for commercialization companies formed by academics is limited
- Enabling surround technologies not available

- Can't start with lab models
- Can't quantify development risks
- Can't easily go back to source for modifications
- Enabling surround technologies not available

TIAX positioning: bridge the gap



- Quickly created the new infrastructure: legal, accounting, HR, IT, procurement, etc.
- Often by repurposing the staff
- I knew culture is hard/impossible to change:
 - Staff used to doing projects for clients
 - Used to assigning IP to the paying client; accepting the BIG IP LIE: “we paid for it so it is ours”
- So came up with CHANGE BUT NO CHANGE strategy by making TIAX the client
- And as feeder, converted knowledge chunks of staff into “kernels” as early stage technologies and repurposed “kernels” for the new trends, needs and wants
- New words for the evolving TIAX Lexicon such as “kernels.”

- Applied many principles, learnings, and vocabulary from the Kenan Systems experiment:

- Me to We

- Situational leadership

- Teach and Learn, Learn and Teach

- Do more with Less

- Dynamically configurable organization

- Flat communication with interruptibility

- The “owner” also works for the Company

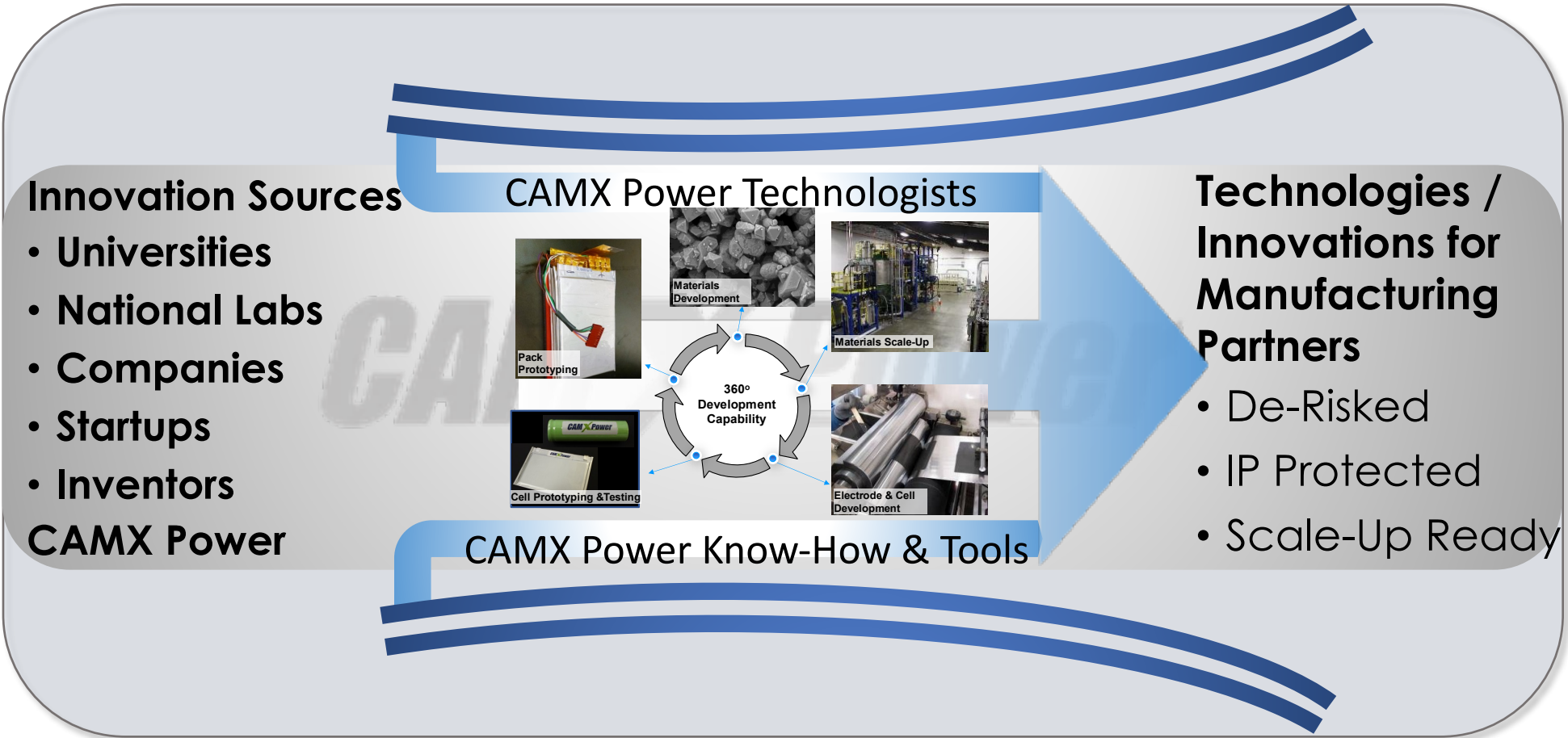
- And many more.

