DISRUPTING MATURE MARKETS WITH INNOVATIVE TECHNOLOGY

Henry Birdseye Weil
Senior Lecturer
MIT Sloan School of Management
50 Memorial Drive
Cambridge, MA 02142, USA

18 August 2004

ABSTRACT

Many markets are dismissed because they are "mature." The conventional wisdom says these markets are lacking in opportunity, particularly for new entrants or new products, because their growth is quite slow, asset lives are long, operators have strong incentives to stretch the life of existing assets rather than replace them, and the markets are dominated by a small number of well entrenched suppliers. Innovative technology can disrupt a mature market and change its dynamics. The incumbent suppliers may be more vulnerable than they appear. The business opportunity could be enormous for a company who understands the market dynamics, constructs an effective competitive strategy, and has the strength and persistence to see it through. This paper presents a system model of the market for technology-intensive assets. It is applied to the market for military transport aircraft, a classic case of slow growth and replacement and dominance by a few suppliers. But the system model is more general. It explains important dynamics of many other markets, e.g., industrial process plants, telecom infrastructure, large-scale IT, media production and distribution, motor vehicles, and not surprisingly commercial aircraft.[1]

[1] The author wishes to thank David Jennings, Head of Marketing at Airbus Military, for his very thoughtful comments on a draft of this paper and providing data on the market for military transport aircraft.

Introduction

Many markets are dismissed because they are "mature." The conventional wisdom says these markets are lacking in opportunity, particularly for new entrants or new products, because their growth is quite slow, asset lives are long, operators have strong incentives to stretch the life of existing assets rather than replace them, and the markets are dominated by a small number of well entrenched suppliers.

Such markets appear to be zero-sum games: a new entrant or product only can succeed by taking share away from the entrenched incumbents. And this seems extremely difficult to do because of very slow growth and replacement rates, and the strong relationships incumbent suppliers have with their customers. Why bother? The likelihood of success looks small.

The reason to bother is that the mental model described in the preceding paragraph is oversimplified and misleading. Innovative technology can disrupt a mature market and change its dynamics. The incumbent suppliers may be more vulnerable than they appear. The business opportunity could be enormous for a company who understands the market dynamics, constructs an effective competitive strategy, and has the strength and persistence to see it through.

Seemingly "stagnant" and "closed" markets actually can be rich in opportunity. Innovative technology can succeed in markets where there is a history of little innovation and a small appetite for risk.

This paper presents a system model of the market for technology-intensive assets.[2] It is applied to the market for military transport aircraft, a classic case of slow growth and replacement and dominance by a few suppliers. But the system model is more general. It explains important dynamics of many other markets, e.g., industrial process plants, telecom infrastructure, large-scale IT, media production and distribution, motor vehicles, and not surprisingly commercial aircraft.

The system model is an extension of research into the commoditization of technology-based products and services.[3] While a simple simulation was developed to demonstrate the key dynamics and provide quantitative results, the work described here was primarily qualitative. The objective was to demonstrate that:

- Widely held mental models of markets can be misleading;
- More complete and correct models can reveal major opportunities; and
- Conceptual models can produce valuable strategic insights.

[2] The term "system model" is used to denote a formal representation of the structure and dynamics of a market. "Model" also denotes a version of a product, in this case, a type of military transport aircraft.
[3] See Weil (1996) and Weil and Stoughton (1998) for a description of this research.

A Model of Technology Adoption

The system model provides a framework for addressing several fundamental questions regarding the dynamics of the market for military transport aircraft. What are the principal drivers of demand? How will the aircraft sales develop? What factors determine the penetration of a new product? What is the realistic scenario for a new transport aircraft? And what are the strategic implications of the dynamics?

Several interrelated dynamics will determine how the market develops.

- Increased user confidence;
- Learning curve effects and economies of scale;
- Requirements driven substitution;
- "Moving down the bottle;" and
- Building programme momentum.

The system model explains these dynamics. The basic cause/effect relationships are presented in Figure 1.

