# New Product Development in the Lean Six Sigma Environment

***Presented by:***

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# Program

- Understanding new product development
- NPD in the lean six sigma environment
- Organizational readiness for NPD
- Managing the NPD portfolio/pipeline
- Management strategies for NPD
- Practical NPD Challenges
- Early stage commercialization
- Case histories

# *Understanding New Product Development*

- Definition
- Drivers for technical innovation
- Multi step  process
- Attributes
- Criteria for success

# Definition

**Product development as distinguished from fundamental research:**

## Fundamental research

- **Technology / knowledge development typically takes much longer than product development**
- **Outcome not predictable**
- **‘Constancy of purpose’ is essential**

## Product development

- **The process of transforming market opportunity and technological innovation into new products**

# Attributes

- **A contact sport with many players**
- **Internal stakeholders**
  - **Marketing / planning**
  - **Engineering / product design**
  - **Manufacturing**
  - **Financial management**
- **External stakeholders**
  - **Customers**
  - **Suppliers**

# Drivers for Technical Innovation

- **Financial profit**
  - For the manufacturer
  - For the user of new technology
- **Government regulation**
  - Technology mandated regulations - environmental
  - Funded research & development - space research
- **Legally required or mandated**
  - Legal mandates are  also drivers for technical innovation. (Consider all of the R&D sponsored by the cigarette industry to circumvent smoking related liability)

# NPD Steps

- Product planning (market survey, technical innovation, concept selection, preliminary design & budget)
- Process design and selection
- Specification creation
- System-level design
- Detailed design
- Testing/prototyping
- Release (marketing, financing, production ramp-up, customer roll-out, maintenance contracts, guarantees, warranty etc.)

# Criteria for Success

- Technical success
- Meets customers' needs
- Is profitable

# The Lean Six Sigma Environment

- Lean strategies in NPD
- Understanding six sigma
- Design for six sigma (DFSS)
- Criteria for excellent design
- Drivers for combining ‘lean six sigma’ with NPD
- Benefits
- Rewards
- Risks

# Lean Six Sigma Strategies in NPD

- **Lean six sigma emphasizes speed in delivering quality product to customers**
- **In NPD, delivery speed is directly related to the number of projects in process**
- **When applied to NPD we must:**
  - Manage the number of projects in the pipeline
  - Focus our efforts on the critical projects that will provide the best return with the best chance of success
  - Rigorously review projects before accepting them

# Six Sigma

- Six Sigma is a corporate culture that emphasizes quality
- It is a management improvement discipline that combines business process management, with operating process improvement
- “Quality” does not refer simply to product, but to all aspects of the business and its relationship with the customer
- First developed at Motorola. Later adopted by GE where Jack Welch championed its benefits and claimed savings of $2 billion in 1999 alone from employing Six Sigma principles.
- Six Sigma provides specific methods to manage the process so that defects and errors never arise in the first place

# Design for Six Sigma (DFSS)

- 6.0 sigma is an idealized goal reflecting 99.9997% of production acceptance
- 3.0 sigma performance (93% acceptance) is commonly achieved by fixing ‘existing’ processes
- 4.0 – 4.5 sigma performance (99.5% acceptance) is achieved by extending this process on a company wide basis
- The largest number of defects and improvement opportunities arise because of quality problems designed into products
- It is generally not possible to get beyond 4.0 – 4.5 sigma performance, on a sustained basis, without designing products for six sigma performance

# Criteria for Excellent Design

- Primary
  - Functional
  - Meet market requirements
  - Manufactured profitably
  - Reliable, easily tested & safe
- Secondary
  - Fit into an existing platform or create a new platform that can be used across product lines or evolve over time
  - Easily adapted to meet customers' needs
  - Readily maintained & serviced
  - Environmentally friendly – easily recycled

# Drivers for Combining '*Lean Six Sigma*' with NPD

- Lean
  - Pressure to develop many more new products, without increasing personnel headcount
  - Speed to market - compressed product development cycle times must be achieved
  - Rapid pace of technical development opens (and closes) new markets that previously didn't exist
- Six Sigma
  - Speed to market is not sufficient unless you deliver high quality products

# Benefits

- Being the first to market enables you to:
  - Establish higher prices before the competition comes to market
  - Gain incremental market share
  - Profit from a longer product life cycle

Compare profits from 1% price increase Vs. 1% sales increase.

| Sales | Direct cost as % | Added Sales | Added cost of prod'n. | Added revenue | Added profit |
|---|---|---|---|---|---|
| $ 1,000,000,000 | 60% | 1% | $6,000,000 | $ 10,000,000 | $4,000,000 |

- For the same product volume, adding 1% to sales based on higher pricing generates $10,000,000 added profit (no incremental costs).
- These profit levels are only realized if the product performs well, and there are no incremental costs associated with returns.

