A tale of two ventures

Frank van Mierlo

www.bluefinrobotics.com
Show Saclant video
The Start

- 1991 - First business plan
- May 1997 - Jim & Frank sign three page shareholders agreement
- August 1999 - First order from ONR
- February 2000 – First payroll
- May 2000 - 2M$ order from industry
Building Technology

Development Chronology

- CETUS
- Odyssey I
- Odyssey II
- Odyssey III (MIT, MBARI, Bluefin)
- Sea Squirt
- BPAUV
- Bluefin-21
- Bluefin-12
- Bluefin-9
- BPAUV-MP
- MCM Mission Package

MIT/MBARI Developments

Bluefin Developments

1990 — 1999 — 2005
Bluefin’s Annual Revenue

- 1997: $0
- 1998: $0
- 1999: $0
- 2000: $0
- 2001: $0
- 2002: $0
- 2003: $12,000,000
- 2004: $12,000,000
- 2005: $12,000,000

Received Positive Customer Feedback
Ramped-up Resources And Capabilities

Number of Employees

![Bar Chart showing the number of employees from Q3 '99 to Q1 '04.]
Bluefin-21   Sidescan Data
Bluefin-9: Man-Portable, User-Friendly

- Length: 65”
- Diameter: 9”
- Endurance: 12 hours
- Depth Rating: 200 meters
- Navigation: IMU, DVL, Compass, GPS
- Sensors: Sonar, CTD, Turbidity

- Proven Bluefin Architecture
  - free-flooded design maximizes payload flexibility
- Accurate Navigation
  - eliminates need for deployment of acoustic beacons in the VSW
- Ease of Use
  - easy L&R from small boats (CRRCs)
  - field removable battery and data storage for quick turnaround
Bluefin-21: Proven Workhorse

- Length: 8 ft - 14 ft
- Diameter: 21”
- Endurance: 20 hours (with 200W payload)
- Depth Rating: up to 3000m
- Navigation: INS/AHRS, DVL, GPS, USBL/LBL
- Sensors: Sonar, CTD, Turbidity, SVS

- Field-Proven
  - In operations in the United Kingdom, Greece, Gulf of Mexico, Italy, and Norway

- Bluefin-21 BPAUV
  - gathers accurate bathymetry and bottom classifications for use in early stages of battlespace preparation
  - on-deck turnaround in under 2 hours thanks to Bluefin’s unique sub sea battery design

- Navigation Accuracy
  - one-sigma navigation performance of 0.25% of distance traveled
So what did we learn?
High Tech = High Tolerance
Success came from

• **Commitment**
  – Set example
  – Equity, Options & Cash Bonus
  – Trust and give away authority

• **Conserve Cash**
  – Low Overhead
  – Raised 800 K$ from customer
  – Negative working capital

• **Culture**
  – Engineers in charge
  – Keep ego and pay in check
  – Diversity is strength
An opportunity to build a $10bn industry leader

and eliminate 6 Bn tons of CO$_2$
SOLAR BY FAR THE CHEAPEST

Total installations in TerraWatt $p\_p$ 0.001 0.01 0.1 1 10

$10.00$

$1.00$

$0.10$

$0.01$

Nuclear

Coal & Gas

Installed Cost

Planned Installations

1975

1990

2005

Today

2030
3 TRILLION INVESTMENT

Global Cumulative Installed Capacity 2016\(^{(1)}\)

Global Cumulative Installed Capacity 2040

Direct Wafer®

High performance silicon wafers at half the cost
Process Video
Key part of the supply chain

Silicon wafers are 1/3 of the panel cost
Standard Wafer Manufacturing
Next Breakthrough in Crystallization

Direct Wafer® Process (2009)

- Advanced manufacturing
- Delivers lowest LCOE
- ½ Cost
- ⅓ Energy
- 2x Si yield
A GREAT PRODUCT BECOMES A SUPERIOR PRODUCT

SIGNIFICANT COST ADVANTAGE

HIGHER EFFICIENCIES

COMMERCIAL READY
Energy Consumption

Sand/SiO₂ → 24 kWh/kg → MG Si 98% → 80 kWh/kg → Solar Grad Si 99.999999%

Wafer

Silicon

Standard

Direct Wafer 5 GW

66% Reduction

Washer 0.56

Silicon 2.39

0.24

Silicon 0.73

24 kWh/kg

201 kWh/kg

23.9 kWh/kg

0.73 kWh/kg
Solar cheaper than coal

2008 - Proof of concept η=10%
2010 - Full size wafer η=12%
2013 - Production equipment η=16%
2014 - Full size manufacturing η=17%
2015 - Gen 2 η=18%
2016 - Gen 3 η=19%
2016 - Ready to scale η=20%
2016 - 10 GW factory

1366 Technologies
A TECHNOLOGICAL ADVANTAGE IN ANY MARKET

EXCEEDED EFFICIENCY OF MULTI REFERENCE GROUP

- EFFICIENCY GAINS OF 0.8% PER YEAR
- DOPING GRADIENT +0.3%
- DARK ANNEAL +0.3%
- WINS ON COST
Customer Projects
GE Installation (New York)
120k wafer shipment
IHI 500kW project
Innovation S Curve

- **Innovation**: Focus on R&D
- **Scale**: Incremental Improvements, Fierce Competition, Commoditization
- **Maturity**: 50 Years
So what did we learn?
VCs need >10X return

Top-Quartile VC Fund Return Profile 1990 - 2006
468 Investments
$1,305 MM Cost / $3,338 MM Value - 2.56X

Data: Professor William Sahlman, HBS

Remember the Right-hand Tail
Human Resources
Make recruiting a core competence

• Talent attracts talent
• Full spectrum skills
  – Engineering
  – Marketing
  – Sales
  – Finance
• Diversity helps
• 60>40 & 80<60
## Pro & Cons of VC investments

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>Ability to invest into the future</td>
<td>Loose control</td>
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<tr>
<td>Long time horizon</td>
<td>Significant extra costs</td>
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<tr>
<td>Access to an amazing network</td>
<td>- Lawyers</td>
</tr>
<tr>
<td>Lay foundations for a very large venture</td>
<td>- Accountants</td>
</tr>
<tr>
<td></td>
<td>- Investment Bankers</td>
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<td></td>
<td>Eliminates immediate pressure to make a profit</td>
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Classic Yankee strengths
Still matter

• Frugal (Make every $ count)
• Hard work
• Build functioning technology