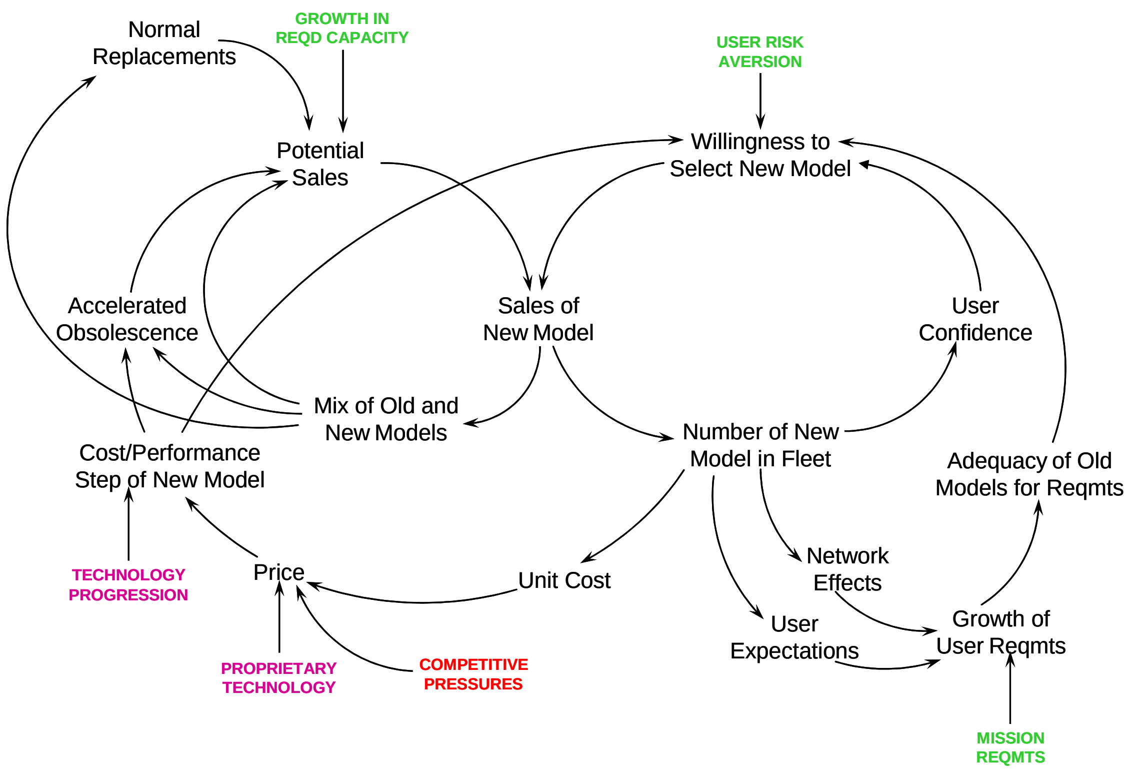


Figure 1: Basic Cause/Effect Relationships

Potential sales of a new aircraft (upper left in Figure 1) has two components, i.e., growth in requirements for airlift capacity and replacement of the existing fleet. Growth in required capacity is an external input to the system model. As indicated above the growth rate is quite low. It has averaged about 2% p.a. Normal replacements are driven by the demographics of the aircraft fleet. Old aircraft are retired at the end of their operational life, which typically is 30 years.

In addition a new aircraft with a substantial improvement in cost/performance can accelerate the obsolescence of the existing fleet. Imagine a new aircraft that uses innovative technology to achieve lower operating costs, higher performance, and greater operational flexibility. Some users may decide that the advantages of this new model justify more rapid replacement of their existing aircraft. The larger the new aircraft's step in cost/performance over the old models, the stronger this effect will be.

There are important balancing loops here. When the fleet is exclusively the older aircraft the normal replacements average 3% p.a. (because of the thirty year normal retirement age) and the potential for accelerated obsolescence is high. As the fraction of the new model in the fleet grows, potential aircraft sales decline. The new model aircraft are young and will not normally be replaced for many years. And they are state of the art, and thus not candidates for accelerated obsolescence.

Some of the potential sales are captured by the new model. The fraction depends on users' willingness to select the new aircraft over established alternatives (the "old models"). This decision is complex. It involves operational, technical, financial, and behavioral factors:

- The adequacy of the old model aircraft for current and future mission requirements;

- The cost/performance step of the new model;

- User confidence in the technology and cost/performance promise of the new model; and

- The willingness of users to take risks (their risk aversion).

Decision makers must contend with important tradeoffs. Be an early buyer of the new model, or wait and see? Replace old aircraft at the normal rate, at an accelerated rate, or stretch their operational life until some of the uncertainties are resolved? Select a new aircraft which better meets mission requirements and promises superior cost/performance, or play it safe with the well established old models?

The psychology of the market is critical in shaping these tradeoffs and decisions. As shown in Figure 2 user confidence is driven by a potentially powerful reinforcing loop. The more that operators select the new model, the larger the number of theses aircraft in the global fleet. Seeing the aircraft in operation builds confidence. The mission effectiveness and cost/performance can be verified.

Early adopters are reassuring, especially if they are high prestige "reference users." For example, decision makers in Japan would find it much easier to justify selecting the new aircraft if the US or Germany had already done so and were very satisfied with its technology, performance, and economics. This important feedback loop is shown (in green) in Figure 2.

