Electronics personal products

<Camera>

<LCD display>
Cell Phone

<i>Suppli Google Nexus One Teardown Analysis
Exploded View
Copyright © 2010 Suppli Corporation</i>

- Capacitive Touchscreen and Controller
- Uni-Body Enclosure
- Main PCB
- 3.74 inch AMOLED Display
- IO Interface PCB
- 5.0 Megapixel Camera Module

<i>LCD module</i>  <i>Cell Phone exploded view</i>
Electronic components

PRODUCTS

MECHANICAL

ELECTRICAL/ELECTRONICS

Computer

Analog

Digital

Hybrid

PCB

Inductors

Transistors

Capacitors

Resistors
Basic question like the charge of the particles was +ve or -ve remained undetermined until 19th century.

- Early research in electrical and magnetic phenomena: 1600 to 1800
- Invention of telephone: 1876
- Invention of the light bulb: 1880
- Invention of the radio: 1897. Electron was identified
Semiconductor Era

The first transistor, a point-contact Germanium device, was invented at Bell Laboratories in 1947. This image shows a replica.

- First Transistor, AT&T Bell Labs, 1947
- First Single Crystal Germanium, 1952
- First Single Crystal Silicon, 1954
- First IC device, TI, 1958
- First IC product, Fairchild Camera, 1961
Microprocessors & Microcomputers

- Microprocessors invented (Intel): 1971
- First commercial MPU (8080&6800): 1975
- First personal computers: 1975
- Apple & Radio Shack computers: 1977
- IBM Personal Computer: 1981
1990s: Infopad

- Designed to store short notes
- Based on the concept of a spiral notebook
- Searchable and expandable

InfoNet - ATM Backbone

- NOW COMPUTE SERVER
- PICOCELL WIRELESS BASE STATION
- VIDEO SERVER
- SPEECH RECOGNITION
- MOSAIC INTERNET INFORMATION SERVER
- CELL SERVER
- PAD SERVER

InfoPad (A Portable Multimedia Terminal)
- Video and Text/Graphics
- Audio & Handwriting I/O
Design flow levels of electronic components

- The defined **global function** of the device.
- **Sub-function** (coordinate with the global function)
- **Assembly** of these subfunctions
- The creation of specific transistors and circuit layouts
2010s

Galaxy Tab  

iPad/iPod
Multi-scale robots
Multi-scale Mass-deployable Cooperative Robot

Mass-deployable

Multi-scale

Communication with small scale robot
Communication with different scale robot
Communication with large scale robot
Multi-scale Mass-deployable Cooperative Robot

Fire detection

Finding!
Multi-scale Robot

Large Scale

Small Scale
Multi-scale Mass-deployable Cooperative Robot (video)
PCB Design & Manufacturing Process

1. Technical Needs
2. Conceptual Design
3. Circuit Drawing
4. Components Assembly
5. PCB Layout
PCB Design Factors

- PCB Design Factors
  - Dimension of Board
  - Dimension of each Components
  - Connector Position
  - Impedance matching
  - Absolute Maximum Current(Power)

- Needs from Customers
  - Driving Voltage
  - Driving Current
  - Data Transfer Rate
  - Sensors
  - etc.
Brief Design Concept of PCB

- Robot Board Design
  - Wireless Communication (High Speed)
  - Motor Driver (DC-Motor, Step-Motor)
    - Buck-Boost Converter (7.4V → 12V)
    - Encoder for RPM Control
  - 3-axis Gyroscope
  - Indicating LED
  - 8 channel SMA Driver
  - Camera
  - Board Outline
Conceptual Design of PCB

- Block Diagram of Functions of PCB

Communication Part
- Wifi
- Indicating LEDs

SMA Driving Part
- 8Ch SMA Driving Circuit (8 FET, 3A MAX)

Sensor Part
- Regulating IC (7.4V – 3.3V)
- Sensor Ports
- MCU (ARM cortex M-3)
- Low-Pass Filter
- Camera

Motor Part
- Battery (Lo-Poly 7.4V)
- Buck-Boost IC (7.4V -> 12V)
- H-Bridge (Motor Driving IC)
- Step Motor (12V) x 2
- DC- Motor (12V) x 3
- Encoder (Hole Sensor) x 3
- Encoder (Hole Sensor) x 3

Camera
Components Selection

- Design Factor of Components
  - Size
    - SMD, DIP, SO-8 etc.
  - Absolute Maximum Values
    - Maximum Voltage
    - Maximum Current
    - Etc.
  - Heat dissipation
  - Power Consumption
  - Frequency characteristics
  - Cost
  - Delivery Time
  - Etc.