# Rewards

- Improved products
- Lower costs
- Increased sales
- Greater profit levels
- Improved bottom line
- Happy shareholders!

# Risks

- Failure to develop new products puts companies at a disadvantage to companies that do
- Success is not always assured:
  - Technical risk
  - Schedule risk
  - Budget risk
  - Market risk
- In the extreme ('bet the company developments') the viability of the enterprise can be put at risk

# Organizational Readiness for NPD

- **Not all companies are equally suited for NPD**
- **NPD infrastructure**

# Not All Companies Are Equally Suited for NPD

Organizational capabilities can limit or enhance the ability to successfully support NPD:

- Skills and knowledge of its employees
- Organizational structure
- Culture, controls and communication

# NPD Infrastructure

***"Commitment to enhancing organizational capabilities is crucial to sustain on-going competitive NPD "***

**Liu, bing, masters thesis, page 12 MIT, June 2003**

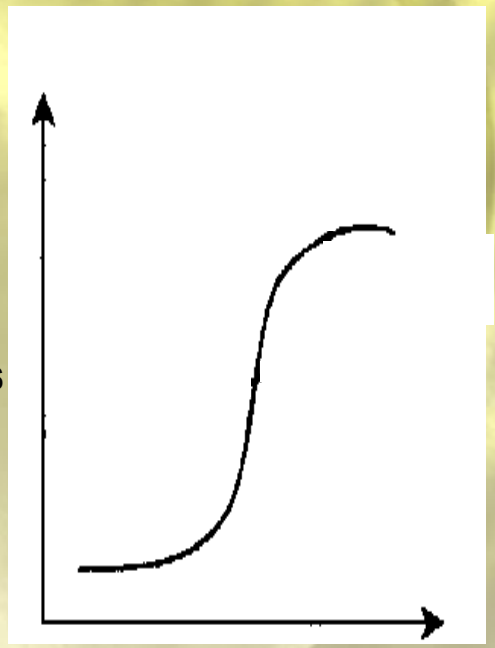
- Management team background and experience
- No organizational barriers - eliminate the 'silo' approach
- NPD teams may be organized along technological or product lines
- Collaborate internally with sales & marketing & manufacturing
- Collaborate externally with customers & suppliers
- Access to manufacturing and pilot production capability

# Managing the NPD Portfolio / Pipeline

- Goal: promote winning concepts, cull losers
- Review team
- Criteria for accepting a project

# Goal: Promote Winning Concepts, Cull Losers.

- Early selection is key to managing costs and risks
- Costs accelerate over time
- Portfolio reviews must be continuous, on-going & proactive:
  - Project rankings change dramatically as more information becomes available
- Best NPD companies have fewer ideas under development, than less successful companies but they are more carefully vetted




Typical Product Development "S" Curve.

# Review Team

- Role: to accept or reject all ideas presented for development and subsequently monitor their progress and continued viability
- Has to represent the views of associated groups:
  - Customers
  - Marketing
  - Engineering
  - Suppliers
  - Quality
  - Manufacturing