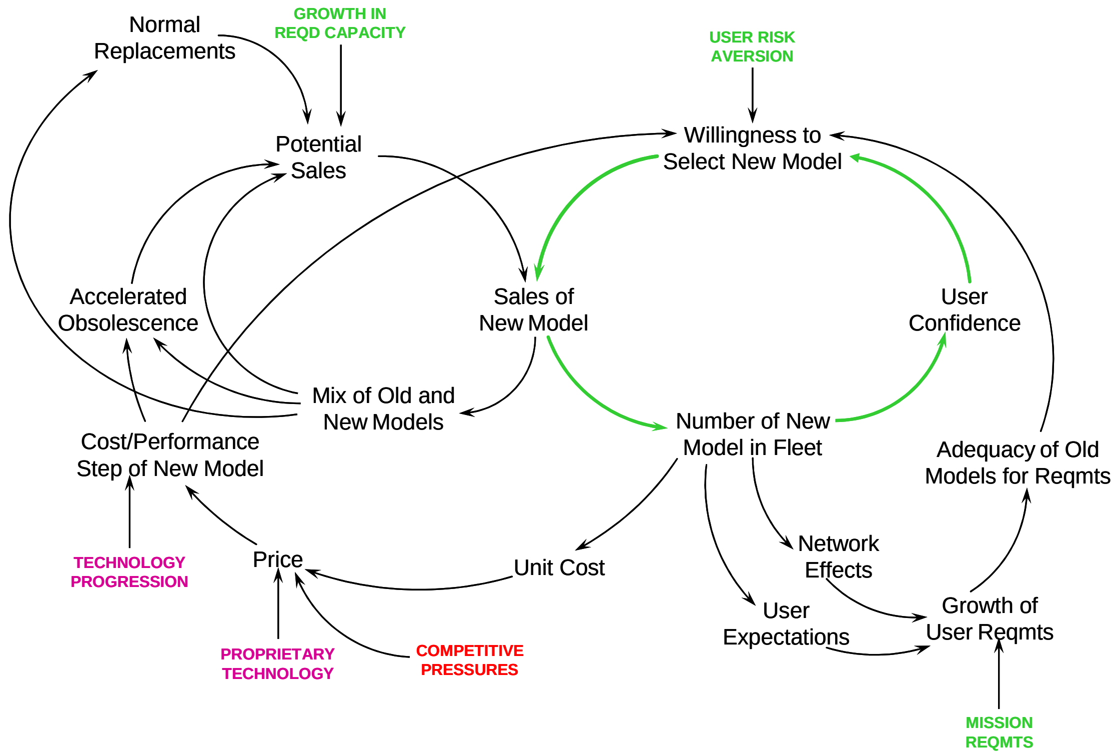


Figure 2: Increased User Confidence

Several other reinforcing loops can come into play as the new aircraft penetrates the world fleet. With most complex manufactured products there is a significant decline in unit cost as production grows. Lower costs result from both the so-called "learning curve effect" and achieving economies of scale. Productivity rises and rework falls with production experience. Non-recurring costs (for example, development of the aircraft) are amortized over an initial number of units. And as the production rate increases fixed manufacturing costs are spread across more output.

Lower unit costs means a better cost/performance ratio for the new aircraft. That will accelerate the obsolescence of older aircraft and increase the incentives and pressures to replace them with the new model. The feedback through unit cost is highlighted (in magenta) in Figure 3. It reinforces the User Confidence loop.

As more of the new aircraft enter service user expectations can change. They begin to take for granted its greater capabilities, which then become the norm. Increased user expectations drive growth of their mission requirements, e.g., range, payload, flexibility, landing/takeoff conditions, and survivability. Indeed the new model may enable entirely new missions. This Requirements Based Substitution loop is shown (in red) in Figure 4.