- All described with context in the Lean Startup book.

- Converged the many areas T&I was in (7 sectors 35 units) to
 - Functional coatings (applied chemistry)
 - Protective wearables
 - Electrochemistry with focus on superior materials for Lithium-ion batteries in particular cathodes
 - Electromechanical for sensors, supersafe cells, short detection, etc.
- Developed additional vocabulary for the TIAX lexicon e.g. business/technology model as Venturi
- In 2014 spun out CAMX Power to focus on Electromechanical and Electrochemistry.

CAMX Power's business/technology model (Venturi) transforms early stage technologies to commercial readiness.

CAMX Power Business Model: THE VENTURI (TIAX is similar)



Benefits to Manufacturing Partners

- Accelerated Organic Growth
- Shortened Time to Market & Profitability
- Lower Risk & Cost
- New Business Areas

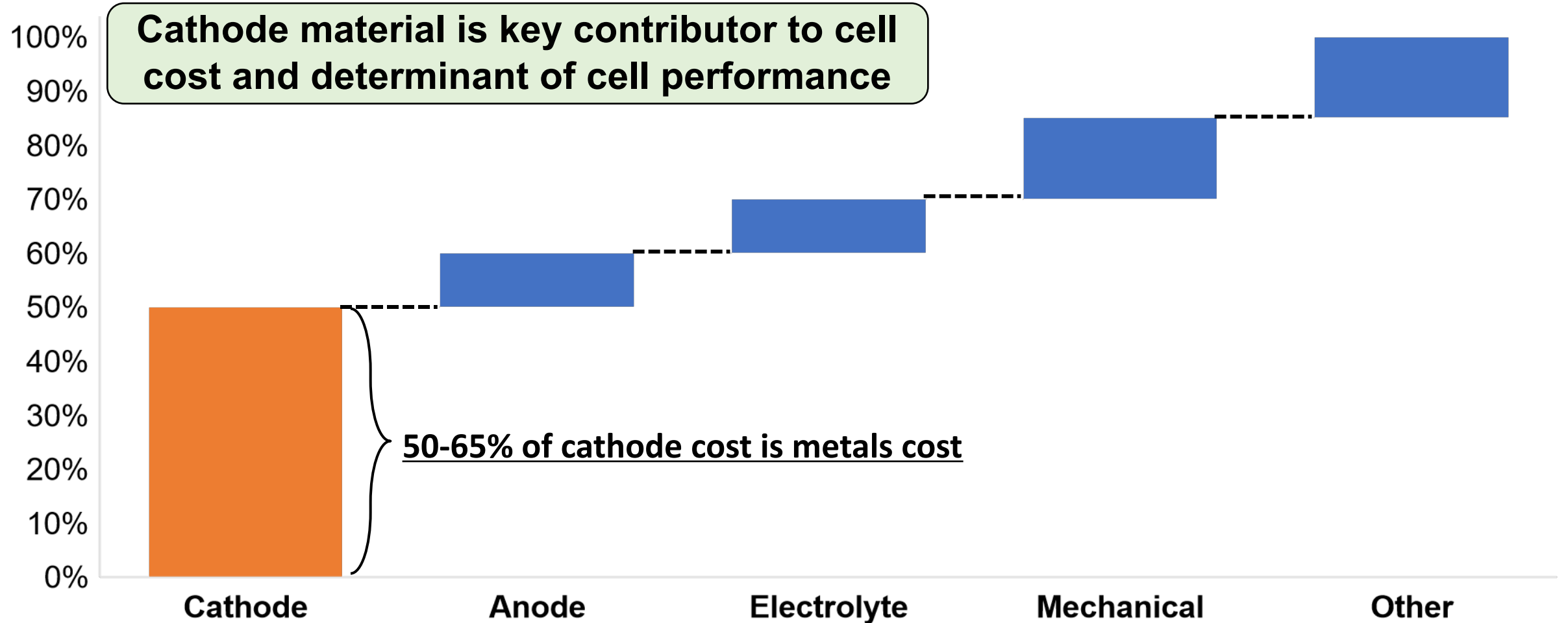
Implemented new laboratory concepts

Vertically integrated development facility spanning the Li-ion value chain for *Iterative incremental improvement*