# Criteria for Accepting a Project

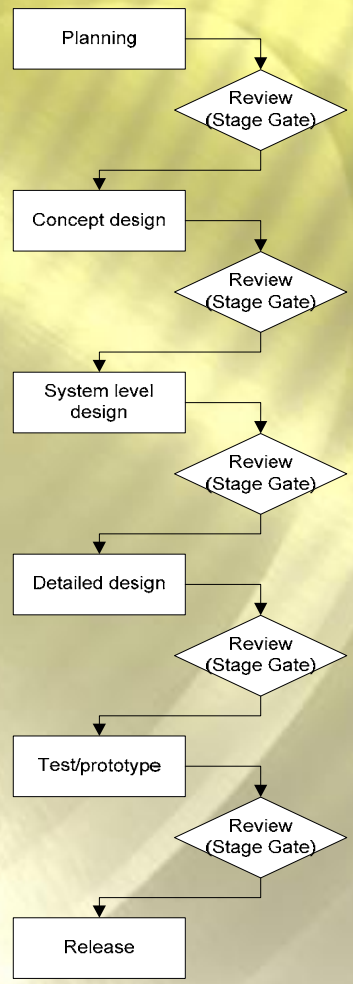
- Market research demonstrates need
  - Don't rely on a salesman's "gut feel". Get good, quantitative data from a well designed market research program
- A regulatory need or legal requirement
- Potential for sales & profit
- Project and product fall within the capabilities of the organization
- Project does not conflict with other company objectives (Rolls Royce should not develop a cheap car)

# Management Strategies

- Anthropologists that study these matters have identified many strategies. Some of the more common are:
  - The waterfall process
  - The spiral process
  - Evolutionary prototyping and delivery
  - Design to schedule/budget
  - Set-based concurrent engineering
  - Development by acquisition

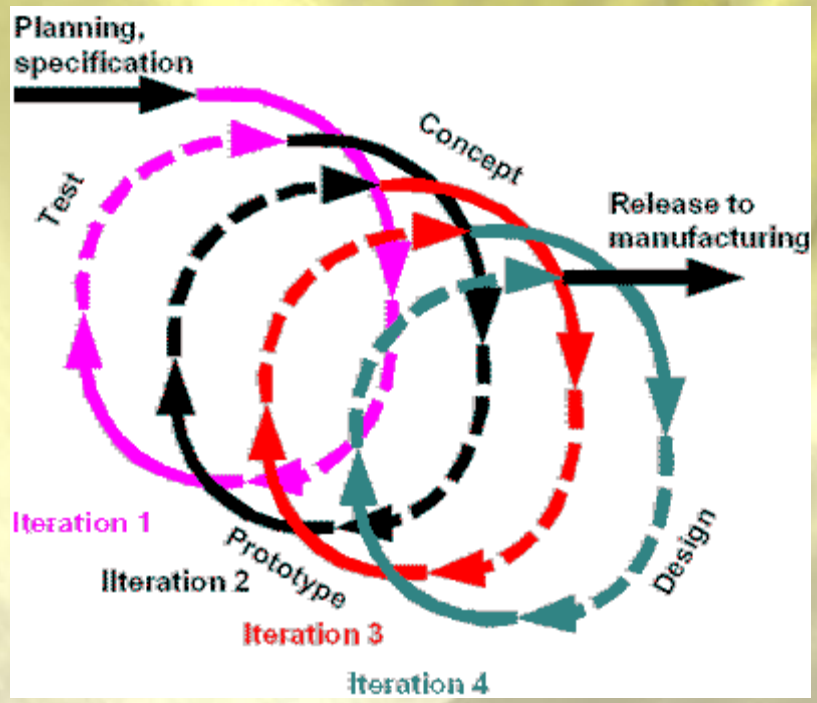
# The Waterfall Process

- Traditionally the most widely-used PD process
- Development proceeds in discrete stages, or phases, from product planning to product release
- Each stage is reviewed, with criteria met, before proceeding to the next stage
- Work continues until criteria are met to go on to the next stage



