Systems Engineering Applied to CycleSimulator

Systems Engineering Integrative Project
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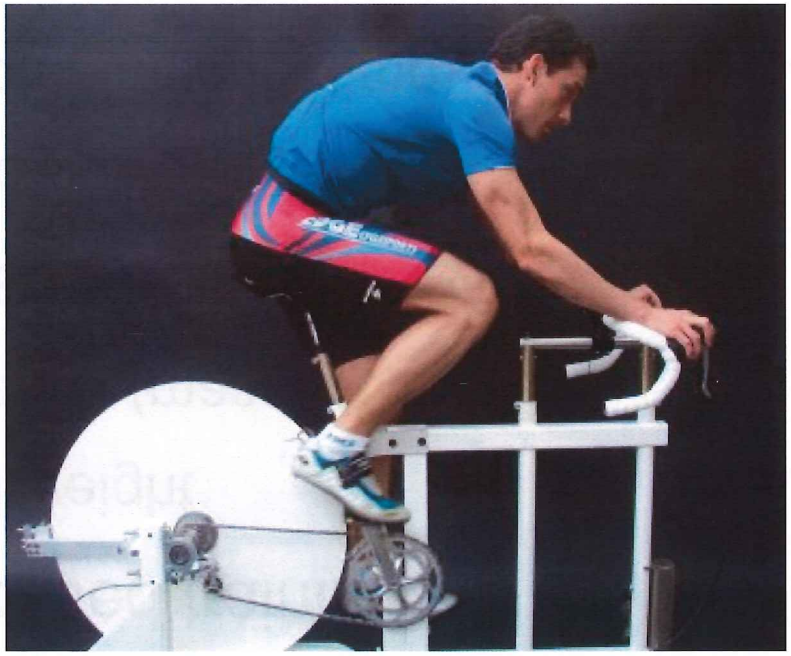
The CycleSimulator



- A power-based training device for pro and semi-pro road and track bicyclists

Power Based Training

- Maximization of human performance
- Strength based training
  - reps and weight
  - work domain (mass x distance)
- Power based training
  - sustained power over time
  - power domain (work/time)

About CycleSimulator (the firm)

- Founded 10 years ago
- Sole proprietorship
- John Kruse
  - avid bicyclist
  - exercise physiologist
- Capital constrained
- In need of revenue
- Both hardware and service firm

Project Objective

- Apply knowledge gained in SELP/MBA program to improve the CycleSimulator business and product

Versions Built Thus Far

- Experimental versions
  - Prototype I (ca. 1995)
  - Prototype II (ca. 1999)
- Production versions
  - Model A (delivered 2003)
  - Model B (in progress)

Market Potential

- 4th most popular sport
  - 51,431,000 participants in 2005
  - Swimming, Walking and Bowling
  - Sporting Goods Manufacturing Association
- $5.8 billion industry
- 13,000,000 bicycles sold each year

Channels

Channel	Revenue Share	Volume Share	Average Price
specialty retailer	**48.9%**	17%	$422
mass merchant	37.0%	**75%**	$72
sporting goods	7.7%	5%	$225
other	6.6%	3%	$324

Customer Profile

- Only 0.3% of riders are professional racers
- Large numbers of semi-professional and serious enthusiast
- 50% of purchasers have household incomes over $75,000
- 31% of purchasers have household incomes over $100,000
- Affluent professionals seeking competitive extreme sports

Customer Profile

	Start-up	Recurring
Bicycle	$3,000-$5,000	$1,000-$3,000
Training	$1,500-$9,500	$2,000-$4,000
Dietary	$100-$300	$1,000-$4,000

- Significant cash outlay both up-front and recurring
- Willing to buy advantage

Competition

Field	**PowerTap**	$1,300 + bicycle
Indoor	**CompuTrainer Pro**	$1,600 + bicycle
Indoor	**CompuTrainer Dynafit**	$4,700
Indoor	**VeloTron Pro**	$8,000
Indoor	**VeloTron Basic**	$5,700 + bicycle

- Field ergometers popular—ego driven
- Indoor friction systems highly inaccurate
- Eddy-current systems delicate and precise

CycleSimulator

Advantages

- Harrison brake
- Simple mechanics
- Durable
- Inexpensive
- Accurate

Disadvantages

- Very heavy flywheel
- Ugly
- No ego appeal
- Freight and assembly

Engineering Challenges

- Heavy product
- Precision calibration in the field
- Service based business

Requirements Analysis

- Most common cause of unsuccessful projects: "incomplete or poorly defined objectives" Kerzner, 2003
- Proper analysis central to good systems engineering
  - clear, unique, stand-alone, and verifiable
  - traceable to source requirement
  - non-redundant, non-conflicting
  - not biased toward any particular implementation

Concept of Operations

- Power Based Training using the Harrison brake
- Stationary ergometer with real-time feedback
- Integrated training regimen
- Daily training by individual or multiple riders
- Usage over months and years
- Club environment

Performance Parameters

- Average speeds of approximately 20MPH
- Peak speeds of approximately 60MPH
- Sustained power output of 200 watts
- Peak power output of 2,000 watts
- Faithful emulation of riding cadence and gearing
- Portability
- Data transfer

Deployment and Distribution

- Mobile platform that can be repositioned between uses without reassembly
- Real-time and offline analysis of training data
- Anonymous rider support
- Field installation
- Worldwide training data system (Internet)

Product Lifecycle

- Durable product with useful life of 5 years
- Refurbishing to cost less than 30% of initial construction costs
- Minimum 20,000Km between major service

Utilization Requirements

- 12-hours of usage per day
- 90% duty cycle
- Mean time between maintenance of 1 month

Environmental Factors

- Corrosion resistance
- Sanitizability
- Tamper resistant audit trail of digital training data
- Configurable “reasonableness” limits

Established TPMs

- Average in-use sound pressure level of 50dB
- Peak input power of 5,000 watts
- Sustained input power of 1,000 watts

Trade Studies

Complex comparisons and evaluation of alternatives

1. Identify objectives, scope and constraints
2. Establish measures of effectiveness
3. Define decision process and rules
4. Generate alternatives
5. Estimate effectiveness of alternatives
6. Estimate sensitivity, uncertainty and risk
7. Make recommendation

•Drive Line Trade Study

- Transfers torque from pedals to flywheel
- Majority of moving parts
- Many possible solutions
- “Build versus buy”

Measures of Effectiveness

- Initial Cost
- Unit Cost
- Lifetime Maintenance
- Power Loss
- Fidelity
- Design Time
- Assembly Time
- Manufacture Time
- Flywheel Placement
- Reliability
- Maintainability

Decision Process

- Normalized
- Abstract
- Weighted
- Summed

MOE	Weight
Initial Cost	50
Unit Cost	5
Lifetime Maintenance	10
Power Loss	80
Fidelity	60
Design Time	10
Assembly Time	20
Manufacture Time	30
Flywheel Placement	5
Reliability	25
Maintainability	10

Alternative Generation

Solid shaft (custom)

Chain drive (COTS)

Sensitivity: 20% shift in estimates required to reverse outcome

Option	Score
Custom	60.33
Standard	91.97

Recommendation:

COTS Chain Drive

Detail Design WBS

1.0.0 Project Management

2.0.0 Simulator

3.0.0 Training Service

4.0.0 Customer Support and CRM

5.0.0 Maintenance and Support Program

Requirements Traceability Matrix