# Some IDEAS for the OZ business strategy

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## The overall goal

provide phenomenal performance
(100 times better than current techniques at same cost)
in a **computer workstation accelerator board**
which executes *critical spatial computation tasks*
(collision detection, dynamics modeling)

and thus to

capture a large portion of a rapidly expanding market
for spatial enhancement computer technologies in

- multimedia interfaces
- entertainment including
  - arcade games
  - mini-attractions
  - theme parks
  - museums
  - gaming establishments
  - film
  - club environments
- computer-aided design and manufacturing
- medical modeling
- military simulation
- scientific visualization
- education and training, and
- telecommunications.

The technical means include

customized silicon chips (massive fine grain parallel processing),
sophisticated mathematics (proprietary algorithms), and
an intuitively easy interface (natural behavior specification).

## The OZ strategy

The OZ core product is the SMART SPATIAL ENGINE which provides powerful yet accessible physical modeling.

We believe that the majority of successful computer applications to be developed in the 1990s will include human interaction with simulated three dimensional spaces. Natural simulated environments mimic or duplicate physical laws, making computer generated effects (images, sounds, remote feedback) feel natural and appealing.

[insert a justification for spatial interface.  Either a longer single example from the list of apps, or (preferred) a simple example from each of the apps.  There is a story relating 3space to functionality behind each.]

* 3D modeling and interaction within multimedia windows
* virtual reality arcade games with natural feedback
* theme park rides using sensory enhancement and realistic environments
* competitive computer gambling
* spatial effects in digital filming
* theatrical staging and production
* environmental modeling and coordination of effects in clubs
* prototyping machine and product designs
* engineering analysis of objects and architectural spaces
* simulation of manufacturing and production processes
* human factors engineering for ergonomics and ease of use
* just-in-time training and educational simulation
* computer-assisted cooperative work
* spatial medical imaging and modeling technologies
* remote laparoscopic surgery
* medical training
* psychological visualization and rehearsal therapies
* military warfighting simulation
* infantry close combat tactical training
* spaceflight simulation
* planetary exploration
* oceanic exploration
* molecular configuration and drug manufacturing
* human genome modeling
* fluid dynamics visualization
* weather modeling and visualization
* historical reconstruction
* emergency training and disaster rehearsal
* interaction and training in dangerous environments
* situated learning environments
* multimedia home communications systems

SMART SPATIAL COMPUTATION is fundamental to the growth of the entire computer industry, since *computer interfaces* are evolving into three dimensional shared spaces.

We support a business strategy poised on the future, first providing the essential computational power to satisfy advanced applications across the computer industry, then rapidly capitalizing on growing markets to deliver *spatial performance, not images*, to the home market.

We propose to develop a core technology with an open interface that enables third party developers to integrate that core within their products and extensions.

Over time, we plan to add strategic capabilities to the core product, expanding its utility and market. The success of the core is at no time dependent on the success of its additions.

## The OZ product line

The SMART SPATIAL ENGINE provides two tightly integrated core capabilities:

physical dynamics and collision detection

These core capabilities provide the critical tools for the designer of a computer application to embed *interaction in three dimensions* within the application. We believe that this capability will be *the next dominant interface* for computers, included in all major new applications and required by all operating systems.

What the core capabilities enable your computer to do:

* real world physics with hundreds of dynamics objects
* collision detection and natural response everywhere
* build virtual machines which actually function
* virtual physics under your control
* accelerate graphics preprocessing
* scalable performance at linear cost

* capable of maintaining accurate physical dynamics
  for up to 1000 interacting objects,
  each modeled by 1000 polygons,
  at 60 Hz display rate
  for $3K manufacturing cost

The following chart outlines a course of evolution for the OZ product line. Each new functional module is optional. OZ can choose to build any module or can incorporate products from other companies. The OZ core is unique.

collision detection + physical dynamics =

spatial modeling (OZ core)

+ oasiis = interactive interface with virtual body

+ logic chip = programmable real-world modeler

+ static object modeling = intelligent CAD interface

+ device integration = Century 2100 workstation

Spatial computation is separate from rendering, thus it is a different market. Rendering, and most other graphic tools, are two dimensional imaging techniques. The OZ core works for all dimensions, so can serve as a screen-based 2D modeler. An example would be the game of billiards: up to 16 interacting dynamic objects on a 2D surface.

