AVEKA

Employee Owned

Technology Readiness Levels and Scale-Up: the Path from R&D to Production

January 25, 2022

Particle Processing Services
Toll Manufacturing
Research & Development
Innovative Solutions





PRESENTED BY: WILLIE HENDRICKSON, CEO & FOUNDER

Presentation Outline

AVEKA Group

- Overview of ***AVEKA*** and Willie Hendrickson
- Some Thoughts on Commercialization and the Valley of Death
- The Inventors –
  - The Professor, the Scientist, and the Station Wagon Guy
- Academia and Industry – Some Large Differences
- Processing Dilemmas
- Technology and Manufacturing Readiness Levels
- Examples
- Some More Thoughts
- Conclusions

Commercialization Memes

- Novel ideas and concepts are difficult to come by
- The valley of death is an academic and government R&D problem
- There is only one sure way through the valley of death (lots of money)
- One person is smart enough to commercialize a product from invention to production

AVEKA Group Overview

- Particle technology company focused on contract manufacturing and process development
- A spin-off of 3M in 1994
- Over 300 customers each year
  - Automotive
  - Chemical
  - Ceramics
  - Aerospace
  - Personal Care
  - Food
- 50-60 Scale-up and development projects per year
- Over 35 issued or applied patents

Willie Hendrickson Overview

- Organometallic chemist by training
- Founder or co-founder of 8 companies
- Over 50 issued or applied for US patents
- 20 publications
- President of the International Fine Particle Research Institute (IFPRI)
- Executive member of the AIChE Particle Technology Forum (PTF)
- Past Adjunct Professor University of Minnesota (Chemical Engineering and Food Science)
- American Birding Association board member

Sunbird of Thailand

The Inventors – The Professor, the Scientist and the Station Wagon Guy

Common Traits

- Have a great idea
- Have passion for the concept
- Have no appreciation for development

Academia

- Professors and grad students

Industry

- Internal idea generators: scientists, engineers, and marketing

Station Wagon Guys

- Retired executives or scientists

Industrial and Academia Approaches to Commercialization

Similarities

Inventors – Up to the Valley of Death

Developers – Drivers through Valley of Death

Funding Sources – Food and Fuel through the Valley of Death

Differences

Academia

- Equations
- Novel concepts based on fundamental research
- Characterization or lab-scale equipment

Industry

- Process optimization numbers
- Standard processes based on applied research
- Automatic, large scale, multi-unit ops equipment
- Station Wagon Guys Belief

