Policy on Emerging Technology: Roles of Individuals and Organizations Case Study Analysis

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Preface

When policy decisions are made regarding emerging technologies, what are the roles of individuals and organizations? Do engineers, social scientists, business leaders, government officials, and the public have better chances as individuals than as part of larger collectives to influence the adoption or failure of technologies? The intuitive answer would seemingly be “it depends.” It depends on the technology, the marketplace, the environment, timing, and so many other factors such that any cross-cutting themes appear elusive. However, through examination of a limited number of emerging technology case studies, perhaps some useful rules of thumb may emerge. In this paper, the goal is to examine packet switching, the minicomputer, the global positioning system (GPS), a re-engineered drug (Allegra), supersonic transport (SST), and unmanned aerial vehicles (UAV) as examples of emerging technologies and draw conclusions on how the roles individuals or organizations affected the outcome of the emerging technology.

Difference between Policies and Decisions

When analyzing the six case studies, it is important to differentiate between policies and decisions. For example, the decision made by Ken Olsen at Digital Equipment Corporation to not pursue the desktop computer market is not a policy. Neither is the FDA pulling Seldane off the market when it was causing harm to people. However, the idea to test for adverse drug reactions through a multi-stage clinical trial process can be captured by a policy geared to protect the citizens. Similarly, if Olsen had adopted a policy of listening to what the users of computing equipment sought, he may have arrived at the conclusion that the microcomputer would eventually unseat the minicomputer. The influential technologist Jay Forrester clearly explains the difference between policies and decisions:

> *Decisions are made moment by moment as time progresses. Decisions control present action. One can act only at the present time. One can not act yesterday or tomorrow. By contrast, policies are the rules that determine the making of decisions. If one knows the policy governing a point in a system, one then knows what decision will result from any combination of information inputs. Unlike decisions, policies are timeless and enduring. If a policy is sufficiently comprehensive, it can continue to apply over an extended interval of time.* [1]

Motivation

Why does it matter for an individual or organization to take on the task of influencing emerging technology policy? Besides the obvious fame and monetary gains to be made in being right about the future, that person or group may be concerned with the positive and destructive consequences of new technologies. For example, policies which encourage technology advances to benefit society or portions thereof may also harm society in unintended ways. Society correctly anticipated trading a reduction in urban manure with an increase of smog in our cities – both consequences due to the introduction of the automobile – so why did society miss the resulting impact of sprawling suburbanization from the inner city?[2] Similarly, the benefits of the antihistamine Seldane were clear to the hundred's of millions who countered their runny noses and itchy eyes with the prescription drug, but who would have suspected that in combination with grapefruit juice or certain shampoos it could cause cardiac arrhythmia? Or what about the effect of supersonic passenger jets on the environment in terms of noise pollution and damage to the atmosphere? Charles Blaschke stated it well when he wrote in 1984, "For a society so adept in developing technology, we have been inept in developing the socio-political, managerial, and organizational innovations for applying that technology in such a way that society realizes its potential benefits.[3]

Massachusetts Institute of Technology (MIT) president Susan Hockfield paralleled Blaschke's quotation in her statement on the aim of MIT's Program on Emerging Technologies (PoET). She stated that rather than forecasting the patterns of future technological change, PoET's aim was to seek to understand how we as a society respond to technological changes. She said this is not just of academic interest, but has tremendous implications in government and industry.[Hockfield, 4] The ability to assess the potential impacts, good and bad, of emerging technologies, should guide our policy making processes.

Hockfield stated that it's not just a matter of being good at forecasting emerging technologies. For example, many analysts place the advent of the microprocessor as the dividing line between two historical epochs: the industrial age and the information age.[5] One such thinker, Christopher Evans, theorized the microprocessor revolution would spell the end of Communism. He predicted the technology would cause the Western economies to surge ahead while the rest of the world would become increasingly technologically dependent. Globalization and the free flow of ideas would democratize governments as the microprocessor enabled information sharing on a level never before experienced. Evans died in 1979, missing the fall of the Berlin Wall by a decade. He was basically right, at least on this portion of his prediction. He also believed the microprocessor would end war by disseminating information so broadly as to offset the traditional power base of bureaucratic elites and war planners. Moreover, the increased flow of information between rich and poor nations would begin to erode their great disparities in wealth. The importance of Evans ideas is that he was concerned with the societal implications of an emerging technology.

Following the remarks by Hockfield at the same conference[6], MIT Engineering Systems Division (ESD) Director Daniel Hastings asserted we will only be able to adequately address these [technology assessment] issues by getting people together so that serious thoughtful engineers, scientists, historians, and policy makers can learn from and build on each others' expertise and perspective. As such individuals open their minds to ideas from other disciplines, they gain new insights on technology's unintended consequences. Furthermore, by better understanding potential unintended consequences through these inter-disciplinary lenses, they may be better able to direct their individual or organized efforts towards desired outcomes.