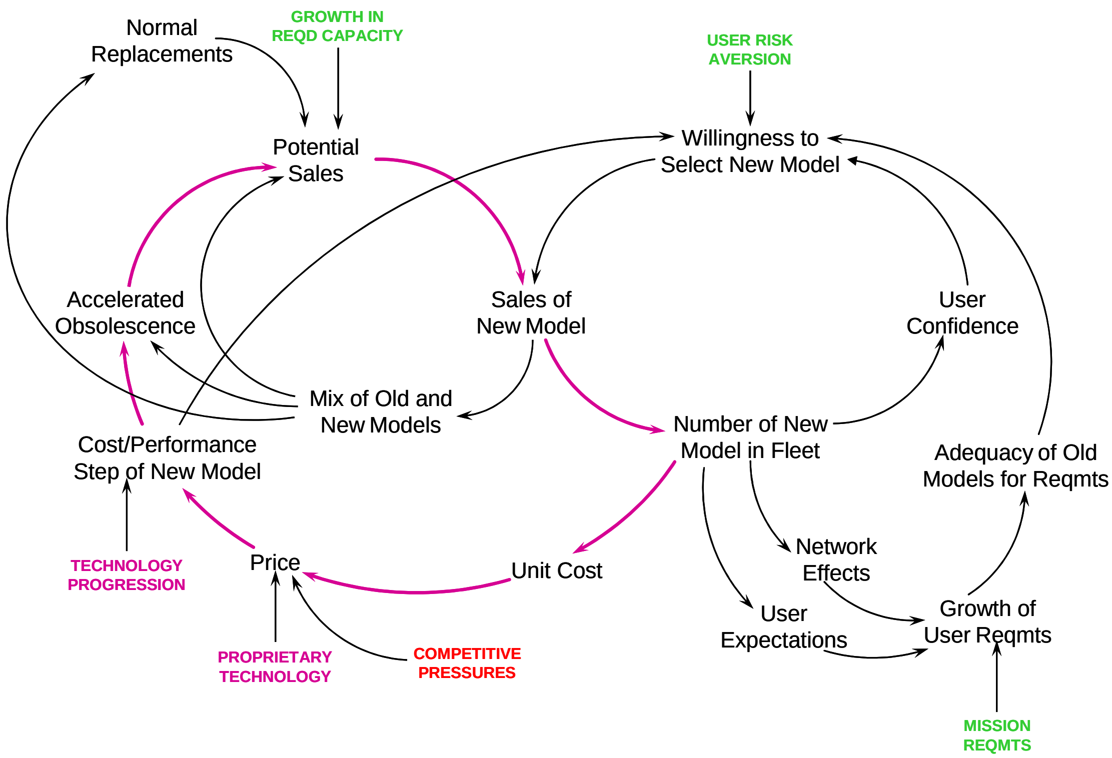


Figure 3: Learning Curve and Economies of Scale

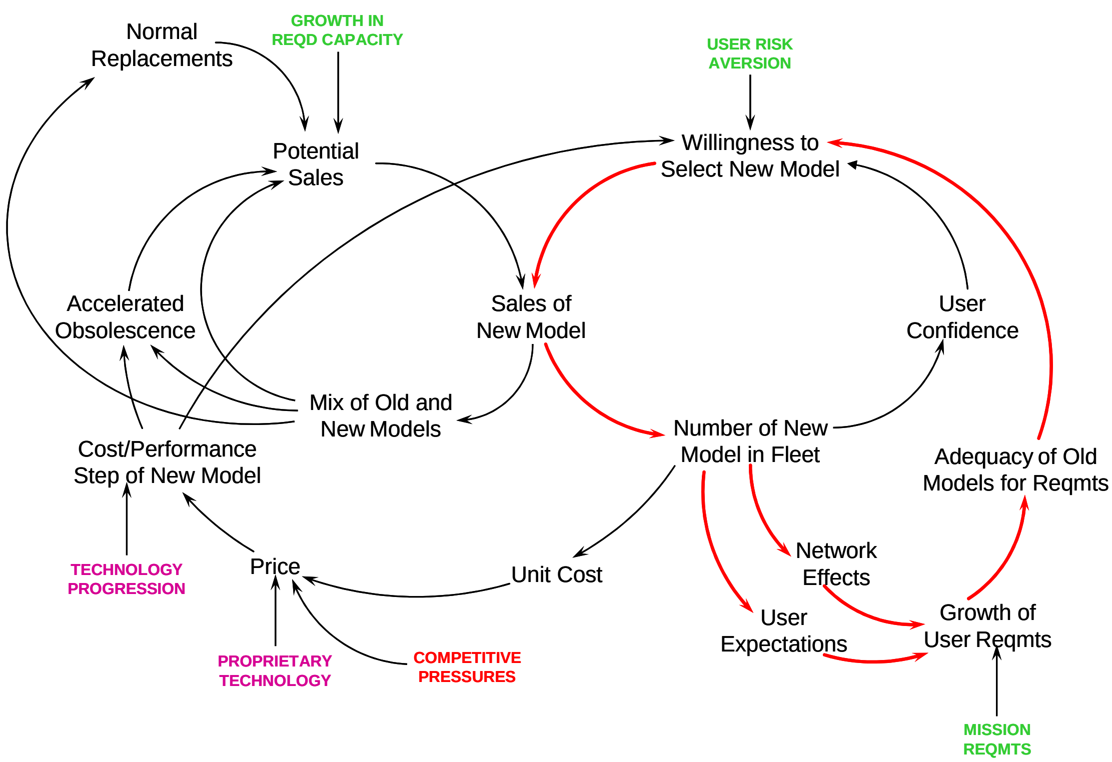


Figure 4: Requirements Based Substitution

“Network effects” denote the increased value of the new model to all operators as more of these aircraft join the world fleet. Users can conduct joint operations with a growing number of other users. They can support one another more easily, for example, with spare parts and technical services. Thus as the number of new aircraft in the fleet increases the old models look more and more inadequate.

As indicated above there are important balancing loops in the system model. “Moving down the bottle” denotes progressing from the heavy cream to the light cream, whole milk, and then thin milk.

When the new aircraft is first offered for sale the entire global fleet consists of old models. The average age of the fleet is high, the normal replacement rate is about 3% p.a., and the opportunity for accelerated obsolescence is quite significant. As the new aircraft penetrates the fleet, the mix between old and new changes. The average age of the fleet, the normal replacement rate, and the potential for accelerated obsolescence all decline. These loops are highlighted (in blue) in Figure 5.

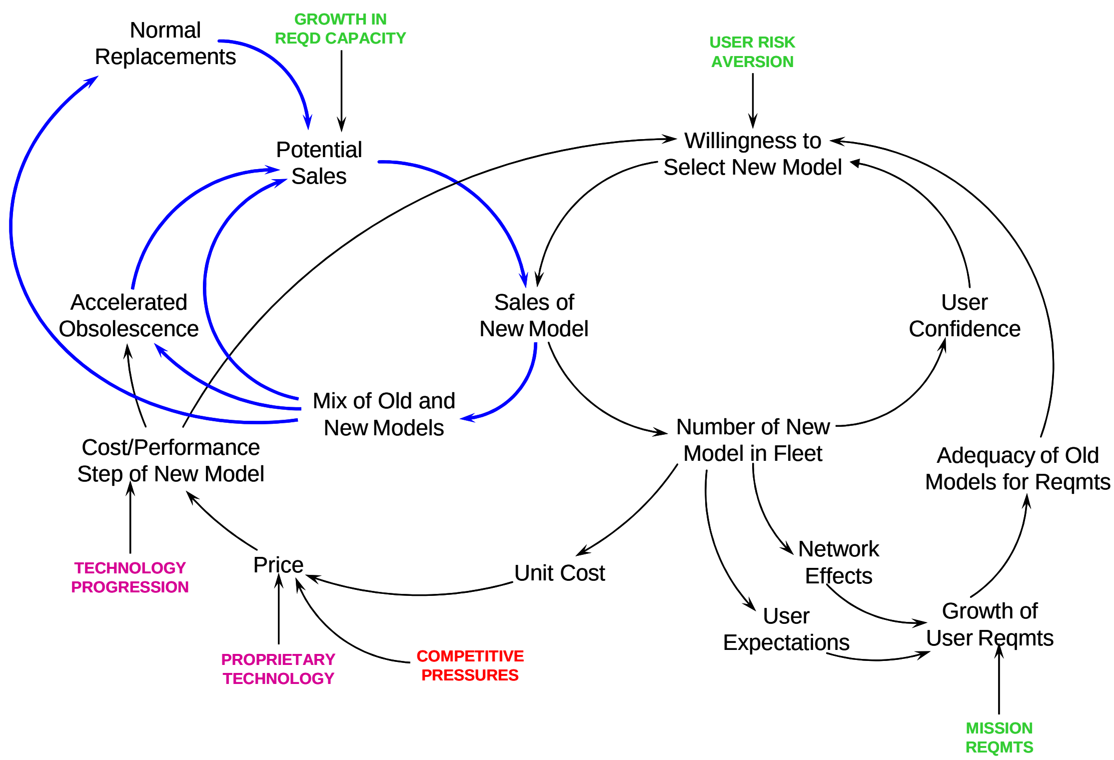


Figure 5: Moving Down the Bottle

Moreover if the new model is more productive than the aircraft it replaces a smaller fleet will provide the required capacity. Once the mix has shifted to be predominately the new aircraft, potential sales will be far lower than when the new model first was announced. The new aircraft will not be replaced for many years. Some users will cling tenaciously to the old models, stretching their lives. At this stage the milk will be ***very*** thin.