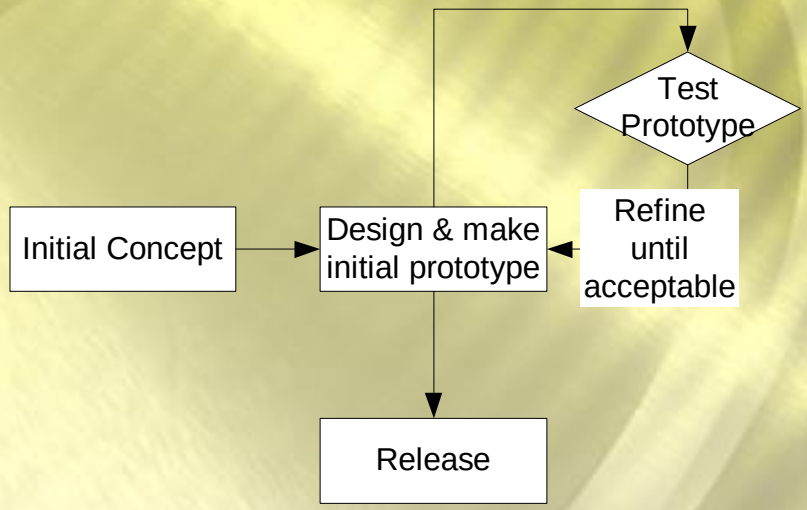
# Spiral Process

- Employs comprehensive iterations that span several phases of development
- Used frequently in the software industry
- Teams can address blocking issues early in process
- Solutions to these issues can be incorporated in early concepts, specs & designs so reducing risk



# The Evolutionary Process - Prototyping

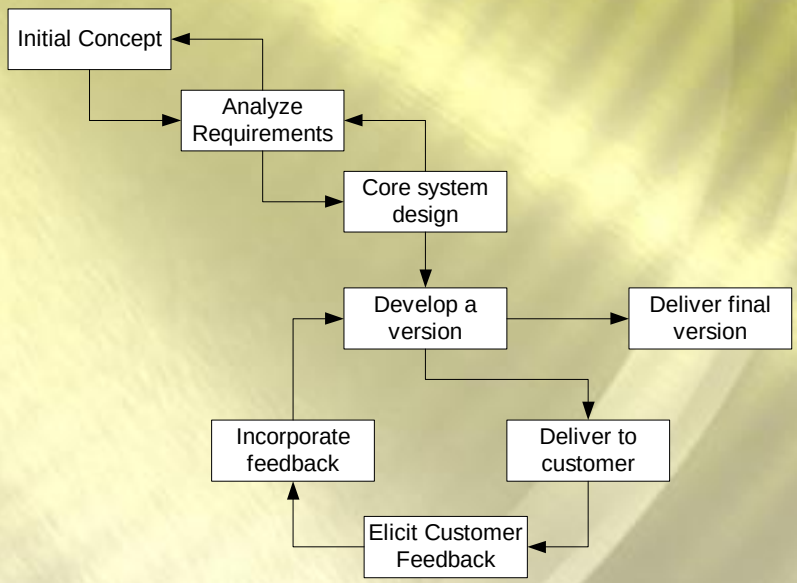
- Emphasis is placed on producing early prototypes
- Iteration is the underlying theme, with emphasis on prototypes
- The goal is to ‘allow mistakes’ and ‘learn from them’ faster than the competition




Evolutionary Prototyping Process

# Evolutionary Process - Delivery

- Iteration is again the underlying theme
- Emphasis on customer feedback




**Evolutionary Delivery Process**

# Design to Schedule/budget

- This is a viable strategy where technical risk is minimal or non-existent
- Designed to limit time and budget risk
- Actual development process might evolve as the development process proceeds
- All risks are subordinated to schedule & budget

# Set-based Concurrent Engineering

- Several alternative designs are pursued in parallel
- Major design decisions are delayed in order to gather more data
- The costs associated with early delays and discarded effort is offset by time and money saved later due to poor product design followed by re-work

# "Development" by Acquisition

- Companies license another company's technologies and products
- Companies acquire rivals and the rights to their products

# Practical NPD Challenges

- Appointing a project manager
- Staying responsive to outside inputs
- Coordinating cross-functional teams
- Collaboration
- Managing resources
- NPD staffing
- Dealing with NPD staff
- Engaging partners
- NPD check list
- NPD failures
- Management conclusions

# Appointing a Project Manager

This is a critical position; this person will have a large influence on the success of the project

Responsibilities and skills:

- **Leadership** - has to lead a team of people with diverse skills
- **Technical** - needs to understand the technical aspects of the development project
- **Schedule** - must keep his eye on the schedule and adjust priorities accordingly. May have to make some difficult decisions
- **Financial** - has to establish a budget and meet its goals
- **Communications** - has to integrate the ideas, efforts, needs and priorities of team members from engineering, manufacturing, sales and marketing finance etc.

