Dealing with the Future: The Limits of Forecasting (U)

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INTRODUCTION (U)

~~(C-CCO)~~ Today the NSA analyst is being cast, to an ever-increasing degree, as an augur of the technological future. The impact of technological change on the continued production of SIGINT has never been greater. Certainly for the SIGINT target analyst, and to some extent the other SIGINT disciplines, this is a job for which we have had no formal training. Additionally, work experience as a target analyst, which is traditionally narrowly focused, provides very poor background in dealing with the very broad trends needed to do technology forecasting.

~~(C-CCO)~~ While written from the perspective of a target analyst trained in the traditional IA career field, the lessons learned probably have wider applicability.

~~(C-CCO)~~ The purpose of this article is not to do a better job of predicting than the Agency's many experts but rather to consider how to think about the future. Where is prediction useful? Where is it harmful? What are the practical limits of forecasting when dealing with technologic change by the various agency targets?

THE PROBLEM (U)

(U) As the director stated in the *U.S. Cryptologic Strategy* last year:

> The Information Age presents the NSA/CSS with unprecedented challenges and opportunities. National security interests will shift, intelligence priorities will change, and new cryptologic customers will request varying types of SIGINT and INFOSEC support. Technologies will advance at exponential rates and demand increased investments at the same time that resources are being severely constrained by the fiscal reality that confronts the nation. Our challenge is to create the optimum cryptologic system – one that works better, costs less, and fosters an environment that seeks continuous improvement.[1]

~~(C-CCO)~~ Clearly, *information technology today is a moving target. In order for the* SIGINT system to not only successfully but optimally intersect this target, we must have some idea of where and how fast technology is moving. Forecasting has clearly become a required SIGINT discipline. Yet forecasting has its limits and pitfalls.

~~(C-CCO)~~ Fielding new systems and modifying existing ones to meet changes in the SIGINT target have also become more and more expensive as target technical sophistication is moving ahead at a rapid pace. Multiple collection and processing challenges must be met and overcome to successfully exploit modern telecommunications.

~~(C-CCO)~~ Because each technology solution will cost so much, the financial risk associated with fielding a new system will increase dramatically. In short, the cost of a wrong guess on the part of the forecaster will continue to increase. Add to this a shrinking financial base for the SIGINT system and the need to be right becomes almost critical.

~~(C-CCO)~~ Finally, the pace of technological change is ever increasing. This means that new or modified systems will have to be fielded more and more often. This in turn leads to the forecaster having to make more and more forecasts, each of the same critical nature.

~~(C-CCO)~~ Future forecasters must deal not only with *what* new technologies will be introduced but also with *when* they will be introduced. Does the SIGINT system need to spend money this year on dealing with a given technology or can it wait until next year?

(U) Working in favor of technology forecasting, there are almost no SIGINT targets left that are financially capable of independently carrying out basic telecommunications research then taking it into actual implementation. This means that trends and developments in the public telecommunications sector, more than ever, are the trends in SIGINT target telecommunications.