The final set of dynamics pertain to building the momentum of the new aircraft programme. When the new aircraft first is offered for sale it only exists on paper and in computer simulations. None have been built; no user is flying them. The commitment of industrial partners and lead users is uncertain. The number of firm orders is small. Quite understandably there are doubts: is this programme for real, is it going to happen, and will it be a success?

Like the psychology of the market, the psychology of the programme is critical. Powerful reinforcing dynamics can build the perceived reality of the new aircraft. But they are difficult to get started. These reinforcing loops can be seen in Figure 6.

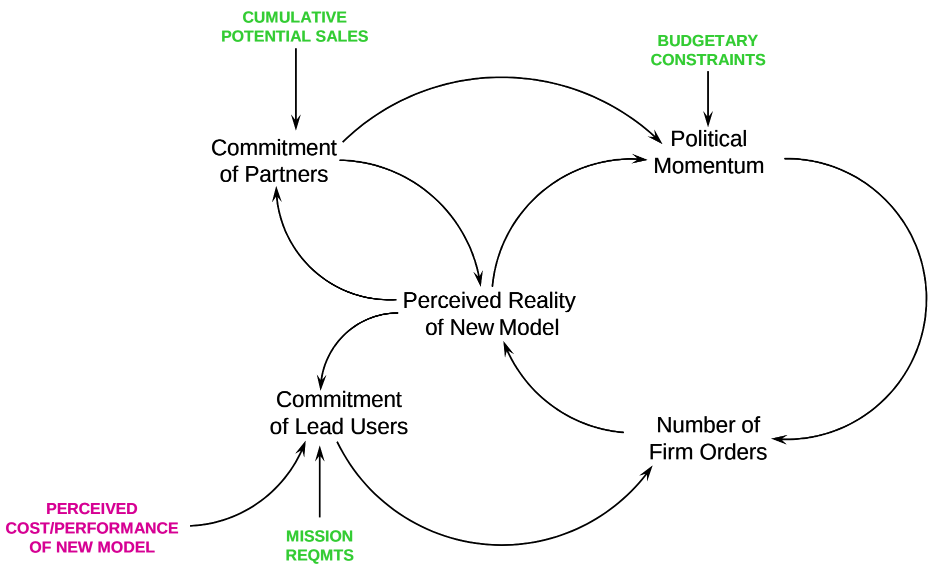


Figure 6: Building Programme Momentum

Since these are military aircraft, purchased by government ministries, building political momentum behind the new model is fundamental. Political momentum is created by the commitment of key industrial partners, particularly major companies in the lead user countries. They could be suppliers of engines and avionic systems, or manufacturers of important subassemblies. If key partners believe the programme is “real” their enthusiasm and commitments (to participate and invest) will have a significant impact.

The number of firm orders is a very tangible and convincing sign that this programme is for real and will be successful. Firm orders come from committed lead users (in this case Defense Ministries) with encouragement, support, and budget allocations from their political masters. The positive feedbacks here are very tight. Partners commit when they are confident the programme is real. So do lead users, and politicians. There can be a very powerful bandwagon effect.

Market Scenarios

The system model described in the proceeding section was used to develop three alternative scenarios for the military transport market.

- Base Case – potential customers for the new aircraft need to be convinced;
- Downside scenario – there are few customers for the new aircraft after the initial group; and
- Upside scenario – momentum for the new aircraft builds rapidly.

These scenarios are not forecasts. They come from a qualitative, but highly disciplined consideration of the elements in the system model and their interrelationships. The scenarios illuminate the range of possible market behaviors and outcomes. Two important criteria guided the selection of scenario elements: very substantial leverage on the dynamics of the market combined with a high degree of uncertainty.[4]

The Base Case is the most likely scenario. The initial orders from launch customers are followed by a slow period where there is considerable interest in the new aircraft but few additional orders. At this stage other potential buyers take a "wait and see" approach. They lack sufficient confidence to select the new model. Suppliers of the old models are dismissive of the new aircraft. The slow period seems to confirm that it has failed to gain momentum in the marketplace. The dominant incumbents feel confident and secure.

In year six the first aircraft are completed and delivered. Now there is a tangible product to evaluate. The cost/performance promise can be validated and satisfied lead users can serve as reassuring precedents. After the new model enters service a second wave of orders occurs. These orders come from a combination of the launch customers, their political allies, and other major users of transport aircraft, e.g., Japan, who are ready to commit.

Suppliers of the old models finally recognize the new aircraft as a serious challenge. They respond with more aggressive pricing, evolutionary product upgrades, generous trade-in offers, and concessionary financing. The competition becomes increasingly politicized, with suppliers of the old model seeking government assistance to pressure potential buyers to select their aircraft. The result is a stalemate. Another slow period follows, with few orders for either the new aircraft or the old models.