Size of SMD (Surface-mount Device) Components & DIP type Device

<table>
<thead>
<tr>
<th>Absolute Maximum Ratings of LM741</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Supply Voltage</td>
</tr>
<tr>
<td>Power Dissipation (W)</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
</tr>
<tr>
<td>Input Voltage (V)</td>
</tr>
<tr>
<td>Output Short Circuit Duration</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
</tr>
<tr>
<td>Junction Temperature</td>
</tr>
<tr>
<td>Soldering Information</td>
</tr>
<tr>
<td>P9050E Package (10 seconds)</td>
</tr>
<tr>
<td>NAB2000 or LMC556C Package (10 seconds)</td>
</tr>
<tr>
<td>M Package</td>
</tr>
<tr>
<td>Vapor Phase (30 seconds)</td>
</tr>
<tr>
<td>Infrared (15 seconds)</td>
</tr>
<tr>
<td>ESD Tolerance (V)</td>
</tr>
</tbody>
</table>
Circuit CAD Design

- Circuit Examples (Motor Driver)
Basic Process of PCB

1. Masking
2. Etching
3. Drilling
4. Plating For Via Hole
5. Demasking
Design for Manufacturing in PCB

- **Basic Design Factors**
  - **Clearance**
    - Track to Track
    - Hole to Hole
    - Hole to Track
  - **Hole Size**
    - Standard Holes
      - 1mm, 2mm (o)
      - 1.22mm (x)
  - **Track Width**
    - Current Limit

Design for Manufacturing in PCB (cont.)

- **PCB Design Factors**
  - Plating Materials
    - Gold
    - Silver
    - Lead
    - Etc.
  - Copper Film Thickness
    - 0.5OZ (18μm)
    - 1OZ (35μm)
    - 2OZ (70μm)
### Absolute Maximum Voltage & Minimum clearance

<table>
<thead>
<tr>
<th>DC, AC, Peak Voltage</th>
<th>With Protection Layer</th>
<th>Without Protection Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum Clearance (mm)</td>
<td>Minimum Clearance (mm)</td>
</tr>
<tr>
<td>0~30</td>
<td>0.25</td>
<td>0.65</td>
</tr>
<tr>
<td>31~50</td>
<td>0.4</td>
<td>0.65</td>
</tr>
<tr>
<td>51~150</td>
<td>0.5</td>
<td>0.65</td>
</tr>
<tr>
<td>151~330</td>
<td>0.75</td>
<td>1.3</td>
</tr>
<tr>
<td>301~530</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Over 500</td>
<td>0.003 mm/V</td>
<td>0.005 mm/V</td>
</tr>
</tbody>
</table>

### Absolute Maximum Current & Track Width (Copper Film Thickness = 1OZ)

<table>
<thead>
<tr>
<th>Track Width (mm)</th>
<th>Amps(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>0.8</td>
<td>1.8</td>
</tr>
<tr>
<td>1.0</td>
<td>2.2</td>
</tr>
<tr>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>2.0</td>
<td>3.4</td>
</tr>
<tr>
<td>3.0</td>
<td>3.8</td>
</tr>
</tbody>
</table>

※Note : This Guidance follows HANSAEM DIGITEC Inc. It is strongly recommended to check the specification of PCB for each company.
PCB Layup Design

- PCB Layout Examples

Motor Connector

65.000mm

SMA Power Connector

45.000mm

SMA Driver Connector

Functional Connector

Power Connector

LED Connectors

PCB Layout Examples
SMT (Surface Mounting Technology)
Final Product

- Connector for Motor
- 3-axis gyro sensor
- Camera
- Communication Antenna
- Connector for SMA
Deformable Wheel Robot

Deformable Soft Wheel Robot using Hybrid Actuation

Je-sung Koh, Dae-young Lee, Seung-won Kim, Kyu-Jin Cho

Seoul National University
Mechanical & Aerospace Eng.
Biorobotics Laboratory

Multi-scale Robotics Laboratory
Flexible Display

2013 Samsung Flexible OLED Phone and Tab Concept
The Ottakringer ladder-chair was inspired by a 19th-century model found in a monastery library in Tyrol, Austria. Ottakringer is the name of the Vienna suburb where it is manufactured today by Section N. The Ottakringer has two purpose functions, as ladder and as chair. Whether it is collapsible is debatable, for it occupies about the same amount of practical space in both roles.
Design for Foldable Structure (cont.)