Processing Dilemmas

- Available equipment dilemma

  Coffee Grinder

- Volume/Scalability dilemma

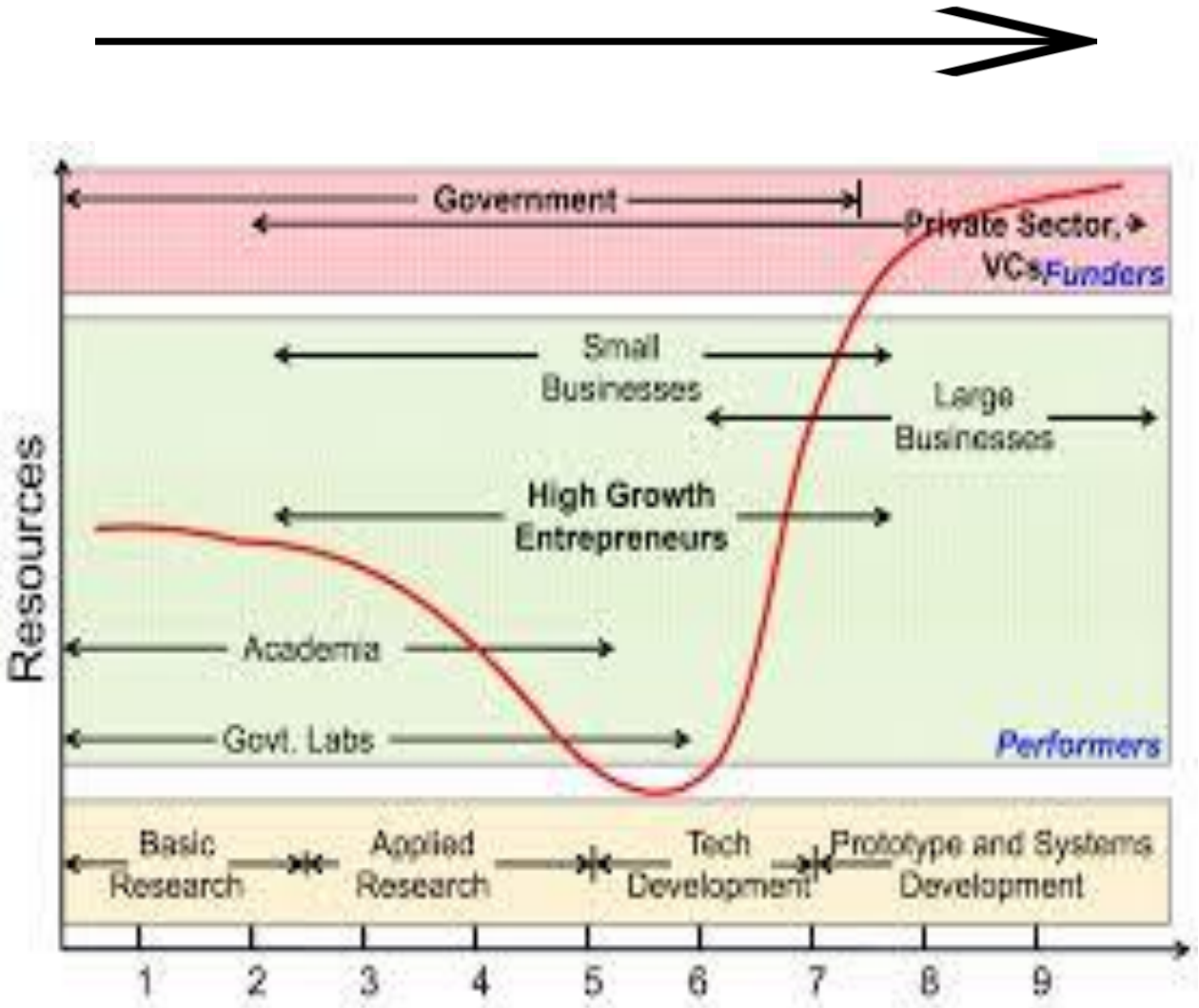
  Pozarnsky Numbers

- Mass balance dilemma
- Optimization dilemma

Technology Readiness Levels and the Valley of Death

TRL	
9	Commercialized
8	Pre-production
7	Field Test
6	Prototype
5	Bench / Lab Testing
4	Detailed Design
3	Preliminary Design
2	Conceptual Design
1	Basic Concept

Concept to grams to kilograms to metric tons



Manufacturing Readiness Levels and the Industrial Valley of Death

Level	Description
10	Full Rate Production
9	Low Rate Production
8	Pilot Line
7	Production System
6	Prototype System
5	Large Scale Prototype
4	Small Scale Prototype
3	Validation
2	Research
1	Idea

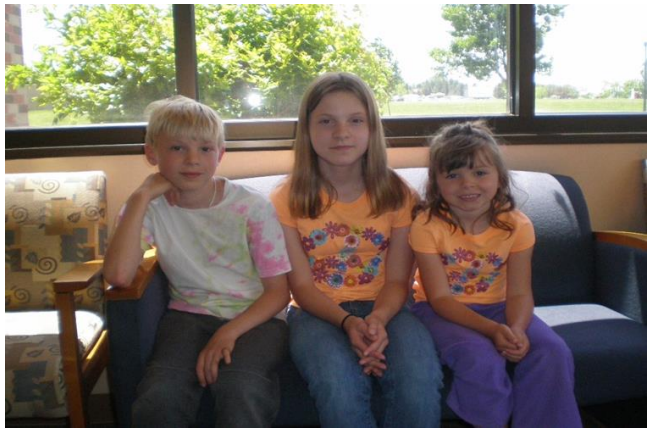
How Does One Traverse the Valley of Death?