As time passes the new aircraft is tested in action. Its innovative technology produces very impressive mission performance. This further increases user confidence and leads to a third wave of orders. The positive feedbacks shown in Figures 2 through 4 and 6 are strengthened. Powerful tipping dynamics build momentum. The network effects, economies of scale, and user expectations and requirements are all driving the market in favor of the new model. The result is accelerated replacement of old aircraft.

---

[4] For discussions of scenario planning see Wack (1985) and de Gues (1988). Weil (1990) describes the synergy between scenario development and strategic modelling.

From this point forward the new model wins a steadily growing share of new aircraft sales. The suppliers of the old models introduce new products, but they are too late for the replacement wave. The replacement wave is limited by the balancing loops highlighted in Figure 5. The fleet stabilizes. It is dominated by young aircraft which will not need replacement for many years. The window of opportunity has closed. And the new aircraft has successfully captured a substantial fraction of the global fleet.

In the Base Case scenario most customers have to be convinced. The developer of the new aircraft makes no serious mistakes, while the suppliers of the old models are complacent and wait too long before taking the challenge seriously. Aircraft sales are quite volatile. There are four waves of orders over 14 years with slow periods in between. Success of the new model is not evident until 7-8 years after product launch. Thus there are very significant risks of misinterpreting the market dynamics and making major strategic errors during the early stages.

The major elements of the Base Case scenario are summarized in Figure 7.

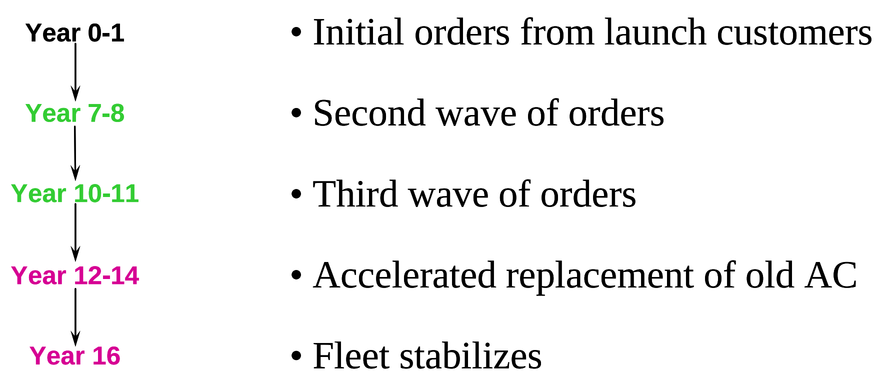


Figure 7: The Base Case Scenario

In the Downside scenario the new aircraft fails to develop momentum. The key difference between the Downside and Base Case scenarios is the reaction of the innovator to more aggressive competitive behavior by the established incumbents. In the Downside scenario the suppliers of old models respond immediately. They offer a combination of lower prices, generous trade-ins, and concessionary financing for their old models and also announce completely new aircraft.

This strong competitor response catches the innovator by surprise. It reacts defensively, without fully understanding the implications of its actions. Development of the new aircraft is accelerated, its price is cut, and many design changes are made. The programme is very seriously disrupted. Significant delays, cost escalation, and technical problems emerge.[5]

[5] The dynamics of programme performance are analyzed in Cooper (1980), Weil and Dalton (1992), and Lyneis, et al (2001).

Potential users of the new aircraft lose confidence and grow increasingly cautious. Moreover the governments supporting the suppliers of old models turn up the heat. The arm-twisting of potential buyers becomes extreme. As a result the old models win several high-profile "trophy" procurements, e.g., Japan or Saudi Arabia.

At this point the launch customers for the new aircraft waver. They refuse to fund the cost over-run and openly criticize the programme's management. Then a key launch customer breaks ranks, saying it cannot wait for the new aircraft, the costs have become too high, and there are too many uncertainties.

The tipping dynamics build momentum in favor of the old models. The new aircraft captures a small number of additional orders over the next few years. But the accelerated replacement is much less than in the Base Case. The fleet stabilizes with a wider age distribution and is comprised primarily of old models. Sales of the new aircraft dry up. The programme is a failure.

As shown in Figure 8 the Downside scenario develops faster than the Base Case. Competitors see the threat and respond quickly. The innovator makes a major strategic error and shoots itself in the foot. There is only one substantial wave of orders. In the Downside scenario there are few customers for the innovative new aircraft after the initial group. The handwriting is on the wall by year five.

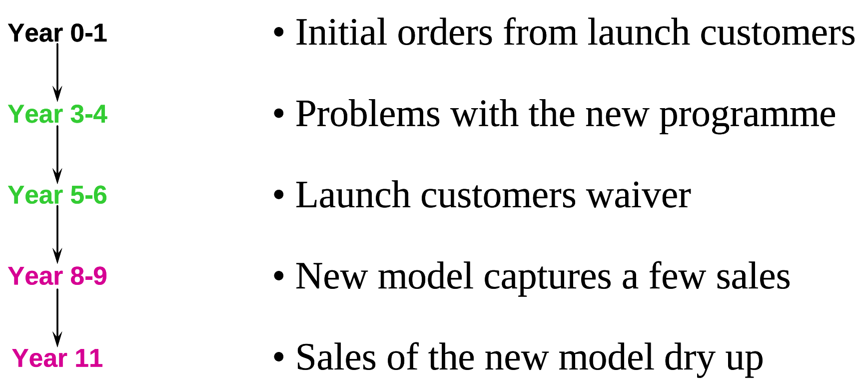


Figure 8: The Downside Scenario

The Base Case and Downside scenarios reveal a very significant issue. The success of failure of a new product with innovative technology depends primarily on how the competitors behave. If the innovator avoids mistakes and the established suppliers are complacent and slow to react, the outcome is success for the new product.[6] If however the incumbents react quickly and effectively they can use their strength to exploit the missteps of the innovator and marginalize the new product. The tipping dynamics are strong and unforgiving.