Designed by Eduard Bohtlink (1986-95)
Design for Foldable Structure (Bicycle)
The Smart Fun roll-up rubber keyboard will withstand all the coffee, Coke and Big Mac that a nerd may spill. It can be cleaned in hot water at 60° C (140° F). Its relatives, the Smart Indupact and Smart Medic, were designed for workshops, laboratories and clinical environments, and can take even tougher cleaning. One day – or so this author foresees – all portable PCs will have ultraflat collapsible keyboards and screens that project onto the nearest wall or float freely in the air.
Design for Foldable Structure (Airplane)

The 1954 RNAF Gannet, by Fairey in the UK, is a three-seat shipboard early-warning aircraft that was designed to take off and land from an aircraft carrier. Its wings fold back for compact on-board storage.

The aircraft carrier USS Franklin D. Roosevelt Sentinel with collapsible aircraft on the flight deck, c. 1970. These days many helicopters and military aircraft have rotor blades and wings that fold to save space on aircraft carriers.
Attachment, Wire Bonding and Packaging

Figure 5.32  Quad flat packaging (QFP) (adapted from Kalpakjian, 1995).
Semiconductor Manufacturing

1. **Crystal growth and wafer production**

2. **Oxidation**: SiO2 is produced by heating the wafer to very high temp.

3. **Photolithography**: Circuit patterns are formed
4. **Doping**: The $n^+$ and $p^+$ dopants are added by ion implantation.

5. **Chemical Vapor Deposition**

6. **Interconnect creation**

7. **Testing and packaging**
Chipmaking Processes

**BASIC CHIPMAKING PROCESS**

1. Steam oxidizes surface (red layer)
2. Photoresist (dark blue layer) coats oxidized wafer
3. Lithography transfers desired pattern from mask to wafer

**REFINEMENTS IN CHIPMAKING**

- Strained silicon
- Silicon-germanium blend
- Oxide
- Silicon substrate

PERFORMANCE HAS IMPROVED with the growing use of wafers having a buried oxide layer or those fashioned to have a thin layer of strained silicon at the top—or by employing both techniques at once, as shown here.

IF MODERN TECHNIQUES such as “optical proximity correction” are applied to compensate for the blurring effects of diffraction, photolithography can create features smaller than the wavelength of light used in projecting the pattern. In this example of optical proximity correction, a complicated pattern used for the mask (left) results in crisp features on the chip (right).
Chipmaking Processes

4. Chemicals and baking harden unexposed photoresist. Other parts of photoresist are removed.

5. Chemical etching selectively strips off the oxide where no photoresist protects it. The rest of the photoresist is removed.

6. Ions shower etched areas, forming source and drain junctions.

7. Metal contacts are added using lithography during later stages of fabrication.

Before cleaning

After cleaning

AS FEATURE SIZES SHRINK, removing photoresist and residues that remain after etching (left) becomes difficult. But supercritical carbon dioxide can penetrate tiny openings and dislodge particles without leaving traces of cleaning fluid behind (right).

AS MANY AS EIGHT levels of wiring now connect the millions of transistors found on a typical microprocessor. Aluminum, the metal long used for this purpose, has given way to copper, which is more difficult to emplace but improves the speed and integrity of the signals carried on the wires.
Geometry of Transistor in a chip
Chemical Mechanical Polishing (CMP)
Chip Manufacturing (video)
LIGA is a German acronym for Lithographie, Glavankformung, Abfomung (Lithography, Electroplating and Molding) that describes a fabrication technology used to create high-aspect-ratio microstructures.


The X-ray LIGA process was originally developed to produce nozzles for uranium enrichment.

(a) exposure
(b) Development
(c) Electroforming
(d) Stripping
(e) Replication
Transistors per Microprocessor

Doubling time: 2 years

Year


Transistors per Chip

10^3 10^4 10^5 10^6 10^7 10^8 10^9

Logarithmic Plot

http://www.singularity.com/charts/page63.html
Moore’s Law

http://en.wikipedia.org/wiki/Moore's_law

*FinFET (fin field effect transistor, 3-D Gate transistor form)
3D transistor

FinFET (fin field effect transistor, 3-D Tri-Gate transistor form)

Intel, http://www.youtube.com/watch?v=YIkMaQJSyP8
Commercial Silicon Wafers

Wafer (substrate for microelectronic): a thin slice of semiconductor material used in the fabrication of integrated circuits and other micro devices
From Design to Manufacturing

- Now we are in the **Manufacturing** domain

- **Design domain:**
  - How to create geometry

- **Manufacturing domain:**
  - How to make part
  - Need to consider
    - Manufacturing process
    - Material
    - Machine
Computer-Aided Manufacturing (CAM)

- Definition
  - The technology concerned with the use of computer systems to plan, manage, and control manufacturing operations through either direct or indirect computer interface with the plant’s production resources.