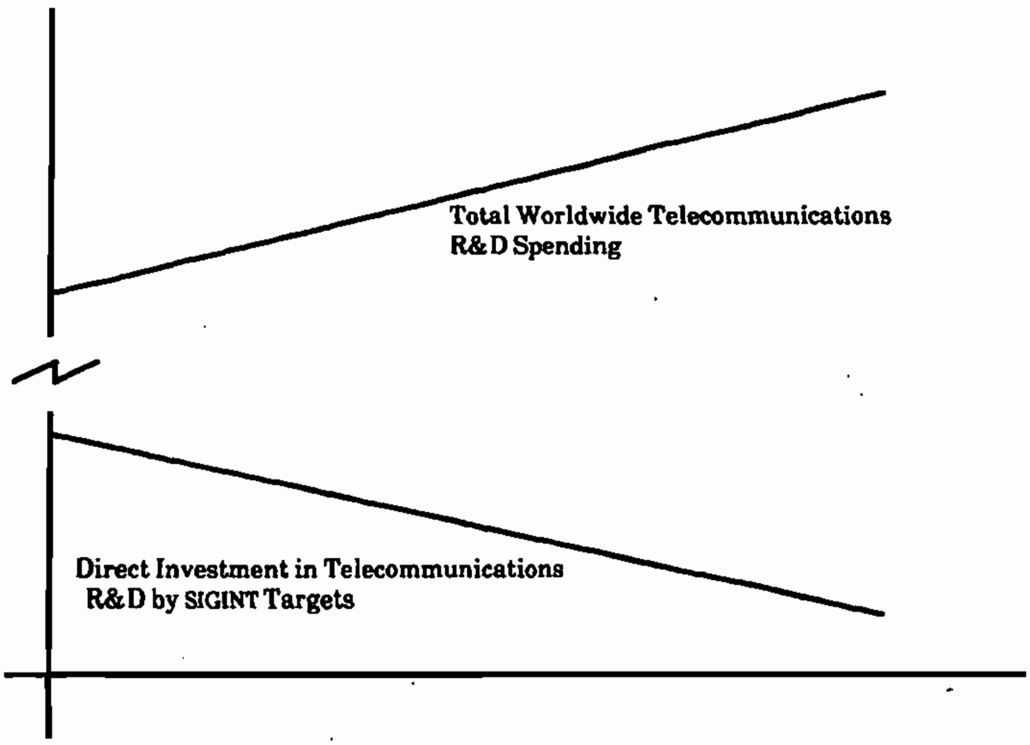

Fig. 1.

(C-CCO) Almost all major organizations in the DDO and DT are called upon to make technology forecasts, each for different reasons. Often all of these different forecasting efforts still fall short of the mark. For example, R Group can understand and make assessments of technologies far off in the future. However, R wants the various target OPIs to make assessments of what new technologies to focus on because their funding will not cover all new technologies. Target OPIs, on the other hand, generally see only what their targets are using today and in some cases what they are installing today. This is far too short a lead time to develop on-time solutions. Without a validated target OPI need, funding for R to develop a SIGINT system is very hard to justify.

(C-CCO) The problem then is how does NSA, corporately, do a better job of forecasting what technology our targets will be using? Can a forecast of future technology ever be certain enough to justify spending millions of dollars? How far into the future can we reliably forecast? What sources are the most likely to be accurate predictors of the technological future? While it is not the intent of this article to formulate the definitive answer to all these questions, perhaps it will be possible to begin a dialogue about how they could be answered.

THE NATURE OF TECHNOLOGY FORECASTING (U)

(U) The history of technology forecasting is replete with examples of failure to correctly anticipate the future. Factors which cause technology forecasts to fail have been characterized as

- Failure of nerve;
- Failure of imagination;
- Technological surprises;
- Underestimating development time;
- Underestimating complexity;
- Legal and political problems; and
- Failure to forecast market constraints.

If I had thought about it, I wouldn't have done the experiment. The literature was full of examples that said you can't do this.

Spencer Silver on the work that led to the unique adhesives for 3-M "Post-It" Notepads

Failure of Nerve (U)

(U) Failure of nerve is characterized as, having been given all of the relevant facts, the forecaster's not seeing that they point to an inescapable conclusion. It is a refusal to believe that anything fundamentally new can happen and is generally based more on emotion than reason. Established experts and committees, including working groups, are most often associated with failures of nerve. [2, 3, 4]

(U) A well-documented technology study was made by the U.S. National Research Council in 1937. The study began, "In an age of great change, anticipation of what will probably happen is a necessity for the executives at the helm of the Ship of State." The study then went on to miss virtually every major development of the next five years including antibiotics and radar (both of which had existed in nascent form for ten years), jet engines (which had been designed in theory), and atomic energy (which had been much speculated about even in the public press). [5]

(U) An example of failure of nerve that is closer to home for the intelligence community was the collapse of the Soviet Union and Communism in Eastern Europe. Despite such well-known works as Andrej Amalrik's *Will the Soviet Union Survive Until 1984?* and a growing mountain of classified data about the poor economic health of the Soviet Union, no official estimates even mentioned that the collapse of Communism was a distinct possibility until the coup of 1989.