Role of the Individual: Agent for Change

> *It's a little scary to contemplate the historical truism that there's never been a leader from one computer technology era who was also a leader in the next. I'd like to defy that tradition.*
>
> – *Bill Gates, 1995* [7]

The computer industry illustrates the significant role of individuals in pushing forward emerging technology. With familiar names such as Gordon Moore ("Moore's Law"), Bill Gates (Microsoft co-founder), Steve Jobs (Apple co-founder), and Michael Dell (founder of Dell Computer), it is difficult to image whether key advances would have occurred as rapidly without a culture recognizing and promoting individual accomplishment. Consider some key contributions made by significant figures in computer history:[8]

- George Boole, published *Laws of Thought*, establishing a link between logic and algebra
- Vannevar Bush, inventor of the first operative mechanical computer
- Jay Forrester, inventor of magnetic core memory
- J.C.R. Licklider, wrote "Man-Computer Symbiosis," describing that computers should interact and serve humans, setting the tone for time-sharing, personal computers, and graphical user interfaces
- Seymour Cray, designer of the world's first supercomputer
- Jack Kilby, co-creator of the microchip
- Thomas J. Watson, Sr., first president and CEO of IBM
- Simon Ramo, co-founder of TRW
- Kenneth Thompson, developer of Unix
- Bob Metcalfe, developer of ideas behind Ethernet, the first non-trivial local area network
- Ray Tomlinson, e-mail pioneer introduced the @ sign in addresses
- Tim Berners-Lee, creator of the World Wide Web and HTML
- Sandra Lerner and Leonard Bosack, co-founders of Cisco Systems
- Linus Torvalds, creator of the Linux operating system
- Marc Andreessen, developer of Mosaic, the first web browser with a graphical user interface, and co-founder of Netscape

Most of these contributors worked sequentially on evolutionary improvements to a predecessor technology. Many of them knew each other or shared common backgrounds such as the schools they attended or regions where they lived. Contrary to their own expectations, often the creators of emerging technology saw the future less clearly than did users and vendors of the emerging technologies.[9] Take the example of famous technologist Thomas Edison inventing the phonograph in 1877. In the following year, 1878, he published an article citing ten ways it may prove useful to the public, picking music as fourth because he thought it trivial. When Edison entered the phonograph business a decade later, he concentrated on marketing it as a dictating machine. Vendors, however, modified it to play popular music on the deposit of a coin. In 1891, Edison still was unwilling to accept these early jukeboxes that distracted from the legitimate employment of the phonograph in offices, but he finally agreed on this “amusement” use of his talking machine by the mid 1890s. The same fate later happened to the tape-recorder. It was developed by Germany during WWII, but was made into a consumer item by Sony[1] in 1950, initially as court-recorders and language instruction devices. Not until the 1960s did sales soar. Neither the phonograph nor the tape recorder were developed to meet some identifiable pressing need – neither the technologists nor the public knew what to do with them initially.[10]

Packet Switching

> *If such a network as I envisage nebulously could be brought into operation, we could have at least four large computers, perhaps six or eight small computers, and a great assortment of disc files and magnetic tape units-not to mention remote consoles and teletype stations-all churning away*
>
> *– J.C.R. (Lick) Licklider* [11]

In the case of packet switching, pre-development visionaries Vannevar Bush and J.C.R. Licklider thought about how the emerging technology may impact society. Bush had novel ideas about automating human memory. He thought connecting people through an automated communications paradigm would provide a swifter, more efficient way to share information between people, thereby allowing knowledge to evolve and endure. Society would benefit from widespread knowledge sharing that would synergistically advance society in other areas. Like Bush, Licklider's contributions to the development of packet switching were ideas rather than inventions. He foresaw the need for networked data communications connecting computers. Leonard Kleinrock and Larry Roberts took the next steps of focusing on the technical aspects of whether packet switching would work and then making it work. Due to their efforts and others, packet switching is now the dominant communications paradigm in telecommunications. Basically, in packet switching, units of information are individually routed between nodes over links which might be shared by many other nodes. This contrasts with the principal other paradigm, circuit switching, which sets up a dedicated connection between the two nodes for their exclusive use for the duration of the communication.[12] Once packet switching worked, the next set of individuals worked on applications such as ARPANET, the Internet, and the World Wide Web.