< Main Phases of discrete part manufacturing >
CAM Software

- NC software
  - NC is a system in which actions are controlled by direct insertion of numerical data at some point. The system must automatically interpret at least some portion of this data
  - Electronic Industries Association (EIA)
  - Computer Numerical Control (CNC)

- Robot programming software
  - Selecting and positioning tools and work-pieces for NC machines

Hyundai factory

BMW factory
CAM Software (cont.)

- **Process planning software**
  - The act of preparing detailed work instructions to machine or assemble a part of parts
    - *Computer-Aided Manufacturing, Chang et al., 1998*
  - Process plan; operation sheet; route sheet
  - Computer-Aided Process Planning (CAPP)

- **Inspection software**
  - Coordinate Measuring Machine (CMM)
Problems in Traditional Production

- Some barriers between design and manufacturing process

< Diagram of tradition design and manufacturing process >
CAD/CAM Integration

- Goal of integration
  - To facilitate coordination of work and information flow across organizational boundaries


< Example concept of CAD/CAM integration >
Integration in Product Cycle Level

DESIGN PROCESS

- Design Need
- Design Specifications
- Feasibility Study with Collecting Design Information
- Analysis
  - Design Documentation
  - Design Evaluation
  - Design Optimization
  - Design Analysis
- Synthesis
  - Design Conceptualization
  - Analysis Model

CAM

- Process Planning
- Production Planning
- Design and Procurement of New Tools
- Order Material
- NC, CNC, DNC Programming
- CAM

MANUFACTURING PROCESS

- Production
- Quality Control
- Packaging
- Shipping
- Marketing

Customer -> Supplier

Product Data Management Enterprise Resource Planning Product Lifecycle Management
Integration in Database Level

![Database Integration Diagram]

- Determination of dimensions
- Material selection
- Assembly method
- CAD
- Conceptual design
- Part drawing
- Part arrangement
- Thickness determination
- Automatic cutting
- CAE
- Simulation
- Automatic assembly
- CAM
- Jigs and fixtures
- Material handling
Integration in Commercial Package Level

- Integrated CAD/CAE/CAM/PDM/…
- All in one package
  - Dassault systems: CATIA, DELMIA, INOVIA… SolidWorks, CosmosWorks…
  - PTC: Pro/Engineering, Windchill…
  - UGS: Unigraphics, Teamcenter, Technomatix…
Coupling Modes in Integration

- There are 3 types of coupling modes between design and manufacturing

<table>
<thead>
<tr>
<th>Coupling Mode</th>
<th>Pros</th>
<th>Cons</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose/ Repetitive</td>
<td>Flexible design</td>
<td>Cost &amp; delay for redesign</td>
<td>Conventional CAD/CAM</td>
</tr>
<tr>
<td>Stiff/ One-way</td>
<td>Guaranteed Manufacturing</td>
<td>Less design freedom</td>
<td>CyberCut, MOSIS</td>
</tr>
<tr>
<td>Strong/ Bidirectional</td>
<td>Moderately flexible design, guaranteed manufacturing</td>
<td>Some loss of design freedom</td>
<td>SmartLite, SmartFab</td>
</tr>
</tbody>
</table>

Example Solutions of Stiff mode

- CyberCut paradigm
Manufacturing Advisory Service (MAS)

Example Solutions of Stiff mode (cont.)

- CyberCut – Feature 1. WebCAD

  DFM paradigm

  1. Tool diameter & Depth

  2. WYSIWYG:
     Corner radius

  3. Design Rule Checker

Example Solutions of Stiff mode (cont.)


(CAD)
- Design
  - Setup
    - Operation Group
    - Single Operation
    - Surface Selection
- Coord. Selection
- Tool Selection
- Cutting Param. Select.
- Post Process (C/G-post)
- Cost Estimation
- FTP G & M Code

(CAM)
- Design
- DFM Info.
  - Tool Selection
  - Corner Radius
  - Cost Estimation
- Automated Planners
  - Macro Planner
  - Micro Planner
- Toolpath Planner

Feature Recognition

Machining
- NC Machine

Hours
- 1~5 Min.
Example Solutions of Stiff mode (cont.)

- CyberCut – Network communication
Example Solutions of Stiff mode (cont.)