# Staying Responsive to Outside Inputs

The development team must stay responsive to outside inputs while:

- Maintaining control
- Maintaining focus on the goals (avoiding ‘feature creep’ or ‘moving goal posts’)

# Coordinating Cross-functional Teams

- NPD teams are composed of people that represent the various functional areas important to the success of the product. They include:
  - Customers
  - Marketing
  - Engineers
  - Suppliers
  - Quality
  - Manufacturing
- Teams need leadership. They must also be empowered to make the decisions to move the project forward

# Collaboration

- Collaboration is a significant challenge for most organizations
- Marketing, engineering, procurement, and manufacturing all have their own objectives, that must be coordinated
- Challenge is to make data and information available to all that need it, in real-time
- Technology helps: On-line collaboration can be used to enhance communications

# Manage Resources

- Technical resources:
  - Mechanical, electrical, software, manufacturing, quality
  - Marketing, project management, test lab time
  - Prototype creation, piloting, outside suppliers
- Planning & scheduling - The mechanisms used to plan and allocate development resources must be fair, flexible, and visible

# NPD Staffing

## Opportunities:

- Make measurable improvement to the world's leading companies
- Have a real impact!

## Characteristics

- Strong technical background – all disciplines
- Able to engage customers
- Capable of solving complex problems
- Commitment to detail
- Leadership, ability to motivate others
- Track record of success
- Perseverance

# Dealing With NPD Staff

- *Smart*
- *Independent*
- *Arrogant?*
- *Not anxious to be micro-managed*

# Engaging Partners

- Customers and suppliers are very important partners in development
- With increasing outsourcing, elements of the development must be done by supplier partners
- Procedures and communication methods between customers and vendors is key
- Technology can help. On-line has supplemented telephone and faxes

# NPD Failures

Projects fail for a many of reasons including:

- Poor project management
- Inadequate company infrastructure
- Underestimating the technical challenges, personnel, and financial resources required
- Lack of clarity regarding objectives
- Inadequate market research
- Etc. etc. etc

# NPD Check List

1. Understand the cultural environment of your organization and determine the changes that must be made to insure successful product development on an ongoing basis
2. Establish a NPD portfolio with performance targets
3. Organize a proactive NPD selection processes
4. Focus on new products that will fuel company growth!
5. Monitor percent sales coming from new products
6. Insure that NPD efforts fit in with corporate strategy
7. Support winners, cull losers, sooner rather than later
8. Implement formal, visible, simple project control strategies
9. Implement NPD processes that insure appropriate phases and criteria for success are achieved before moving to the next step
10. Use of cross functional teams
11. Limited resources managed for maximum impact
12. Customers and suppliers integrated into the development process
13. Data available to all participants for timely NPD decisions

# Management Conclusions

- Developing new products is vital for the continued viability of an organization and can bring huge rewards
- The success of NPD is very dependent on the nature and culture of the organization
- Product development entails risk
- Lean, Six Sigma management strategies help mitigate these risks
- Checklists can help

# Early Stage Commercialization

- Crossing the finish line
- Capturing & Controlling value
- Pilot production including gaining and utilizing customer feedback
- NPD case histories

# Crossing the finish line

- Relay race analogy: ‘first out of the gate’ with new technology is often not the one that crosses the ‘commercialization’ finish line
- Many examples exist of companies that were successful in developing great technology, but didn’t follow through with commercialization. (They dropped the baton)
- Many similar examples of companies that were very effective in taking technology developed by others and successfully commercializing it (picked up the baton)
- Technical success – commercialization failure!
- Strategies are needed to capture & control value at every stage of the commercialization race.

# Capturing & Controlling Value

- Knowledge
  - Patents
  - Trade secrets – knowledge & expertise
  - Trademarks
  - Standards
- Operations
  - Supply chain
  - Manufacturing operations
- Sales & Marketing
  - Distribution
  - Sales contracts
  - Marketing contracts & relationships
- Joint ventures, Industrial partnerships

# Pilot Production / Field Trials

- Process optimization based on statistical data not achievable in the laboratory environment.
- Iterative improvement to both product and process based on running ‘standard operations’
- Factory workflow improvement – Cost reduction
- Market testing / customer feedback - Beta testing both product and manufacturing
- Capture value by establishing a ‘market presence’ early in the NPD cycle, and by coming down the cost curve faster than competition.
- Pilot production anticipates but does not resolve all issues associated with full manufacturing