- I thought we would reach profitability in 7 years. It took a little longer: 15 years.
- Attrition did bring equilibrium. So we protected nearly 300 jobs allowing those highly trained great ADL staff that wanted to leave do so comfortably
- TIAX/CAMX Power in appearance looks like T&I but in substance it is vastly different like a restored old building looking the same in its façade but different inside
- And TIAX/CAM Power has made big impacts in each of its areas
- We have **>100 key patents, >400 disclosures, >150 SBIR wins**
- We have developed and put in the market **>10 products** with more in development
- Since 2017 **solid profitability**
- CAMX Power, the real transformation of T&I with TIAX as the bridge
- Let me highlight some of the products.

Lithium ion cell component costs



- The cathode component is the key determinant of the lithium ion battery cost and performance
- Lithium ion batteries are the key cost and performance factors of electric vehicles
- Since 30% to 40% of CO₂ emissions is from the transportation sector, electrifying vehicles is the most promising way to slow climate change/volatility
- Hence the focus of TIAX/CAMX on cathode chemistry
- By far the most popular chemistry is the nickel chemistry
- In ten years the annual production/sale of EVs in North America is expected to be 10 million annually
- At 100 kg of cathode per vehicle, the supply needed is one million metric tons which is around \$25 billion per year.

TIAX/CAMX invented and globally patented the GEMX cathode platform

GEMX® overcomes the issues associated with nickel cathode materials and offers unique benefits

Reduced Cobalt

Higher Power

Higher Energy

Better Extreme Temperature Performance

Longer Cycle Life

Lower Impedance Growth

Flexible Synthesis with Minimal Processing Steps

Improved Electrode & Cell Fabrication Properties

GEMX Cathode Platform based products (as services platform): Showroom model

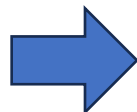
** Grain boundary enriched materials are prefixed with “g” (e.g. gNMC®, gNCA®, gNMCA®)*

GEMX* sample products (Numbers in parentheses: Co % by mole)

Down-select and sampling

Customer requirements

- Energy density
- Power density
- Fast charging
- Cycle life
- Calendar life
- Operating temperature range
- Cost
- ... (Others)



gNCA	gNMC	gNMCA
<ul style="list-style-type: none"> ➤ gNCA(9) <i>Ni(87%)Co(9%)Al(4%)</i> 	<ul style="list-style-type: none"> ➤ gNMC(10) <i>Ni(82%)Mn(8%)Co(10%)</i> 	
<ul style="list-style-type: none"> ➤ gNCA(8) <i>Ni(89%)Co(8%)Al(3%)</i> 	<ul style="list-style-type: none"> ➤ gNMC(6) <i>Ni(92%)Mn(2%)Co(6%)</i> 	<ul style="list-style-type: none"> ➤ gNMCA(7) <i>Ni(87%)Mn(3%)Co(7%)Al(3%)</i>
<ul style="list-style-type: none"> ➤ gNCA(6) <i>Ni(91%)Co(6%)Al(3%)</i> 	<ul style="list-style-type: none"> ➤ gNMC(5) <i>Ni(90%)Mn(5%)Co(5%)</i> <p><i>High Mn High Ni</i></p>	<ul style="list-style-type: none"> ➤ gNMCA(6) <i>Ni(90%)Mn(2%)Co(6%)Al(2%)</i>
<ul style="list-style-type: none"> ➤ gNCA(5) <i>Ni(92%)Co(5%)Al(3%)</i> 	<ul style="list-style-type: none"> ➤ gNMC(4) <i>Ni(85%)Mn(11%)Co(4%)</i> 	<ul style="list-style-type: none"> ➤ gNMCA(5) <i>Ni(93%)Mn(1%)Co(5%)Al(1%)</i>
	<ul style="list-style-type: none"> ➤ gNMC (6) <i>Ni(39%)Mn(55%)Co(6%)</i> 	