- CyberCut – Feature 3. Universal fixture

  - Work Piece
    - (a) Encapsulation
      (Fusible Alloy/thermoplastic)
    - (b) Machining
    - Heat
    - (c) Filling & rotation
    - Final part
    - (e) Melt Encap.
    - (d) Machining

Example Solutions of Stiff mode (cont.)

- CyberCut – Fabricated parts
Web-based CAD/CAM Integration

- Micro Machining System (MIMS)
  - Micro machining service using the internet
  - Communication with 3-tier client-server model
  - Upload STL file

Web-based CAD/CAM Integration (cont.)

- Micro Machining System (MIMS)
  - Provide the NC code viewer
  - Fabricated by micro-endmill according to scanning and pencil-cut toolpath

- G&M Codes on NC code Viewer
- Micro channel
- Two Types of Toolpath
- 3D Scanned Head
- Micro Fluidic Channel
Web-based CAD/CAM Integration (cont.)

- **SmartFab**
  - Micro machining using SolidWorks

---

**Architecture of SmartFab**

1st Tier
- CAD API
- CAD Software

2nd Tier
- Web Server
- NC Code Generation
- Cost Estimation

3rd Tier
- Micro Fab. Data base
- PolyCAM

Fab.
- Micro *CNC

- Tool/Material information
- Design check
- NC codes
- Cost estimation

*DFM: Design for Manufacturing
*CNC: Computer Numerical Control

< Architecture of SmartFab >
Web-based CAD/CAM Integration (cont.)

- **SmartFab – Sketch validation**
  - Improve machinability
  - Based on the tool information and DFM philosophy

< Check for minimum Gap >  < Check for fillet >
Web-based CAD/CAM Integration (cont.)

- **SmartFab – Pocket validation**

  ![Pocket Validation Diagram]

  **Case I. Depth limit**
  - Limit of depth < stock height – initial depth

  ![SolidWorks Warning 1]
  - Case I. Depth limit

  ![SolidWorks Warning 2]
  - Case II. Depth limit and initial depth

  **For Multiple Pocketing:**
  - Limit of depth < stock height – initial depth

  ![DFM in Pocketing Diagram]
SmartFab – Cost estimation

### Cost Estimation Service

<table>
<thead>
<tr>
<th>Service Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cw (Workpiece cost)</td>
<td>20</td>
</tr>
<tr>
<td>2. Cp (Preparation cost)</td>
<td>875</td>
</tr>
<tr>
<td>3. Cm (Machining cost)</td>
<td>11275</td>
</tr>
<tr>
<td>4. Cn (Nonproductive cost)</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total cost ($C_{total} = C_w + C_p + C_m + C_n$) is 12170 (won)**

- $C_p = T_p \times W$
  - $T_p$: Preparation time (0.35 hr)
  - $W$: Operator's wage (2500/hr)
- $C_m = C_{om} + C_t = T_m \times W + C_t$
  - $T_m$: Machining time (0.41 hr)
  - $W$: Operator's wage (2500/hr)
- $C_t = y \times (T_m / T)$
  - (11,275 won, 92% of total cost)
  - $C_t$: Tool usage cost
  - $T$: Tool life (4 hr)
  - $y$: Tool cost (100,000)
Manufacturing Advisory Service (MAS)

- Concept level manufacturing and
- Material selection tool
  - For educating designers
  - Informing experienced designers about new tech

Enquires about

- Batch size
- Typical tolerances
- Size
- Overall shape
- Cost requirements
DUCADE, Domain Unified CAD Environment, is a web enabled collaborative management system that aids the concurrent design process of electronic printed circuit boards and mechanical enclosures.
DUCADE

- Tracks couplings between mechanical and electrical features over the life cycle of the product
- Gives feedback to designers when feature properties (size, location, etc.) are altered and coupling criteria are violated
- Compiles history of design changes from both domains
Example (Google glass)
**BEE Couplings**

**Thermal constraint**

Design of Experiments Testbed (DOET)
Rapid Prototyping

- Clearance and fit between electrical components and mechanical package can be verified
- Functionality and structural strength of package can also be tested
Final design and Fabrication

- Electrical & Integrated Circuit Design
- Concurrent Engineering
- Heat Survey & Cooling Method Selection
- Material & Manufacturing Process Selection
- Computer Aided Design
- Design of Experiments & Thermal Simulation
- Rapid Prototyping
- Final Design
- Fabrication
Broad Integration

- **PDM (Product Data Management)**
  - Control CAD file revisions
  - Manage all data related to project

- **PLM (Product Life-cycle Management)**
  - Product Development Management (PDM)
  - Include all actors (company departments, business partners, suppliers, OEM, and customers)
  - Share product data
  - Apply common processes
  - Leverage corporate knowledge
Data Exchange

- Standard formats for data exchange
  - IGES (Initial Graphics Exchange Specification)
    - 3D CAD data
  - STEP (Standard for the Exchange of Product model data)
  - DFX (Drawing eXchange Format)
    - 2D drawing data
  - STL (Stereo Lithography)
    - De facto standard in rapid prototyping
  - VRML (Virtual Reality Modeling Language)
    - 3D model on web
Data Exchange (cont.)