From a societal implications perspective, packet-switching is particularly interesting because it is a technology that has significant impact on how we communicate and share information. For the creators, it had the intended consequences of being economical, robust, and expandable. Unintended consequences included higher competi-

[1] At the time, Sony was Tokyo Telecommunications

tion for the incumbent telecommunications firms, an impact on the regulatory framework including FCC deregulation, a shift to a decentralization paradigm, and the notion of open architecture. Economics played a key role in the widespread adoption of packet-switching. It was deemed cheaper to implement than circuit-switching as far back as 1969, although it took about 30 years for digital packet switching to overtake analog circuit switching as the dominant technology used in telecommunications.

A rule of thumb gathered from packet-switching's emergence is that the individuals appeared focused to varying degrees on the societal impacts of the technology based on *when* they became involved with the technology. The pre-development visionaries tended to think about how the emerging technology would impact society. The intermediate stage technologists focused less on societal implications and more on making the technology work. The later stage technologists worked on applications of the technology and, like the pre-development visionaries, also thought about societal implications. While this rule of thumb focused on the role of individuals, one could argue that the organizations involved in launching this emerging technology significantly influenced how it developed as well. Assorted Academic Institutions (MIT, Lincoln Lab, Stanford, and UCLA), DARPA who ran the project out of the academic lab, RAND research funded through Project Air Force/DoD, and corporations like AT&T and BBN all affected the development with their own internal dynamics and culture. Lastly, it is important to realize the term "rule of thumb" is purposefully used because it is conceivably easy to select another group of individuals involved in the development of the technology and derive a different pattern. The "rule of thumb" is just that – a generalized pattern based on observed and recorded occurrences during the development of the technology.

Minicomputer & Ken Olsen

I think there is a world market for maybe five computers.
–Thomas Watson, Chairman of IBM, 1943

There is no reason for any individual to have a computer in their home.
– Ken Olsen, 1977 [13]

Ken Olsen, the visionary founder of Digital Equipment Corporation (DEC) who disrupted IBM's dominance of the computer industry, exemplifies the staggering effect one individual can have in wrongly assessing emerging technology. If bystanders who were there at the time are correct, Olsen missed the importance of the emergence of the microcomputer, UNIX, and networking, even though DEC initially played a significant role in the emergence of each of those technologies. Even while Olsen missed the significance of these technologies, DEC continued to do several things right. Internally, DEC established Internet connectivity, e-mail, and a variety of network services for employees years before others. In 1985, DEC was the first computer company to register an Internet domain, www.dec.com.[14] Nonetheless, DEC was in trouble. Olsen unsuccessfully tried to introduce a DEC PC in 1992 (after having failed once in 1982), but he never really committed to it. In 1992, Ken Olsen stepped down amidst massive layoffs. DEC had dominated the minicomputer business during its 35 year existence, but a rapid descent underscored miscalculated decisions made at the helm. At its peak in 1989, DEC employed close to 130,000 employees and had worldwide revenues of $14 billion, over half of which came from outside the United States. On its way down, DEC's market cap fell from $26.3 billion to $2.5 billion.[15] During the same period, IBM's market capitalization hit a high of $106 billion in 1987, but by late 1992, IBM was out of cash; its stock price had fallen 77%.

From an emerging technology perspective, the advent of the minicomputer clearly provided the technology bridge from mainframe to microcomputer. While IBM's systems were designed for highly structured, centrally-managed enterprises (with an expensive IBM mainframe at the center), DEC's minicomputer gave users freedom to get work done on flexible schedules. The mainframe, on the other hand, was rigidly controlled, located in a "glass house" guarded by strict MIS personnel who consistently explained why things could not be done or, if they could be done, why they'll be expensive and time-consuming.[15] As a result, during the two and half decade minicomputer era, ninety-one companies attempted to sell their brand of minicomputers in various industry segments.[16] The emergence of "category killers", firms that specialized in one or only few categories of product and offered a wide selection of merchandise in these categories at relatively low prices, started gnawing at DEC's spread-out businesses in the 1980's. The 800 pound gorilla was undisputedly DEC and everybody wanted a share of DEC's business. Besides direct competition from firms such as Data General (started by defecting DEC co-founder Harlan Anderson) and Prime Computer, DEC faced competition from Microsoft in the applications segment, from Oracle and Cisco in the infrastructure segment, from Sun, Compaq, Dell, and Intel in the processing segment, and from HP and EMC in the storage segment. Note that currently the 800 pound gorilla is Microsoft, which once faced serious peril in initially missing the Internet paradigm, yet managed to turn itself around to catch up and beat Netscape in the first browser wars – something akin to turning a Navy aircraft carrier on a dime to catch up with a fast moving speed boat. Like Olsen at DEC, another influential technologist, Bill Gates, is widely acknowledged as the driving force behind Microsoft's success. So far, Gates has successfully kept his company on top. Currently, Microsoft finds itself up against open source browser Firefox, open source Linux, and search-engine turned software-giant Google.