# NPD Case Histories

- Optical fibers
- Advanced materials – HTSC.
- Biotechnology

# Lean/SS NPD Report Card

- **Organizational Readiness?**
  - **DFSS / Total Quality objectives clear**
  - **Use of cross functional teams**
  - **Infrastructure to facilitate timely exchange of information**
- **Rigorous project portfolio management?**
  - **Market demand**
  - **Technology**
  - **Profit potential**
- **Project management?**
  - **Strong leadership**
  - **Clear lines of responsibility**
  - **Project organized for success**
  - **Proactive periodic reviews**
- **Customer & vendors integrated into the NPD cycle?**
- **Strategies to capture & control value?**

# Optical Fibers

- **Corning: Low loss fiber**
- **Exponential Market Demand**
- **Patent Strategy**
- **Manufacturing Strategy**
- **Optical Fiber Report Card**

# Corning: Low loss fiber

- Breakthrough - September 1970
  - single-mode fibers with attenuation below 20 dB/km at 633-nanometers
  - High purity vapor phase deposition of fused silica glass
  - Robert Maurer, Donald Keck and Peter Schultz
- Converging innovation fuels commercialization
  - Material science - optical fibers
  - Sources – lasers, LED’s
  - Detectors

# Exponential Market Demand

- Voice
- Fiber cost vs. equivalent copper
- Deregulation - early 1980s
- The race was on!
- Data
- Internet: multi-media

# Patent Strategy

- Overlapping ‘picket fence’ patent strategy designed to keep competition out.
- Joint technical development and cross licensing agreements  (Bell Labs)
- Aggressive patent enforcement – injunction barring Sumitomo from operating its Raleigh NC plant

# Manufacturing Strategy

- Pilot production: commercial scale demonstrations
  - Northeast corridor link
  - Winter Olympics – Lake Placid
- Aggressive technology scale-up
- Aggressive cost reduction based on process improvement
- Forward pricing to keep out competition
- JV manufacturing partnerships
  - sell the technology, sell the equipment, and sell the product
  - worldwide market penetration

# Optical Fiber Report Card

- **Organizational Readiness**
  - **DFSS / Total Quality objectives clear – Total Quality Management**
  - **Use of cross functional teams √**
  - **Infrastructure to facilitate timely exchange of information – Cutting edge Digital VAX**
- **Market demand – exponential**
- **Technology? – proprietary, breakthrough!**
- **Project management**
  - **Strong leadership √**
  - **Clear lines of responsibility √**
  - **Project organized for success √**
  - **Proactive periodic reviews √**
- **Management strategies – concurrent engineering, spiral, acquisition √**
- **Customer & vendors integrated into the development cycle √**
- **Strategies to capture & control value**
  - **strong patent position – effective in keeping out competition**
  - **early pilot production**
  - **JV manufacturing partnerships**

# High Temperature Superconductors

- Advanced materials
- AMSC
- International R&D partnerships focus on enabling technology
- Concurrent engineering
- Joint Development & Marketing Partnerships
- Revolutionary new products
- Patent & licensing strategy
- Strategic business partnerships

# HTS: Breakthrough discovery

- 1986: Alex Müller and Georg Bednorz discover 30 K ceramic superconductor with a perovskite structure (IBM Research Laboratory Switzerland)
- 1987: Nobel Prize
- Since then many different forms of perovskites have been produced resulting in materials that superconduct at temperatures over 130 K.
- Compared to conventional superconductors, these are High Temperature Superconductors (HTS).
- Enabled use of Liquid nitrogen (77K) as a coolant (cheaper than milk).

# American Superconductor

- AMSC: VC financed start-up founded 1987 based on MIT technology
- Public company since 1992
- Mission: develop and commercialize HTSC wire & cable products

# New Product & Market Targets

- HTS wire and power electronic converters
- HTS power cables
- SMES - superconductor magnetic energy storage
- Ship propulsion systems
- Industrial motors
- Utility generators
- Specialty magnets

# International R&D Partnerships

- Focus pre-competitive enabling technology
- National Laboratories
- Department of Energy
- EPRI - formerly the Electric Power Research Institute

# Pilot Production

- Concurrent Engineering
  - Multiple technologies pursued to keep options open
  - Early focus on products – wire & power controls
  - Assert the ‘pull’ of manufacturing on the development process
- Manufacturing and engineering operations initiated while fundamental research was still at the early stage
- Pilot production implemented to enable early demonstrations of the technology
- Long range manufacturing strategy targets aggressive future cost reduction
- Understand the ‘value chain’ and outsource non-critical path elements