(a) Diagram showing the relationship between multiple systems (System 1, System 2, ..., System n).

(b) Diagram showing a neutral file connecting various systems (System 1, System 2, ..., System n).
Smart Factory (Manufacturing)

Computer-Integrated Manufacturing
Real-time and accurate collection of production line data

Real-time Production Monitoring
Greater control over the production process

Automated Process Control
Reduce the need for manual intervention in the production line

Environmental Conditioning and Monitoring
Monitor and control environmental conditions to optimize efficiency

Source: MOXA (http://www.moxa.com/Event/DAC/2013/Factory_Automation_IO/index.htm)
Smart Factory (Manufacturing)

https://www.youtube.com/watch?v=9R_P8FpsiBY
Business Plan

Introduction
  Mission Statement
  Product Use and Market Introduction

VDM Product Description
  Overview
  Detailed Drawings
  Design for Manufacturability

Scuba Diving Market
  Economics
  Demographics
  Existing Product

VDM: Venus Dive Monitor
Business Plan (cont.)

Manufacturing & Marketing
  Strategy and Cost Estimates
VDM Prototypes Costs
  Personnel
  Overhead Costs
Prototype Production Costs
Financial Scenarios (Expected return etc.)
Appendix (Part Assembly drawings etc.)

Business plan (example of VDM)

1.0 Introduction

1.1 Mission Statement:

Adonis will revolutionize the scuba diving industry with the introduction of the world’s first hands free dive computer. The Venus Dive Monitor (VDM) will allow today’s diver to monitor critical information without removing his eyes from the ocean environment, thereby eliminating the stop-and-go diving necessitated by current dive computers.

1.2 Product use and market introduction:

Every time a diver submerges into the underwater frontier he must constantly monitor key data such as depth, bottom time and remaining oxygen. A digital dive computer, which dangles near the diver’s waist, generally provides this information. This requires the diver to stop swimming, remove his eyes from the ocean environment and fumble around to find the dive computer. Such stop-and-go diving reduces the time the diver can spend enjoying the underwater world and, in an environment that allows for movement in three dimensions, may cause disorientation - especially in a strong current.

The VDM addresses these problems; it displays the essential information to the diver in his peripheral vision. It allows the diver to keep his hands free and his eyes on the ocean. No more disorientation, no more unwanted movement in currents and more time to enjoy the surroundings.

The VDM will make its entry into the dive computer market by targeting dive instructors and dive boat operators. Seeing expert divers sport the VDM will encourage their clients to adopt the VDM and allow for VDM to become a significant player in the dive computer market and rapidly generate a significant return on investment.
## Business plan (example of VDM)

- **VDM Product Description**

2.0 VDM Product Description

2.1 Overview

The Venus Dive Monitor (VDM), by Adonis Ltd., is a scuba diving accessory that allows a diver to continuously monitor his dive data by placing that information in his peripheral vision. The diver’s depth, bottom time, remaining air pressure, and water temperature are displayed on an LCD screen that is attached to an armature assemble mounted to the diver’s mask. An overview of this system is shown in Figure 2.1.

![Figure 2.1: Overview of VDM System](image)

Figure 2.1: Overview of VDM System. Item A shows the Display Assembly, Item B shows the Armature Assembly, and Item C shows the Mask Attachment Assembly.

The Display Assembly (A) consists of an LCD screen fitted into a circular housing. This housing fits into a pin with a spherical head that goes through the armature slot and is threaded into a tightening knob. The spherical head allows the display to rotate to any preferred viewing angle. The receptive slot in the arm allows the display to slide horizontally to an optimum viewing position. The tightening knob affixes the Display Assembly to the arm in the desired position. The electronics of the LCD display are contained within the housings, and a set of wires brings in the data that gets displayed.
Scuba Diving Market

3.0 The Scuba Diving Market

3.1 Economics

In North America alone recreational diving becomes a multi-billion dollar industry.\(^1\)

The overall annual revenue from scuba diving is $1.5 billion in the United States.\(^2\) Of that, the National Sporting Goods Association forecasts $373 million will be spent on purchasing consumer scuba diving equipment this year, up from $362.5 million in 1999.\(^3\)

Scuba diving equipment, in general, includes: buoyancy control devices, fins, masks, regulators, computers, tanks, wet-suits, and dry-suits. A complete basic package costs on the order of $1,500.