[6] This is the behavior of incumbents described in Sull (1999) and Christensen and Overdorf (2000).

In the Upside scenario the innovator seizes the initiative. The objective is to drive the tipping dynamics quickly and irreversibly in favor of the new aircraft. The developer of the new model announces a major product variant, i.e., a commercial freighter version, during the slow period which follows the launch orders. Now it can use two products to build momentum in the reinforcing loops. In addition the innovator extends capacity leasing, which has changed the face of commercial aviation, to military airlift. This enables it to win several trophy orders sooner, e.g., from Canada, Australia, or FedEx.

The established suppliers are caught wrong-footed. They react defensively with price cuts, low-cost upgrades for older aircraft, and very generous trade-in offers. The developer of the new model strikes again. It announces an innovative service proposition: "airlift à la carte," a total service where the customer pays for aircraft use. Governments friendly to the innovator attack the incumbents for predatory pricing and abuse of market dominance. The weakest of the old model suppliers throws in the towel. It sells its military transport business and exits the market.

Multiple crises requiring substantial airlift erupt around the world. Each crisis is different, demonstrating the requirement for great mission flexibility. This stimulates very accelerated replacement of older aircraft. Highlights of the Upside scenario are shown in Figure 9.

Year 0-1	• Initial orders from launch customers
Year 5-6	• Trophy orders for the new model
Year 7-8	• Innovator announces airlift à la carte
Year 9-11	• Very accelerated replacement
Year 13	• Fleet stabilizes at a higher level

Figure 9: The Upside Scenario

Even in this scenario the new aircraft does not dominate the market. Industry consolidation results in fewer but stronger competitors, analogous to the situation in commercial aircraft. The new model does win more than 50% of orders. And the total volume of orders is higher than the other scenarios because of greater replacements plus the sale of freighters. When the fleet stabilizes, it is larger than in the Base Case. It is dominated by young aircraft and the new model has captured a substantial fraction of the global fleet.

In the Upside scenario momentum for the new aircraft builds rapidly. These dynamics are driven by a series of carefully targeted and timed preemptive moves by the innovator which stimulate the reinforcing loops. In addition the innovator redefines the market, first by extending it to commercial freighters and then by transforming the products into a service proposition. This strategy puts competitors on the defensive, and keeps them there. It leads to a larger overall market, shared by a smaller number of competitors. The developer of the innovative new aircraft is the big winner in the Upside scenario.

Conclusions

All three scenarios have common features. The early years are the defining period. As discussed above the market dynamics and outcomes are particularly sensitive to the behavior of the competitors immediately following launch of an innovative new product. The reactions of the innovator and incumbents determine the strength the reinforcing feedbacks, momentum the new product acquires, and direction of the tipping dynamics. The combinations considered are summarized in Figure 10.

INCUMBENTS \ INNOVATOR	missteps	no mistakes	attack
complacent		Base Case	Upside
quick response	Downside		

Figure 10: Summary of Scenarios Considered

In all of the scenarios there is a significant delay between the launch of the new product and the major sales opportunity. The largest wave of sales occurs 7-10 years later. And following one or more waves of sales the installed base stabilizes, dominated by young equipment which will not be replaced for many years. At that point the principal opportunity shifts from product sales to after-market services.

Several strategic conclusions emerge from this analysis:

- Mature markets can be disrupted with innovative technology;

- Momentum and tipping dynamics are key;

- Initiative is rewarded;
- Once on the defensive, it is very difficult to recover; and
- The prize is the installed base!

The system model and conclusions presented in this paper apply to markets with slow growth, long asset replacement cycles, and dominance by a few suppliers. The model explains important dynamics of these markets, e.g., aircraft, industrial process plants, telecom infrastructure, large-scale IT, media production and distribution, and motor vehicles.

The strategic conclusions are significant. The conventional wisdom about mature markets is oversimplified and misleading. Innovative technology can disrupt a mature market and change its dynamics. The business opportunity could be enormous for a company who understands the market dynamics, constructs an effective competitive strategy, and has the strength and persistence to see it through.

For example, there are approximately 2,200 military transport aircraft in the world fleet with an average age of 27 years.[7] This market could generate sales of 1,000 aircraft over the next 20 years, assuming a retirement and loss rate of 2.5% p.a. The Base Case scenario sales projection from a simple simulation of the market is presented in Figure 11.[8]