Failure of Imagination (U)

> This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us.
>
> Western Union internal memo, 1876

> So we went to Atari and said, 'Hey, we've got this amazing thing, even built with some of your parts, and what do you think about funding us? Or we'll give it to you. We just want to do it. Pay our salary, we'll come work for you.' And they said, 'No.' So then we went to Hewlett-Packard, and they said, 'Hey, we don't need you. You haven't got through college yet.'
>
> Apple Computer Inc. founder Steve Jobs on attempts to get Atari and H-P interested in his and Steve Wozniak's personal computer

(U) To be successful, a technological advancement must be useful. Failure of imagination is the inability of experts or the marketplace to see what an innovation would be good for. Transistors are an example of failure of imagination. They were first seen as a limited application replacement for vacuum tubes. Overlooked were the transistor's inherent advantages of being able to be mass produced and miniaturized. Similar tales can be told about lasers, fiber optics, plastics, piezoelectric crystals, and many other fundamental inventions. It seems that the more basic the innovation, the more prone it is to failures of imagination. [3]

Technological Surprises (U)

> Heavier-than-air flying machines are impossible.
>
> Lord Kelvin, president, Royal Society, 1895

(U) Technological surprises are closely related to, or possibly just another face of, failure of nerve. Who in 1940 could have made a reasonable case for the computer? In 1945 for the transistor? In 1950 for the laser? In 1955 for pulse code modulation? By their very nature technological surprises are not predictable but yet ultimately have the greatest impact on the world. Who could have predicted high-temperature superconductors? Who can predict what impact they will ultimately have on technology? [4]

(U) Technological surprises can also come from the interplay of old and new inventions. The basic idea of a cellular mobile telephone system was patented in the United States in the 1920s. However, cellular telephone service was not practical until the development and maturation of the microprocessor, which made possible cell-to-cell handoff of multiple users in real time.

Underestimating Development Time/Underestimating Complexity (U)

~~(C-CCO)~~ Working in favor of the SIGINT system is the inherent lag time between the appearance of a fundamental invention and its penetration of the market place. The fundamental invention must go through the process of finding a use, the years needed to develop a manufacturing process and find developmental funding, and finally a plan to phase it into operation without disrupting ongoing operations.

(U) On the other hand, in terms of forecasting, once a technology is developed there is almost always an overestimation of how soon and how far the new technology will penetrate the marketplace. A recent telecommunications example is Integrated Services Digital Network (ISDN). Despite having been available to the public for many years and touted by many telecommunications providers as the "latest and greatest," its market penetration is still peripheral in the United States and minor in the major countries of Europe.[7,8,9,10] Estimates in 1990 placed the number of ISDN lines installed in the U.S. at around 200,000, yet a 1994 estimate [21] projected only 350,000 lines installed in 1995. By contrast, a 1990 estimate revised its projected number of installed ISDN lines by 1994 to 1.4 million. ISDN was originally tariffed in the U.S. as long ago as 1987, yet 1995 is the latest year that ISDN is expected "to turn the corner."[11] A more current example appears to be Asynchronous Transfer Mode (ATM). [6, 20]

(U) The extremely long development time for ISDN, however, appears to be the exception rather than the rule. In general, the lag time between the development of a basic invention and its large-scale impact on the marketplace appears to be ever decreasing.

Legal and Political Environment (U)

(U) The political and legal environment, and changes to it, are yet another major factor impacting on the nature, speed, and scope of technological change, especially telecommunications technology. Anyone who doubts whether the regulatory environment impacts on telecommunications developments needs only look at the new direct satellite television services. How much market penetration can they achieve if local television programing cannot be bundled and sent to the consumer when competing cable television providers are allowed to do so?