Dive computers are generally between $250 and $400 and have either a wrist or a console mount -- some with the option of both. Scuba masks generally average between $70 and $100. Various accessories, ranging from dive lights (~$50) to hands-free propulsion vehicles (>~$1000), are available to the avid scuba diver.

3.2 Demographics

There are approximately 15.5 million certified scuba divers worldwide. In the U.S. alone, there are 8.5 million certified scuba divers. The industry continues to grow: an estimated 500,000 new scuba divers are certified in the U.S. each year.

Scuba divers are generally affluent and well educated. 62% of divers have an average income over $50,000. Half of all scuba divers have a college degree, with almost 40% in professional or managerial occupations. The average scuba diver is thirty-six years old.\(^4\) Though females comprise less than 30% of divers, they are continually growing in size.

While people generally think of scuba diving as a recreational activity, scuba diving is commonly used for search and rescue of downed aircraft, and repair of offshore drilling rigs. For these applications, it is imperative that the divers have unlimited use of their hands and arms.

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1. [http://www.marinai.org/pulmonary/books/scuba/sections.htm](http://www.marinai.org/pulmonary/books/scuba/sections.htm)
3. [http://www.nasa.org](http://www.nasa.org)
Business plan (example of VDM)

- Manufacturing & Marketing

acceptance, competing with the current players in the market will be reduced to producing a better and cheaper product, something that Adonis is confident will be done.

The table below summarizes the costs of manufacturing the VDM. A note is needed regarding the pricing of the VDM. The dive computer market is a relatively small one with less than a million units sold per year worldwide. This means that the profit margins on both the wholesale and retail sales must be large in order to support both the manufacturer and retailer respectively. Note, however, that the projected retail price of the VDM enters the low end of the dive computer market with an inexpensive retail price of $250.

<table>
<thead>
<tr>
<th>Manufacturing Cost Estimates</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Printed circuit board</td>
<td>$2</td>
</tr>
<tr>
<td>LCD</td>
<td>$4</td>
</tr>
<tr>
<td>Misc. electronics</td>
<td>$4</td>
</tr>
<tr>
<td>Water proofing</td>
<td>$1</td>
</tr>
<tr>
<td>Materials</td>
<td>$1</td>
</tr>
<tr>
<td>Assembly labor</td>
<td>$3</td>
</tr>
<tr>
<td>Packaging</td>
<td>$0.50</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>$15.50</td>
</tr>
<tr>
<td>Manufacturing set-up</td>
<td>$9</td>
</tr>
<tr>
<td>Overhead and labor</td>
<td>$16</td>
</tr>
<tr>
<td>Marketing</td>
<td>$6.50</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>$1.50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$48.50</td>
</tr>
<tr>
<td><strong>Projected Wholesale Price</strong></td>
<td>$175</td>
</tr>
<tr>
<td><strong>Projected Retail Price</strong></td>
<td>$250</td>
</tr>
</tbody>
</table>

1 Printed circuit board and LCD costs are estimated based on high volume manufacturing.
2 Miscellaneous electronics include hydraulic pressure gauge to monitor depth and pressure gauge to monitor air.
3 Waterproofing includes materials for making the unit watertight at pressure. Includes rubber gaskets and silicon sealant.
4 Assembly labor assumes complete assembly of the unit utilizing overseas manufacturing.
5 Manufacturing set-up includes all costs associated with mold making and process set-up. Cost is estimated based on a production run of 160,000 units amortized over three years.
6 Overhead and labor are costs associated with Adonis Ltd. This includes the salaries of the principles of the corporation and all costs of rent, utilities, insurance, accounting, secretarial, custodial and legal. Costs are amortized over three years with a total production of 160,000 units.
7 Marketing costs assume 24 magazine ads a year, trade show appearances, and other product promotions and giveaways. Costs are amortized over a three-year production run of 160,000.
8 Research and development costs are amortized.
Business plan (example of VDM)