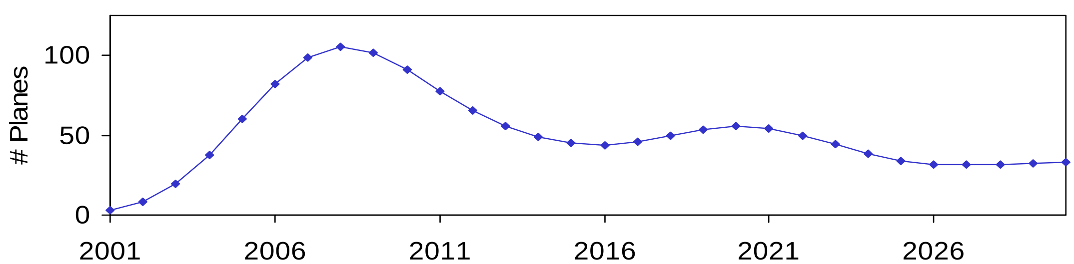


Figure 11: Base Case Scenario Aircraft Sales

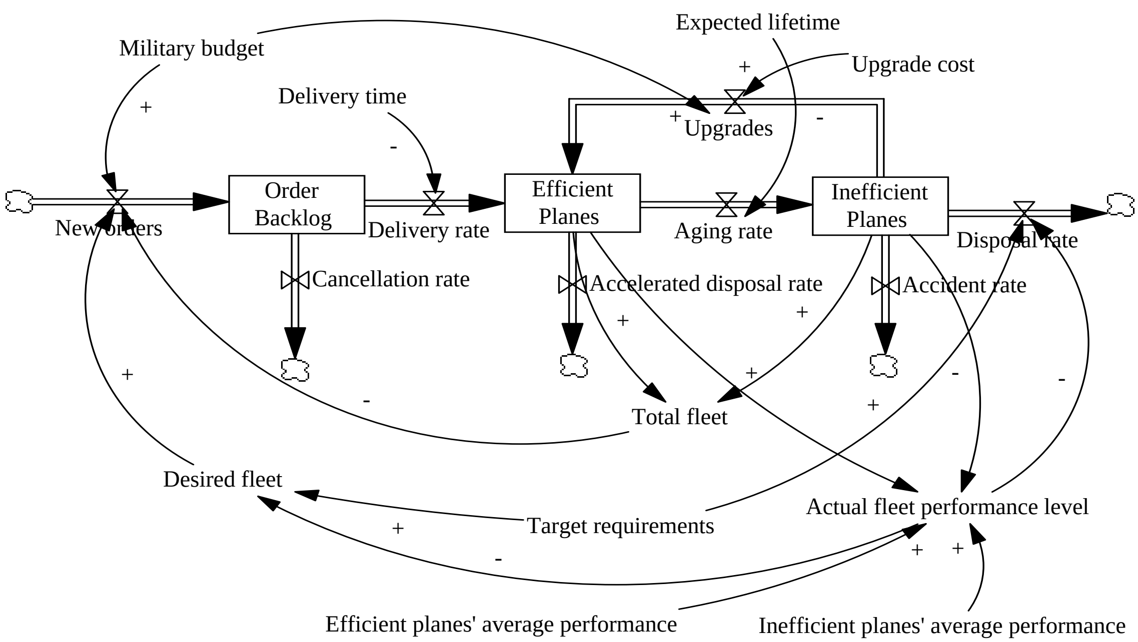
Accelerated replacement could substantially increase the opportunity. At a price of $80 million per unit sales of 1,000-1,300 aircraft would translate into a $80-100 billion market. And if an innovative new product captured 30% of that revenue the prize would be $25-30 billion. It is a major opportunity, and with the right strategy, worth the bother!

[7] Source: Airbus Military.
[8] Source: MIT Seminar in Competitive Strategy, 2001, Military Transport Aircraft Project. A diagram of the simulation model is included in Appendix A.

Appendix A

The simulation model represents the overall demand for military transport aircraft.[9] There are four principal determinants of demand:

- The projected need for airlift capabilities (Target requirements);
- The availability of funding (Military budget);
- The age and performance of the existing fleet (Expected lifetime, Actual fleet performance level); and
- The length of the order lead time (Delivery time).



[9] Source: MIT Seminar in Competitive Strategy, 2001, Military Transport Aircraft Project.

References

Christensen, Clayton M. and M. Overdorf, “Meeting the Challenge of Disruptive Change,” Harvard Business Review, March-April 2000, pp. 66-76; reprint no. R00202.

Cooper, Kenneth G., “Naval Ship Production: “A Claim Settled and a Framework Built,” Interfaces, Vol. 10, No. 6, 1980, pp. 20-36.

de Gues, Arie P., “Planning as Learning,” Harvard Business Review, March-April 1988; reprint no. 88202.

Lyneis, James M., K. G. Cooper, and S. E. Els, “Strategic Mangement of Complex Projects: A Case Study Using System Dynamics,” System Dynamics Review, Vol. 17, No. 3, Fall 2001, pp. 237-260.

Sull, Donald N. “Why Good Companies Go Bad,” Harvard Business Review, July-August 1999, pp. 42-52; reprint no. 99410.

Wack, Pierre, “Scenarios: Uncharted Waters Ahead,” Harvard Business Review, September-October 1985; reprint no. 85516.

Weil, Henry Birdseye, “Strategic Learning: Preparing Senior Managers for the Future,” in Vers une École Européenne du Management Stratégique, Paris: AFCET/AfplanE, 1990.

Weil, Henry Birdseye, “Commoditization of Technology-Based Products and Services: A Generic Model of Market Dynamics,” Sloan School of Management Working Paper #144-96, Massachusetts Institute of Technology, Cambridge, March 1996.

Weil, Henry Birdseye and W. J. Dalton, "Risk Management in Complex Projects," in J. A. M. Vennix, J. Faber, W. J. Scheper, and C. A. T. Takkenberg, eds., System Dynamics 1992, Utrecht University, 1992.

Weil, Henry Birdseye and M. Stoughton, “Commoditization of Technology-Based Products and Services: The Base Case Scenarios for Three Industries,” Sloan School of Management Working Paper #176-98, Massachusetts Institute of Technology, Cambridge, January 1998.