Assume that time to get through the valley of death is 10x what the discovery phase is……if:

- You are lucky or
- You have an infinite amount of money
- The equipment, knowledge, and trained manpower for scaling your invention are already available
- You know the tricks

Karl Friedrich Gauss

Orrin, Nora, Laina



Why is scaling up so difficult?

Preparation is all done with small scale processing – one becomes immune to:

- Inefficiencies
- Not understanding alternative processes
- Bad choices of equipment
- Poor to no mass balances
- Not enough money

Acceptance of a new product or process needs to fit within current understandings of:

- Process standards
- Equipment modifications
- Trained operators
- Safety considerations
- Internal vs. external IP

The Examples…. Finally

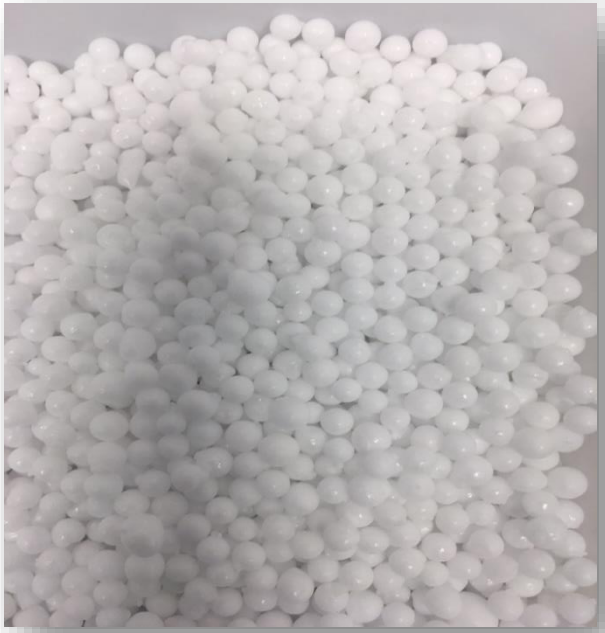
Organometallic Photocatalysts
- University of Florida
- 3M

Edible Cellulosic Fiber
- USDA
- Small Company
- USDA Part II
- ***AVEKA***

Pigments, no Rocket Fuel, no Conductive Films
- University of Toronto
- 3M
- SBIR
- ***AVEKA***
- Nanopowders (Israel VC Funded)
- Cima Nanotech (Angel and VC Funded)

Monodisperse Beads for Bioassay
- ***AVEKA***

Particle Coating for Dry Powder Flow and E-Readers
- 3M
- ***AVEKA***

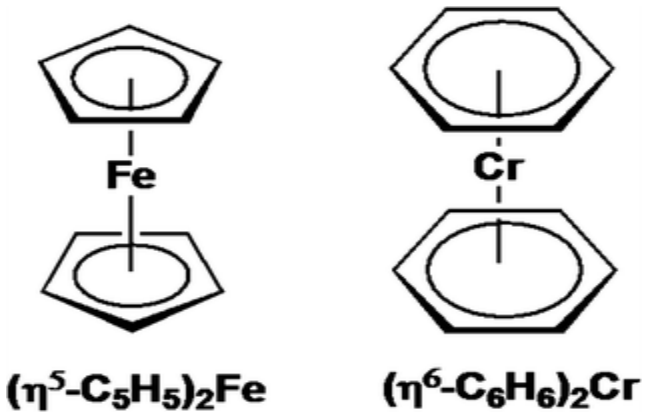


Organometallic Photocatalysts

Specific End Use
- Sandpaper

Development Pathway
- Internal

Time in the Valley of Death
- 16 years



WHAT WENT WRONG?

