Stakeholder Value and the Evolution of Commercial Aircraft

Paul Collopy
Engineering Economist
DFM Consulting, Inc.
Design For the Marketplace

Stakeholder Value and the Evolution of Commercial Aircraft

• Evolution of Commercial Aircraft
  – Aerospace Products are Complex Adaptive Systems

• Stakeholder Value
  – Who are Stakeholders?
  – Surplus Value Theory
  – Applications
Motivation for this Research

• A simple paradigm for understanding success and failure in commercial air transport

• A guide to developing successful air transportation equipment

• A decision support model for airline strategies

• Basis for a technology evaluation model over the domain of aircraft, airlines, airports, etc.
Evolution in Commercial Aircraft
Evolutionary Processes

Aircraft manufactured per year

Design For the Marketplace

Success

Extinction

Failure

Piston Props

Turboprops

Jets
Evolution of Complex Adaptive Systems

Value Landscape

Mature System
entrenched design

Early System Life
fundamental innovation

Design For
the Marketplace

per Stuart Kauffman, *The Origins of Order*
and Kim Clark & Carliss Baldwin, *Design Rules*
A Closer Look at Evolution

- Metal Monoplane (Boeing 247)
- First Jets (Comet, 707)
- Concorde
- Turbofans
- Turboprops
- Piston Props
What Is Value?

*Altitude in the Mountain Metaphor*

- Net Value delivered to Stakeholders
  - Benefits minus costs or penalties

- Almarin Phillips (RAND) rule:
  - New DOC + Cost of Capital < Old DOC

- Questions Remain:
  - Who are Stakeholders?
  - How is value to particular Stakeholders combined?
Stakeholders

- Passengers
  - Freight Customers
- Airlines
- Airports
- Equipment Manufacturers
  - Airframes
  - Engines
- Society (Externalities)
  - Noise and Pollution
  - Economic Growth
Design For the Marketplace

Contract Stakeholders

- Airport
  - Infrastructure Costs
  - Rent
  - Oper Costs

- Airline
  - Ticket Price
  - Travel
    - Passengers
  - Price
  - Operating Costs

- Manufacturers
  - Production Costs, Development Costs
  - Speed
    - Flexibility
    - Comfort
    - Reliability
Design For the Marketplace

Single Firm Model

- Operating Costs
- Infrastructure Costs
- Production Costs Development Costs
- United Aircraft and Transportation Co.

- Speed
- Handling
- Reliability

- Transport
  - Freight
  - Rates

- Travel
  - Passengers
  - Ticket Price

- Speed Flexibility
- Comfort
- Reliability
Design For the Marketplace

Single Firm Model — Elaborated

- Speed
- Handling
- Reliability
- Transport

- Freight
- Rates

- Travel
- Passengers
- Ticket Price

- Speed
- Flexibility
- Comfort
- Reliability

Payload

Utilization

Operating Costs

Infrastructure Costs

Production Costs

Production Volume

Development Costs

Surplus Value
Design For the Marketplace

Surplus Value Theory

The Profit Pie

- Competition determines how the pie is sliced, but the bigger the pie, the larger the pieces

- Transportation Revenue
- Engine Profit
- Aircraft Profit
- Operator Profit
- Engine Mfg Cost
- Aircraft Mfg Cost
- Operating Cost
Key Theorem of Surplus Value Theory

Any technology, product design, or strategy that increases surplus value will increase or not affect the profits of each contract stakeholder, assuming effective bargaining.

A rising tide lifts all boats
Example: Surplus Value Maximizing Networks

• Lowest cost per mile traveled is on point to point service
• Surplus Value maximizing networks concentrate traffic on point-to-point service by discounting nonstop flights
• Revenue maximization, on the other hand, leads to
  – hub and spoke network
  – premium charge for point to point (what the market will bear)
• In the long run, Surplus Value maximizers will drive revenue maximizers to extinction
  – or, at least, to small niche operation
Some Implications for the Future

• Great leaps across the design space are difficult until we better understand optimal design
  – Blended wing body aircraft are out of reach
• Passenger networks will tend more toward point-to-point
  – Aircraft designs that cater to point-to-point service will be more successful
  – Boeing’s 7E7 is better targeted than Airbus A380
    • However, 7E7 does not seem to balance cost / performance to maximize surplus value (trade $250 mfg cost / lb. of weight)
    • Same argument suggests engine bypass ratio should be < 8
Evolution of Commercial Aircraft — Summary

• Commercial aircraft can be viewed as a community of complex adaptive systems
  – branching and extinction are common processes

• Evolutionary success is determined by relative contribution to surplus value
  – Revenues minus costs around the boundaries of unified contract stakeholders provides a simple model of surplus value, the driving force for evolutionary success

• Surplus value model provides a metric for comparing aircraft designs, prospective technologies & airline networks