While category killers were gnawing away at various segments of DEC's business in the 1980s, the missed assessment by Olsen that the cheaper microcomputer would threaten the minicomputer market was the killing blow. "I'm quoted all the time as saying (early during the PC revolution) that there was no reason to have a computer in the home," says Olsen, "what I said, I said very carefully and knew exactly what I was saying because I had prepared it. I said, 'I don't think we want our personal lives run by computer.' If you steal something from the refrigerator at midnight, you don't want it entered into the computer."[17] Still, DEC missed the chance to play a major role in the desktop market when Bill Gates offered Olsen the chance of producing what ultimately became WindowsNT. Dave Cutler, a founder member of the DEC VMS operating system team, had the idea of a new desktop OS, but Olsen wasn't interested so Dave jumped ship to Microsoft.[18]

Note that meanwhile in 1985 at IBM, another influential technologist made his own high-impact mistakes. IBM personal computer (PC) chief Bill Lowe realized that Moore's law was working – microcomputers had been doubling in speed roughly every 18 months. He also figured out that if IBM made PCs based on Intel's fast new 386 chips, IBM's expensive and absurdly fat-margin mid-range computers would face serious competition.[15] To prevent cannibalization of the mid-range product line, the IBM response was to pass on the fast 386 chip and declare the slower 286 chip the endpoint of the IBM PC line. A small Texas maker of sewing-machine size portable computers known as Compaq seized the opportunity and charged ahead with a 386 offering that ran much faster than anything IBM had. From this point forward, in computer magazines and in the minds of consumers, PCs became designated by their processor speed more than their brand name. Although IBM soon changed directions by manufacturing 386 chip PCs, they became lumped in with the rest of the clones as just another PC. IBM's share of the personal computer market steadily declined from about 50% in 1984 to about 15% eight years later. Ironically, the small computer maker Compaq had a spare $9.6 billion laying around to buy the remains of DEC in 1996.

GPS & Brad Parkinson

> *We cancelled 621B, but what I want you to do is go back, reconstitute it as a joint program, and bring it to me as quickly as you possibly can, and I am very, very certain that we are going to approve it.*
>
> *– Brad Parkinson's account of Deputy Secretary of Defense for Research and Engineering Dr. Malcolm R. Currie's instructions to Parkinson to resurrect GPS (then known as 621B) within one hour after being cancelled[19]*

According to Dan Hastings, the Global Positioning System (GPS) is both a success and a failure: it is a technology success, but the creators failed to assess the impact it would have during its development. It was cancelled three separate times by the Air Force, each time for budgetary reasons supported by the arguments that it was only a back-up system for the existing LORAN system[2] and accuracy greater than 15 meters was not needed for nuclear weapons anyway. Each resurrection of GPS was due to the efforts of one or more individual champions, making the case for the necessary role of strong leaders in the adoption of emerging technologies.

Brad Parkinson was a critical part of every GPS resuscitation. Steven Strom summarized Brad Parkinson's role in pushing GPS forward:

> *As a young Air Force colonel in the 1960s, Parkinson was the person most responsible for synthesizing elements of the competing navigational systems proposed by the Space Division and supported by Aerospace, the Applied Physics Laboratory, and the Naval Research Station into a single, viable concept. He then tirelessly pushed his vision through the Department of Defense (DOD) until he obtained approval for the program in 1973. After receiving permission to go ahead with GPS, which became the first joint, multiservice, military program office, he shepherded GPS through the developmental phase of concept validation. This phase successfully launched the first GPS satellites, tested the user equipment, and verified the 10-meter accuracy proposed by Parkinson. With the validation complete, he retired from the Air Force in 1978.*[19]

[2] LORAN (LOng RAnge Navigation) is a terrestrial navigation system using low frequency transmitters that use the time interval between radio signals received from two or more stations to determine the position of a ship or aircraft.

Parkinson said the whole enterprise "came perilously close to cancellation." The Defense Systems Acquisition Review Council rejected the first GPS proposal presented to them in August 1973 on the grounds that it was an Air Force creation, not a true joint effort. Dr. Malcolm R. Currie, the deputy secretary of defense for research and engineering (and number three person in DoD), immediately encouraged Parkinson to resubmit GPS as a joint program with high assurances that it would find funding approval. Parkinson gathered a dozen GPS program officials together and over a holiday weekend in a "neutral" room on the deserted fifth floor of the Pentagon synthesized a truly multi-service approach that gained quick approval.[20] According to Parkinson, following that first failure, there were a series of decisions made every three or four years in which the Air Force offered up GPS for total cancellation. In each case it usually was someone in the civilian chain of command, usually at DOD, who stepped in and reversed the decision.[19]