- Yield issues needed to be addressed
- Patent interference case with Ciba-Geigy
- Initial management indifference

THE REALITY

- Production equipment in place
- Reorientation of company from phenolics to epoxy resins

Preparation of Cellulose Fiber from Corn Bran

Specific End Use

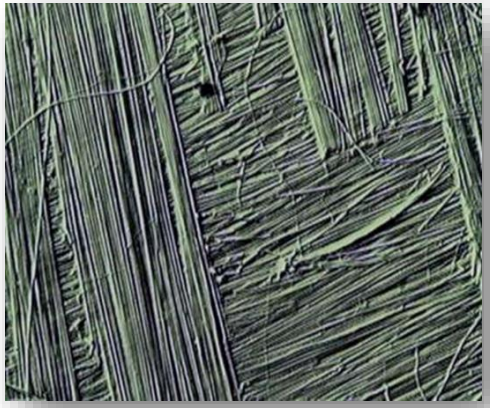
- Fat Replacement in Foods

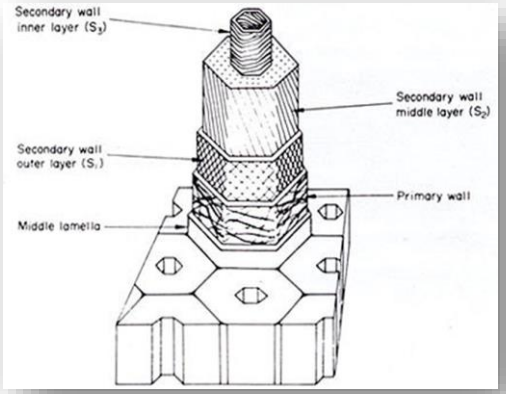
Development Pathway

- Government
- Internal
- Government
- Outsourced

Time in the Valley of Death

- Never left





WHAT WENT WRONG?

- Process and science not understood
- Patent infringement suit

THE REALITY

- Company ran out of money
- New ownership and continued low production rates and volumes

Pigments, Rocket Fuel, Conductive Films

Specific End Use

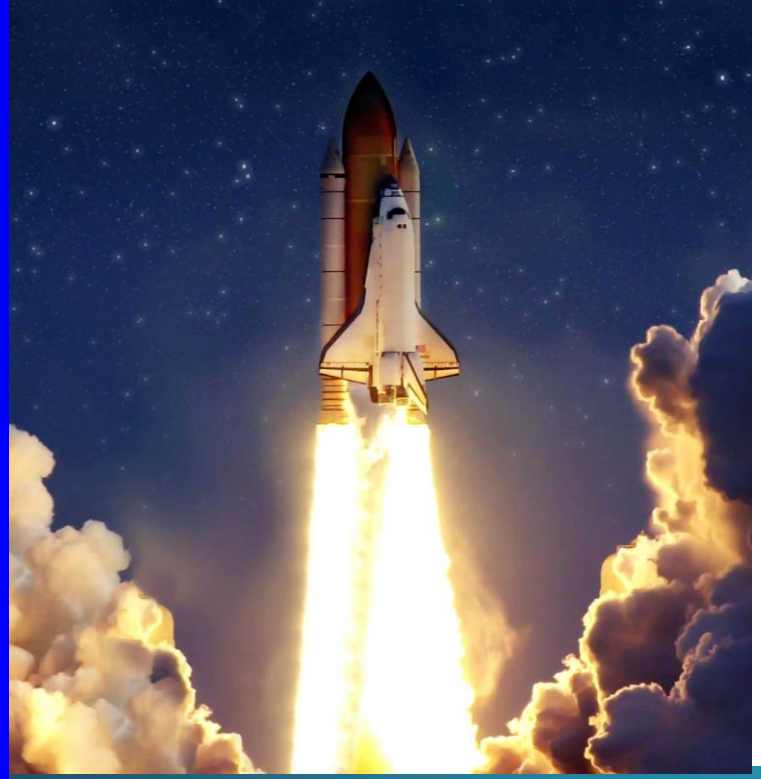
- Contact Lens
- Rocket Fuel
- Conductive Films

Development Pathway

- Academia
- Internal
- SBIR
- Internal
- VC Funded

Time in the Valley of Death

- Died in the Valley



WHAT WENT WRONG?

- Inventors and scale-up drivers were the same
- Variable end uses – no focus

THE REALITY

- Ran out of Funds (~$25MM)
- Only one investor made money

Preparation of Monodisperse Wax Beads

Specific End Use

- Bioassay beads

Development Pathway

- Customer Funded

Time in the Valley of Death

- Died in the Valley (one year)

WHAT WENT WRONG?