# Strategic Partnerships

- Technical development and manufacturing partnerships
  - Inco Limited
  - Hoechst Gmbh
  - Pirelli - The world's largest producer of power cables
  - Electricité de France - The world's largest electric utility
  - ABB power transmission and distribution company - The world's leading manufacturer of transformers
  - GE industrial systems - manufacturing products to distribute, protect and control electrical power and equipment
  - Northrop Grumman ship systems - A leading ship builder
  - Alstom - A global power equipment company
- Provide an important component of corporate revenue
- Validation of market demand

# Patent & Licensing Strategy

- Patent in-house developments, license the discoveries of others
- Insure AMSC a place at the ‘negotiating’ table whichever technology prevails
- Establish AMSC as the ‘go-to’ company for superconducting wire & cable
- Negotiate rights to AMSC technologies for different applications, in different markets around the world.

# AMSC HTS Report Card

- **Organizational Readiness – 'green field' opportunity with emphasis on doing things right**
- **Rigorous project portfolio management – more forgiving, given the uncertainty of which technology will win**
- **Market demand – yes for 'critical at any cost' applications**
- **Technology – Gen II with limitations that restrict market applications**
- **Profit potential - not yet, but perhaps in the future**
- **Project management – first class team assembled**
- **Management strategies – concurrent, spiral, and acquisition (cross licensing)**
- **Customer & vendors integrated into the development cycle**
  - **Funded joint development programs**
  - **Collaboration with national labs and researchers around the world**
- **Strategies to capture & control value?**
  - **Strong patent position**
  - **Pilot production, technology demonstrations**

# International Consortium Completes Human Genome Project

**International Consortium Completes Human Genome Project**

**All Goals Achieved; New Vision for Genome Research Unveiled**

**BETHESDA, Md., April 14, 2003 –** The International Human Genome Sequencing Consortium, led in the United States by the National Human Genome Research Institute (NHGRI) and the Department of Energy (DOE), today announced the successful completion of the Human Genome Project more than two years ahead of schedule.

The international effort to sequence the 3 billion DNA letters in the human genome is considered by many to be one of the most ambitious scientific undertakings of all time, even compared to splitting the atom or going to the moon.

The International Human Genome Sequencing Consortium included hundreds of scientists at 20 sequencing centers in China, France, Germany, Great Britain, Japan and the United States.

The Human Genome Project was finished two and a half years ahead of time and, at $2.7 billion in FY 1991 dollars, significantly under original spending projections.

# 454 Life Sciences Completes Whole Genome Sequence Using Novel Technology

-**Complete Adenovirus sequence generated by first sequencing method designed to sequence whole genomes not genes –**

**BRANFORD, Conn., Aug. 21, 2003** -- 454 Life Sciences today announced the submission of the whole genome sequence of adenovirus to GenBank(R), the National Institutes of Health genetic sequence database.

The submission marks the first time that a new method has been used to sequence a whole genome since Walter Gilbert and Frederick Sanger won the Nobel Prize in 1980 for the invention of DNA sequencing in 1977.