As any emerging technology, GPS had both anticipated and unanticipated applications. For example, Global Positioning Systems are being used in Iraq to fight the war, in Africa to smuggle diamonds, in the U.S. to track prisoners on parole, and just about everywhere from Mongolia to Memphis to guide boats, cars and even farm tractors.[21] Along with early military applications in the first Gulf War, other uses from the same period of development included navigation for sailboat racing and surveying for land development.[3] According to University of Arkansas Professor Mary Good, much later DARPA later initiated a program to put GPS in wristwatches, but Casio did it before DARPA's programs even got funded [Good, 4], demonstrating again the rapid adoption of the technology by previously non-represented interests.

The public, originally completely non-represented in this technology's development, became a significant force in policy formulation as the technology matured. Specifically, the unintended consequence of turning off selective availability (GPS' encrypted signal mode for degrading the accuracy of navigation from about 10 meters to about 100 meters) during the first Gulf War was a public outcry to keep the signal off.[4] President Clinton signed an executive order in May 2000 to keep selective availability off to benefit both non-military equipment bearers as well as tens of thousands of soldiers outfitted with commercial GPS receivers (which was the original reason selective availability was turned off during Operation Desert Storm: 10,000 commercial receivers not capable of decrypting the selective availability signal were rushed to deployed troops). The next generation of GPS, called Block III, shall push development of new technology which will allow focused degradation of the signal over selected geographic areas rather than the current all-or-nothing approach. Many sources interpret the ability to derive an accurate location estimation even when selective availability is "on" as an indication that the encryption had been broken. This is not correct – cunning work-arounds evolved to arrive at similar accuracies with the degraded signal on or off. For example, a method known as differential GPS takes many measurements over a period of time to probabilistically derive accurate location measurement.

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[3] A marvel of engineering for its time, the Texas Instruments TI-4100 led the way by being the first commercially available GPS receiver. While bulky by today's standards, the $140,000 instrument was snapped up by surveyors and explorers and used for remote surveys all around the world. The unit was about the size of a small box, weighed probably 80 pounds, needed two 12V car batteries to power it, and tracked a only 5 GPS satellites using a multiplexing technology (at this time there were only about 4 or 5 operational GPS satellites available).22. GPS City. *GPS City's Corporate History*. [cited 2005 December 12]; Available from: http://www.gpscity.com/history.htm.

[4] I was chief attitude control system engineer of the GPS Block IIA/IIR vechicles from 1991-1993. This reference is from personal experience.

Roles of Organizations

Often the culture of an organization can overshadow the influence any individual may hope to have. Bureaucracies are often perceived to be purposefully designed to do just that – reduce the risk of any single individual screwing things, usually at a cost of reducing the overall efficiency of the organization. This can lead to difficulties. For example, large organizations may have trouble in listening to small signals that may cause undetected changes in the overall system behavior. Sometimes it is not as simple as that – the organizational influence can be quite complex. One has only to think of NASA as an example of a complex organization where a strong culture can dominate over individual impact. Professor Alex Roland of Duke University asserted recently that NASA's space program is crippled by politics and ideology and is failure of technical assessment.[Roland, 4] The assessment of the Challenger Accident Investigation Board of NASA's space shuttle failure started by focusing on the technical problems with foam adhesion, but went on to state very clearly the role it believes the NASA enterprise played in the space shuttle disaster:

> *In the Board's view, NASA's organizational culture and structure had as much to do with this accident as the External Tank foam. Organizational culture refers to the values, norms, beliefs, and practices that govern how an institution functions. At the most basic level, organizational culture defines the assumptions that employees make as they carry out their work. It is a powerful force that can persist through reorganizations and the reassignment of key personnel.*[23]

This notion of deep-rooted organizational problems leading to significant system failures has etched itself into our national consciousness through the nightly news. More recently, for example, we heard of symptoms of this in FEMA's inability to aid distressed citizens in a timely manner after Hurricane Katrina.

Organizational influencers are not necessarily negative as in the above example. It depends on the situation. When confronted with complex and expensive technology problems such as healthcare, supersonic transport, and national airspace policy as in the three examples below, it takes government, large business, and the public combined to affect progress.