- Nothing, process worked
- Unexpected problem - absorption of water in beads

THE REALITY

- Timeliness for customer caused death in the valley
- Too long in development (one year!!!) –multiple solutions

Surface Coating of Particles with Small Particles or Liquids

Specific End Use

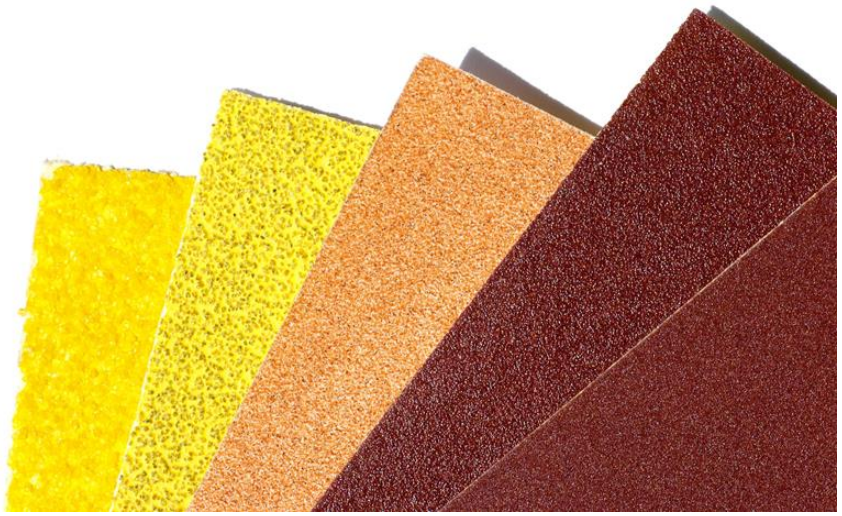
- Sandpaper
- Electronic Displays

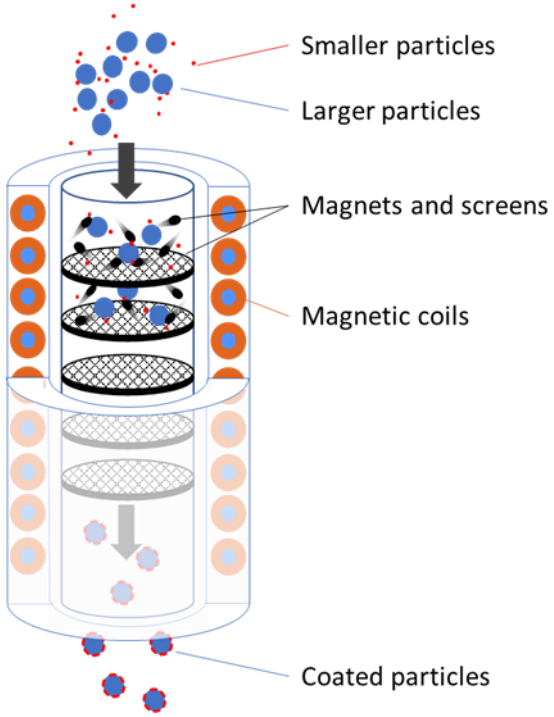
Development Pathway

- Internal
- Internal
- Customer Funded

Time in the Valley of Death

- 8 years
- 4 years





WHAT WENT WRONG?

- Nothing – rapid development for both processes

THE REALITY

- Same process with different materials used in both development processes
- Development into known industries

Commercialization Memes

- Novel ideas and concepts are not difficult to come by and can be distracting
- The valley of death is an academic, government, and industrial R&D problem
- There are many ways through the valley of death, if you have lots of money
- One person is not smart enough to commercialize a product from start to finish

So, What Did I Leave Out?

- Scale-up is underappreciated and is all about risk mitigation
- Control your ego – there are others smarter than you
- Believe in yourself - do not let your ego be run over
- Do not be greedy
- The valley of death is harder than anything you will face – be prepared, get help, and have an occasional beer

Summary

Commercialization - Scale-up - Getting through the valley of death is all about:

- Money
- Available equipment
- Finding help in areas that you have no experience
- **Answer enough questions to convince your partner that you have mitigated risk**

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