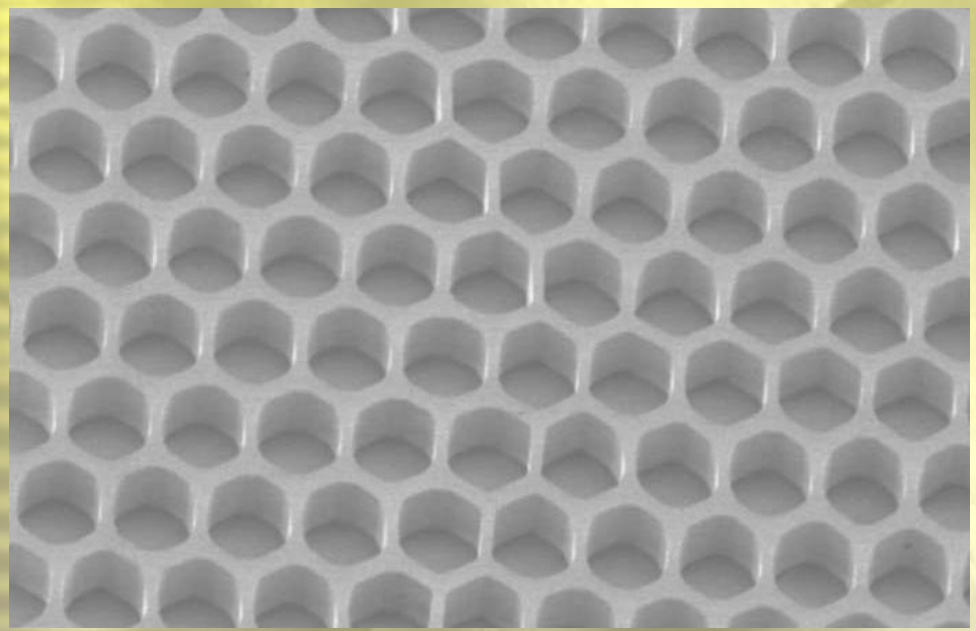
In order to sequence the adenovirus genome, 454 Life Sciences' proprietary method required only one preparation of the adenovirus genome, as compared to the hundreds of sample preparations required by traditional sequencing methods.

The entire process from sample preparation to data analysis was accomplished in less then one day.

# Optical Micro-Arrays

- Sequencing of the human genome took many years, involved thousands or researchers, and cost billions of dollars.
- The ability to accelerate this process and reduce the cost will enable an era of personalized medicine
- Goal is to develop instrumentation capable of analyzing genomic or proteomic material on a massively parallel scale at very high speed with unprecedented accuracy
- One strategy involves sequencing done within thousands of minute ‘test tubes’ that have been formed on a uniquely designed glass plate
- Other applications include chemical detection

# Incom Micro-Array Plates



- Multiple optical fibers are fused to form an optical array
- Selective removal of core material leaves wells that serve as ‘test tubes’
- Reactions occurring in the ‘test tubes’ can be monitored optically, through the remaining fiber
- 1 million reactions can be simultaneously monitored on a single reaction plate.

# Incom Today - Glass Products Based on Optical Fiber

Optical Faceplates

Image Conduits

Fiber Optic Tapers

Inverters

Capillaries

ISO 9000

Mil- Spec

- CATHODE RAY TUBES
- INTENSIFIED CAMERAS
- IMAGE INTENSIFIERS
- NIGHT VISION SYSTEMS
- X-RAY CAMERAS
- BLOOD ANALYSIS
- DENTAL/UV CURING
- VIRTUAL REALITY
- LARGE SCREEN PROJ.
- LIQUID CRYSTAL DISPLAYS
- ELECTRON MICROSCOPE
- CCD WINDOWS
- HIGH AMBIENT DISPLAYS

# Incom Tomorrow:
# Create a 'life sciences' focus

Glass forming

Optical design

Custom finishing

Surface coatings & treatments

Characterization

GMP Best Practices

DNA / Genomic Micro-arrays

Proteomic Micro-arrays

Biosensor Micro-arrays

Artificial Nose

Explosives Detection

Chemical Sensing

Micro Channel Plates

Single fiber probes

Micro Fluidic Devices

Filters & Detectors

Homeland Security

Others

# Establish a Life Sciences Market Focus

- Apply company's core competence in glass forming, finishing, surface treatments, characterization and manufacturing technology to the emerging life sciences market
- Develop a platform of products that address multiple customer needs
- Form 'customer vendor' joint development partnerships
- Establish Incom Inc. as a leading supplier of micro-fluid reaction plates for the emerging life sciences market

# NPD Challenges

- Technical – glass technology combines both art and science
- Portfolio / pipeline management – sorting multiple opportunities
- Business development – educating prospective customers to know what is possible
- Finding ‘market pull’ among competing customers

# MicroArray Report Card

- Market demand – strong development stage demand, commercial demand TBD
- Profit potential – strong in a niche market
- Technology – company know how
- DFSS / Quality criteria – being implemented
- Portfolio management – need to manage multiple opportunities with limited resources
- Management strategies – L/SS, spiral, evolutionary with heavy emphasis on prototype delivery
- Strategies to capture & control value
  - customer vendor agreements, patents and trade secrets.
  - pilot production established,

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