- Metal prices
- Matching algorithm
- Selector algorithm



- Down-select to one or a few products
- Pilot plant and cell testing
- Production at scale

GEMX cathode platform a finalist in Business Model Transformation in Japan at ICEF



GEMX portfolio in the market

- **2018 Johnson Matthey** licensed the earlier GEMX portfolio. Joint press release issued
- **2020 Samsung SDI** licensed the earlier GEMX portfolio. Press release issued
- **2022 Johnson Matthey sold its cathode assets to EV Metals and with CAMX consent GEMX license transferred to EVM.** Joint press release issued
- **2022 LG Energy Solution (LGES)** licensed the expanded GEMX portfolio. Joint press release issued
- **2023 L&F of Korea** licensed the latest GEMX portfolio. Joint press release issued
- **2023 Umicore** licensed the latest GEMX portfolio. Joint press release issued
- More in the pipeline.

- CAMX is positioning to bring one or two big chemical companies into the \$multi-billion cathode market using its pilot plant, patented cathode platform GEMX and its end-to-end development facilities
- Using its 360 degree facility and the “showroom” concept, CAMX is accelerating the choice of chemistries for Lithium ion batteries for EVs.

TIAX/CAMX invented, patented and developed CELX-RC®: A Rugged and Ultra Safe Li-ion Battery

Comparison of CELX-RC to Conventional Li-ion

Metric	CELX-RC™	Conventional Li-ion
Zero Volt Storage/Transportation	possible for years	not possible
Extreme Abuse Tolerance	safe field deployment	not possible
Overcharge Stability without Electronics	robust protection	not possible
Minimal or Optional BMS	radiation tolerant	not possible
Cycle and Calendar Life	> 10,000 cycles	ca. 1,000 cycles
Fast Charge	< 10 minutes	> 30 minutes
High Power Discharge	comparable	comparable
Gassing	minimal	problematic
Impedance Growth	minimal	problematic

CELX-RC is now in many field test programs.

- Invented, patented and developed
 - Battery short detection instruments
 - Being used by NASA and the Navy
 - Battery health monitoring device
 - Being installed on various battery packs for systems
- Developed underwater heading sensors for rugged environments, now widely deployed
- Developed and patented a variety of contactless sensors
- Extended the applications of scroll pumps.

- Over 15 years developed, tested and deployed IAE (Integrated Aircrew Ensemble) multi-layer, multifunction flight suit for jet pilots and crew
- Replaces legacy that goes back to Viet Nam years
- It has been fielded to all F-22 pilots
- Preparations are under way for other pilots.

The Integrated Aircrew Ensemble (IAE) provides full-spectrum protection to aircrew, replacing antiquated clothing and flight gear

Over the past 15+ years, the IAE has gone through all stages of development and was verified against 126 performance requirements

IAE is currently fielded to the F-22 community, with seven modular configuration items that can be purchased separately.

MAJOR TEST AREAS:

- Water Survival & Flotation
- SERE & Detectability
- Centrifuge & Altitude
- Ejection Readiness
- Ejection
- Thermal Immersion
- Thermal Stress
- Parachute Jump
- Environmental Conditions
- Aircraft Integration
- **Sizing, Fit and Human Factors**
- Safety & Occupational Health
- Fire Resistance
- Maintainability



Integrated Aircrew Ensemble

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WHAT IS NEXT

- We are expanding our core model of Technology/innovation processing (Venturi Model) to develop de-risked, IP protected, scalable products for others to make and sell for maximum impact
- With the enhanced Venturi Model and planned expansion of facilities and staff, we will be getting into adjacent domains and markets to **make a bigger dent in reducing the innovation backlog and move many more innovations and early stage technologies into implementability and implementation.**

Conclusion

- Restoration strategy/framework for a heritage company can work and is worth it
- I am writing a book to describe such a framework
- Royal Little had written a book ***How to Lose \$100 Million and Other Valuable Advice***
- My book's subtitle will be ***How to Lose \$100 Million and Not Regret it and Other Valuable Recommendations.***

Some references (chronological)

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