Re-engineering Drugs: Seldane/Allegra

No matter how deep one digs through historical accounts or how long one spends interviewing first-hand sources, organizational dynamics sometimes just flat-out appear more influential than individual accomplishment. For example, the influence of any single individual on policy is not at all clear in the case study of the replacement of the antihistamine drug Seldane (terfenadine) with Allegra (fexofenadine) in 1998. Specifically, the Food and Drug Administration (FDA) pulled Seldane from public prescription sales after years of growing concern about adverse drug-on-drug interactions causing cardiac arrhythmia that led to at least 15 deaths. Common household items such as shampoo containing ketoconazole or large quantities of grapefruit juice were found to potentially trigger an irregular heart rhythm in patients on Seldane. In response, Hoechst A.G., the maker of Seldane, engineered Allegra, the active metabolite[5] of the former, which did not have the toxic effects. Re-engineering the existing drug Seldane to arrive at an improved drug was an engineering first, yet was overshadowed by the tragic circumstances of why it was developed in the first place. The small Massachusetts firm Sepracor managed to claim fame and huge profits by licensing the patent rights for Allegra to Hoechst when Hoechst had missed sealing loop-holes in the way the improved version of the drug was patented. Consequently, Sepracor built a business model that lasted for several more drugs before companies got smart about closing the patent loop-holes. Ultimately, Allegra replaced Seldane just before Seldane would have gone over-the-counter anyhow, which would have greatly reduced the profit margins for Hoechst. This left open the question whether the Hoechst timing was that good or if co-ordination had taken place between the drug-maker and the FDA in timing the ban of Seldane. Hoechst quit selling Seldane in February 1998, one year after the FDA first proposed to ban it in January 1997. No individuals stood out in the examination of this case study. Historical accounts of the interactions between the doctors, FDA, drug-makers, and consumers tell a story of these active entities at an organizational level.

For the outside analyst looking in, it appears as if the organizational dynamics between these entities could be analyzed using Graham Allison's "rational actor" model of decision process.[6] In this model, stakeholders examine goals, evaluate them according to their utility, and then pick the one that has the highest "payoff." For the consumers, Seldane was of high utility – it suppressed their allergy reactions and was one of the most popular selling drugs ever with in excess of 200 million prescriptions from 1985-1992 in the US alone. Consumers still took Seldane for nine more years after the first US drug-on-drug interactions were noted and publicized. This seemed incongruous to a 1999 survey of the biggest consumer drug fears.[24] In it, the fear of adverse drug interactions was second only to the fear of being given the wrong drug. Surprisingly, many consumers actually were quite irritated when Seldane was pulled off the shelves. From the perspective of the drug-maker, Hoechst kept selling the cash-cow Seldane, generating a peak $800 million per year in 1991, while internally researching the development of Allegra. At the time, competition from Claritin was intense, but fortunately for Hoechst, it was able to masterfully time the market introduction of Allegra. On the government side, the FDA accomplished its mission of ensuring public safety according to policies which had evolved over decades. Whether the FDA was responsible for the deaths of the 15 people or if they reacted as fast as possible given the data available at the time is unclear. The FDA did mandate warning labels and increased the post-market monitoring of adverse drug reactions as a result. The FDA had the arduous task of balancing consumer safety precautions with faster drug-approval turn-arounds to help get medications to those in need. Finally, the doctors and pharmacists appeared to be acting rational as well, prescribing Seldane to those who needed it. To the doctors, Seldane was an ap-

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[5] Allegra is a metabolite of the former, providing the antihistamine effect without the toxicity. Seldane is metabolized by the liver's cytochrome P450 system, an energy-consuming degradation pathway that is easily overwhelmed. If patients take only the antihistamine, the P450 enzymes break the drug down at a predictable rate and keep blood concentrations in the therapeutic range. Unfortunately, many naturally occurring compounds are also broken down by cytochrome P450, so if a patient drinks grapefruit juice before taking Seldane, the combination saturates the pathway, allowing the drug to reach toxic levels in the blood.

[6] In *Essence of Decision: Explaining the Cuban Missile Crisis*, political scientists Graham T. Allison and Philip Zelikow describe three different ways (or "lenses") through which analysts may examine events: the "Rational Actor" model, the "Organizational Process" model, and the "Governmental Politics" model. While the book illustrates each model through specific events that took place during the 1961 Cuban Missile Crisis, its utility in general matters of organizational decisionmaking is broadly applicable to many scenarios.

proved and highly regarded early second-generation antihistamine which did not have the drowsy side effect of first generation antihistamines. Why shouldn't they prescribe it? All of these entities behaving as rational actors may help explain the interactions and, ultimately, the sequence of events leading to the ban of Seldane when it became clear it was dangerous. The suspicion that Hoechst and the FDA may have conspired in timing the ban of Seldane only once Allegra was ready, complicates the use of Allison's "rational actor" model, in which case his "governmental politics" model may better describe the politicking and negotiations that may have gone on behind closed doors. Yet no evidence or individual leadership accounts provide a basis for this suspicion.