- VDM Prototypes Costs

Personnel

Overhead Costs

<table>
<thead>
<tr>
<th>Expense</th>
<th>Cost/month (in USD)</th>
<th>Total Expense (in USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensation</td>
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<td>219230</td>
</tr>
<tr>
<td>Rent</td>
<td>2500</td>
<td>12500</td>
</tr>
<tr>
<td>Insurance</td>
<td>169</td>
<td>845</td>
</tr>
<tr>
<td>Utilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSL Connection</td>
<td>250</td>
<td>1250</td>
</tr>
<tr>
<td>Power</td>
<td>200</td>
<td>1000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>75</td>
<td>375</td>
</tr>
<tr>
<td>Computer Leasing</td>
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<td></td>
</tr>
<tr>
<td>Hardware</td>
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<td>2500</td>
</tr>
<tr>
<td>CAD License</td>
<td>2000</td>
<td>10000</td>
</tr>
<tr>
<td>Furniture Rental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Expenses</td>
<td>360</td>
<td>1800</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td><strong>Total Overhead Costs</strong></td>
<td></td>
<td><strong>250000</strong></td>
</tr>
</tbody>
</table>

Prototype Production Costs
### Business plan (example of VDM)

- **Financial Scenarios**

<table>
<thead>
<tr>
<th>Table 1. Expected returns for worst case scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td><strong>Sales price</strong></td>
</tr>
<tr>
<td><strong>Number of units sold</strong></td>
</tr>
<tr>
<td><strong>Net sales</strong></td>
</tr>
<tr>
<td><strong>Cumulative net sales</strong></td>
</tr>
<tr>
<td><strong>Unit cost (target)</strong></td>
</tr>
<tr>
<td><strong>Unit cost</strong></td>
</tr>
<tr>
<td><strong>Cost of product sold</strong></td>
</tr>
<tr>
<td><strong>Cost of product sold</strong></td>
</tr>
<tr>
<td><strong>Gross margin</strong></td>
</tr>
<tr>
<td><strong>% gross margin</strong></td>
</tr>
<tr>
<td><strong>Development cost</strong></td>
</tr>
<tr>
<td><strong>Manufacturing setup cost</strong></td>
</tr>
<tr>
<td><strong>Marketing</strong></td>
</tr>
<tr>
<td><strong>Overhead &amp; labor</strong></td>
</tr>
<tr>
<td><strong>Total operating expense</strong></td>
</tr>
<tr>
<td><strong>Pretax Profit</strong></td>
</tr>
<tr>
<td><strong>% profit</strong></td>
</tr>
<tr>
<td><strong>Cumulative profit</strong></td>
</tr>
</tbody>
</table>

*Cost without amortization or manufacturing cost*
Business plan (example of VDM)

- Financial Scenarios

<table>
<thead>
<tr>
<th>Table 2. Expected returns for reasonable case scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td><strong>Sales price</strong></td>
</tr>
<tr>
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<tr>
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</tr>
<tr>
<td><strong>Cumulative net sales</strong></td>
</tr>
<tr>
<td><strong>Unit cost (target)</strong></td>
</tr>
<tr>
<td><strong>Unit cost</strong>*</td>
</tr>
<tr>
<td><strong>Cost of product sold</strong></td>
</tr>
<tr>
<td><strong>Cost of product sold</strong>*</td>
</tr>
<tr>
<td><strong>Gross margin</strong></td>
</tr>
<tr>
<td><strong>% gross margin</strong></td>
</tr>
<tr>
<td><strong>Development cost</strong></td>
</tr>
<tr>
<td><strong>Manufacturing setup cost</strong></td>
</tr>
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<td><strong>Marketing</strong></td>
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<tr>
<td><strong>Overhead &amp; labor</strong></td>
</tr>
<tr>
<td><strong>Total operating expense</strong></td>
</tr>
<tr>
<td><strong>Pretax Profit</strong></td>
</tr>
<tr>
<td><strong>% profit</strong></td>
</tr>
<tr>
<td><strong>Cumulative profit</strong></td>
</tr>
</tbody>
</table>

***Cost without amortization of manufacturing cost
### Financial Scenarios

<table>
<thead>
<tr>
<th>Table 3. Expected returns for best case scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Sales price</td>
</tr>
<tr>
<td>$175.00</td>
</tr>
<tr>
<td>Number of units sold</td>
</tr>
<tr>
<td>Net sales</td>
</tr>
<tr>
<td>Cumulative net sales</td>
</tr>
<tr>
<td>Unit cost (target)</td>
</tr>
<tr>
<td>Unit cost***</td>
</tr>
<tr>
<td>Cost of product sold</td>
</tr>
<tr>
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</tbody>
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***Cost without amortization manufacturing cost
Design for Manufacturing Award

- Award to the Best Team!!!
- No money, but Honor!

You CAN do it!