FIRST PRODUCT COMPONENT DEVELOPMENT
- collision detection chip
- integrated physical dynamics/coldet board
- natural interface

ADD-ONS
- oasiis
- interactive interface
- logic
- animation/simulation system

## What are PHYSICAL DYNAMICS and COLLISION DETECTION?

*Physical dynamics* is expressed by Newton's Laws, relating the mass and the movement of objects to the forces acting upon them. Our physical world embodies physical dynamics, and all real world simulations require the computation of forces and accelerations. We need physical dynamics to model the trajectory of a thrown ball, the fit of two milled parts, the wear on a ball joint under various usage patterns, the effect of mechanical assemblages.

There are three major classes of physical dynamics: spatial, free-body interactive, and articulated. Each is increasingly more challenging for current computational techniques. The SSE provides a complete solution, computing all forms of dynamics.

*Spatial dynamics*, used in flight simulators, addresses motion through the air without collisions. The computer provides the flight trajectory that results from forces delivered by engines on the plane. Spatial dynamics models one simple object on one trajectory through a three dimensional space. The computational difficulty is that in many cases the laws of physical dynamics do not have simple algorithms; often an implementation requires a time-consuming iterative numerical approximation to arrive at a solution.

*Free-body interactive dynamics*, used in batch mode animations, addresses the motion and collision of many single objects. The computer provides the flight trajectory of every object, and it must make these trajectories contingent upon every other object that might be in the way.

*Collision detection* is the computational ability to identify when an object enters another object's space. In the physical world, objects cannot occupy the same space at the same time. In the graphical world, this rule must implemented as an additional constraint. Collision detection provides apparent hardness to graphical objects.

Collision detection provides ground planes, surfaces which do not move and prevent penetration (such as the surface of the Earth). Actions as simple as placing a glass on a table, picking up a piece of paper, and bouncing a ball, all require interactive dynamics with collision detection.

The central issue for interactive dynamics computation is integrating collisions with behavioral effects. The ball hits the wall and bounces off. This simulation is difficult in real-time for two reasons: the trajectory of the ball must be tracked, predicted and interrupted when it intersects the space of the wall; and the interruption must change the movement of the ball, according to the effect of the wall on the ball (the wall may be soft or hard). At the instant of collision, the ball and the wall cease to be free-bodies, instead they form a joined system, a larger articulated body which obeys different dynamical equations. The computer must be able to change models in real-time.

Finally, articulated dynamics addresses objects that are connected in some way. The simplest case is the above example of instantaneous collision. Other cases of articulated objects are pendulums, chains, and human bodies. In order to model articulated systems, the computer must provide the movement of each articulated piece, constrained by the kind of articulated connection to the whole (examples: rigid connection, simple two dimensional hinge, ball joint, surface contact, instantaneous contact).

The computational difficulty for articulated systems is that constraints interact with each other throughout the system. Current techniques for predicting dynamical behavior of articulated systems break down due to complexity after only a dozen articulated pieces. OZ has developed proprietary algorithms that eliminate this breakdown.

## Technical Difficulties

Software solutions to the general collision detection and physical dynamics problem are slower that real-time responses when more than a couple of objects are interacting (given current workstation performance levels). Extra distributed hardware power does not improve performance unless specialized high-speed networking is provided. Even then, the amount of data flow for spatial computations is tremendous, even in parallel systems. The technical difficulties facing development of any spatial modeler include:

1) implementing the formal algorithms for O(n), linear-time physical dynamics

2) passing sufficient data through the processing system to model interesting spaces for collision detection (large, fine-detail, seamless)

3) integrating numerical, symbolic and display processing.

The OZ proprietary solutions to these problems:

1) augmented Kane dynamics

2) highly-modified CAM fine-grain parallel processing

3) spatial encoding languages

Each solution is unique and rare. OZ technical staff are leaders in each of these fields.

## Why the OZ core technology is important

In order to achieve its goals, OZ has developed innovative computational approaches to collision detection and physical dynamics. We have embedded extremely efficient general algorithms for physical dynamics and for collision detection into a specialized silicon accelerator board.

We intend to sell this accelerator board to the workstation marketplace initially, then as volume increases, to the general PC market. The OZ product growth plan assures an increasing demand for higher performance functionality,

[lots of markets]