Supersonic Travel: SST

While key individuals played important roles in developing the technology for supersonic transport (SST), the cost and scope of commercial supersonic travel made it a viable technology only with substantial government support. As such, it was a technology solely enabled by the organizational influence of government at the nation-state level, big aerospace firms, and the public rather than by key individuals. It never achieved the vision of widespread use, although British Airways and Air France's Concorde service lasted for about 30 years. In the US, Congress shut down a funded effort which lasted from 1961-1971 that never saw a US manufactured SST go beyond prototype development (Boeing never finished building the two prototypes that had been funded).

The key influencers for the development of the SST were government and big aerospace manufacturers. The sellers of the new technology tended to over-estimate the economic benefits (210-250 commercial aircraft, 50,000 jobs). However, debates surfaced as to why the technology was to be developed with government funds and if it were ever likely to be profitable for the airlines and manufacturers. Additionally, as a symbol of Cold War competition, the SST became less important on the list of US priorities as the more intense space race ate into national funds.

More significantly, in the US, the environmental concerns over sonic booms and the damage the SST might do to the upper atmosphere caused a public outcry. "The proponents of the SST were surprised by the intensity and effectiveness of the public criticism of their pet program."[10] The SST symbolized big government acting in behalf of big business without regard for the rights and well-being of ordinary citizens. Why were the proponents of supersonic travel oblivious to the factors that ultimately influenced Congress to cancel the project? In the past, the aerospace industry had consistently measured progress by faster aircraft, so it was natural to accept the SST as necessary progress. Additionally, who would have expected the public to enter the debate normally reserved for the government and business elite?

While the US cancelled its own SST program, the Anglo-Franco Concorde program was received with mixed emotions. For example, New York banned the plane outright. This destroyed the Concorde's economic prospects – it had been built with the London-New York route in mind. When the Washington-Dulles service became very popular, New Yorkers complained that they didn't have it. It wasn't long before the

Concorde was flying into JFK after all. Ultimately, however, even the London-New York route did not help. The Concorde kept flying out of national prestige until 2003 when it was deemed economically unviable. The London Times suggested British Airways was actually doing well with the Concorde economically, but was forced into retiring Concorde in 2003 because Air France and Airbus-France, the French half of the manufacturer, refused to continue supporting it. Lord Marshall, spokesman for British Airways, told The Times: “Concorde can’t keep flying unless the manufacturer is willing to go on producing the parts.” However, a 1962 treaty between the French and British governments was never invoked which obliged both to continue supporting the aircraft even if one wanted to withdraw.

Unmanned Aerial Vehicles

> *I see a manless Air Force. . . . For twenty years the Air Force was built around pilots, pilots, and more pilots. . . . The next Air Force is going to be built around scientists—around mechanical minded fellows.*
>
> *– General Hap Arnold addressing panel of scientists in 1944, as recorded by Theodore von Kármán* [25]

Hap Arnold was the visionary Air Force General who saw the future of the Air Force as one of technologists and scientists. He imparted his vision on General Bernard Shriever who headed up the Air Force’s intercontinental ballistic missiles (ICBM) programs. He also influenced a core value of the Air Force of continually seeking out cutting edge technology to support the warfighting mission. One of the latest such technologies is the unmanned aerial vehicle or UAV. As we see more of these pilot-less aircraft, concern has mounted about how to integrate them with our National Airspace System.

Formulating policy for the National Airspace System (NAS) requires organizational involvement of government agencies and the public. Traditionally, the FAA, the military, aircraft manufacturers, the airlines, and the public have been the key stakeholders. In the case of integrating UAVs safely into the national airspace, additional stakeholders include NASA, Department of Homeland Security (DHS), and the National Oceanic and Atmospheric Administration (NOAA – “the weather people”). The complexity of collaborating with many entities and obtaining consensus on NAS UAV policy has not yet become an issue, because there is none – the existing NAS evolved exclusively for manned operations and lacks regulations for UAVs. One exception to this has been devised. In 1999, the DoD and FAA developed a Certificate of Authorization (COA) for a case-by-case safety evaluation of every single UAV flight. Because the COA is a cumbersome process taking weeks to months, in the Fall of 2003, the DoD and FAA devised a special national COA specifically for the Global Hawk UAV.

Handling the ascent and descent through non-military airspace in the US has not been a public issue so far, but as the military increases the number of vehicles and the number of UAV sorties, safety concerns for the public will grow. If an UAV related accident were to occur in US skies or airports, a political reaction causing a slow-down in the development of this technology could happen, although in the long run, demand swell for current and new, yet unknown applications should keep development on track. In this case study, the public is not yet represented, but can be expected to be a major stakeholder in the future. Societal implications of unmanned autonomous flight for UAVs sized from the size of a dragon-fly to that of a jumbo-airliner should be significant. Issues of safety, privacy, environmental effects, homeland security, business models for shipping companies, and others will have to be considered, ideally by experts from different disciplines.

Conclusions

These case studies generated several ideas about the role of the individual and that of the organization in the formulation of emerging technology policies as well as the decisions made as a result of those policies. With a focus on the societal impacts of emerging technology, we see these potential rules of thumb:

- Opportunity for individuals to significantly impact emerging technology in the role of an individual appears greater in some industries. For example, in the computer and networking industries, we see a culture that recognizes and rewards individual accomplishment in developing technology.
- Less complex technology requires less collaborative input from larger multidisciplinary groups in development. Developing a microprocessor may be done in small teams while developing a supersonic travel program requires many technologists as well as policy, legal, and organizational experts.
- The societal impacts of a technology are not correlated to the complexity of the technology. Using the previous example, the impact of the microprocessor on world economies, political systems, and individual's every day way of life appear to be greater than the impact of the SST.
- Individuals appear focused to varying degrees on the societal impacts of the technology based on *when* they became involved with the it. Early visionaries and late application developers, for example, seem concerned with the applications and impacts of the technology, while intermediate stage technologists appear focused on whether the technology will work and on how to make it work.
- Contrary to their own expectations, the creators of an emerging technology often see the future less clearly than the consumers of the emerging technology. Ken Olsen and Thomas Edison both missed understanding what the consumers wanted, although in different ways. In the case of the minicomputer, Ken Olsen missed the consumers' signals about which technology (the microcomputer) they would want next. In the case of the phonograph, Edison had the right technology – he just misjudged the application consumers found for it (music instead of office dictation). In the case of GPS, enough flexibility was built into the technology to allow for many unintended applications, but what the creators missed was anticipating the public's outcry to use the more accurate mode. This eventually resulted in President Clinton's executive policy to turn off selective availability. The SST designers missed that faster was not necessarily better anymore as well as missing the interest and participation of the public in the decision to cancel the program. Prior to Seldane, the FDA was remiss in a policy to monitor post-

marketing adverse drug-on-drug reactions, simply because it had not been a significant issue before.

- The decisions made by Ken Olsen and J.C.R. Licklider support a notion that decisions depend on the prior personal preferences of key actors.
- In the analysis of the decisions made in how and when to launch emerging technology, there is little rational pro and con analysis.[McCray, 4] Often, when initially unknown information is uncovered, decision makers irrationally still ignore such data. Even after Moore's Law had been widely publicized and was clealy correct, ignoring it nearly flattened both IBM and DEC. Irrational decisions are made at the individual level and the organizational level. Allison's "rational actor" model of organizational decision making may help with case analysis, but oversimplifies the real-world and incorrectly assumes things are rational.
- Many decisions get caught up in the political environment they exist in, rather than be the consequence of rational reasoning. For example, the timing of the ban of Seldane was probably coordinated to benefit the drug-makers and perhaps political special interest groups. Rationally, the drug-maker could have decided to recall it sooner.
- Champions can save emerging technologies from failure. Brad Parkinson's dedication in reformulating GPS and appeasing the organizational entities that threatened to cut funding several times showed the effect that an individual can have on saving such a far-reaching technology.
- Champions can also willingly influence termination of a technology. It appears that while it may be very important for someone to save a program, it is less likely for a single individual to take responsibility for killing a program. Often political means are devised to hide the intentions of a single individual canceling a program by shifting the responsibility for cancellation to an organization. For example, while key politicians and engineers made each possible, the ability to point at a single figure responsible for the cancellation of the SST or withdrawal of Seldane is less likely as the influencers that terminated each appear entrenched within their organizations according to historical accounts. First-hand accounts used to uncover what really happened become valuable in this instance. When an individual does take responsibility for shutting down a technology, personal risk increases. For example, the IBM manager responsible for the decision to not shift the IBM PC to 386 chips risked his job by his faulty decision.
- The packet switching case showed that observers tend to overestimate the short-term impacts of new technologies and underestimate their long-term impacts.[26, 27] The societal impacts of the Internet were not envisioned by J.C.R. Licklider when he thought of connecting only several computers together in a network.
- Emerging technology stakeholders could benefit by staying aware of traditionally non-represented entities. In the case of the SST, we saw the public enter the decision process normally reserved for the government and business elite. In the GPS case, we saw the role of the originally non-represented public increase as the technology matured.
- The Challenger Accident Investigation Board implied a notion that large organizations may have trouble in listening to small signals that may cause undetected changes in the overall system behavior.

Scrutiny of these proposed "rules of thumb" as well as further investigation of additional case studies will help determine if they are correct, and even more importantly, useful for characterizing how society responds to changes due to emerging technolgy.

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