FAILURE TO FORECAST MARKET CONSTRAINTS (U)

(U) Market constraints are perhaps the most vexing of all forecasting issues. Market acceptance is almost always the ultimate test of whether an innovation succeeds or fails – and, thus, whether the SIGINT system has to spend money dealing with it or not. The vagaries of the marketplace have often scrapped the best of technical solutions and even massive investment by major telecommunications providers. Who can forget the Sony/Beta versus JVC/VHS battle for acceptance in the early days of the VCR? By all accounts Sony/Beta should have won as it was clearly a technically superior solution (better picture, more reliable tape transport mechanism, etc.) as well as a larger and more well-financed backer. Yet today even Sony makes only VHS-format VCRs.

CASE STUDIES OF TECHNOLOGY FORECASTING (U)

(U) In an effort to avoid these forecasting pitfalls, to what sources can the SIGINT analyst cum futurologist turn for assistance? Are technical experts the answer? Are the actions and plans of the large telecommunications providers of the world a more reliable indicator? Can the SIGINT analyst seek to "follow the money" in anticipation that innovations that receive the funding will win the prize of market acceptance?

The Technical Expert (U)

(U) To determine the veracity of the technical expert, a review of a telecommunications technology forecast made in the past by an accepted expert might prove instructive. Such a study published in 1971 [4] listed the following as the telecommunications inventions that would have a "shattering effect" on society in the "next two decades" (i.e., until about 1990):

- Communications satellite
- Helical waveguide
- Laser
- Large-scale integration (LSI)
- On-line real-time computers
- Picturephone
- Large TV screens

- Cable TV
- Voice answerback
- Millimeter-wave radio
- Pulse code modulation
- Computerized switching
- Data banks

In the "more distant future" chapter of his book, the author looked forward to the late 1990s.

(U) An examination of the accuracy of these predictions today clearly shows that the technical expert missed the mark by a considerable margin.

Communications Satellite (U):

> Suddenly this has provided telephone and television links to the underdeveloped world. Much larger satellites will be built and will have an enormous impact on education and communications both in the United States and throughout the world. The satellite antenna[s] in some underdeveloped countries stand next to fields ploughed by oxen.

(U) Certainly the author was very close on this one, but, to date, most communications satellite capacity is used by the developed countries, and very little is used for education in any country.

Grade: A

Helical Waveguide (U):

> A pipe, now operating, that can carry 250,000 simultaneous telephone calls or equivalent information over long distances.

(U) The waveguide plays a important but limited role in present-day telecommunications carrying microwave communications from antennas to receivers.

Grade: C

Laser (U):

> This means of transmission, still in the research laboratories, has the potential of carrying many millions of simultaneous telephone calls or their equivalent.

(U) Lasers now play a major role in telecommunications but not in the way the author envisioned. Today, long-haul communications via fiber-optic cable make almost exclusive use of laser diodes as a light source.

Grade: B

Large-scale Integration (U):

> A form of ultraminiaturized computer circuitry that probably marks the beginning of mass production of computers and computerlike logic circuitry. It offers the potential of extremely reliable, extremely small, and, in some of its forms, extremely fast computers. If large-enough quantities can be built, this circuitry can become very low in cost.

(U) A good attempt but almost a textbook definition of failure of imagination. The author did not project what effect his predicted fast, reliable, high-speed microprocessor would have on other aspects of telecommunications.

Grade: C

On-line Real-time Computers (U):

> Computers capable of responding to many distant terminals on telecommunications lines at speed geared to human thinking. They have the potential of bringing the power and information of innumerable computers into every office and eventually every home.

(U) True to a limited extent. With the advent of the personal computer, such a need was largely obviated. Interestingly, with the advent of the Internet, this may be true of the near future.

Grade: C

Picturephone (U):

> A public dial-up telephone system in which the subscribers see as well as hear each other.

(U) A clean miss.

Grade: F

Large TV Screens (U):

> TV screens that can occupy a whole wall if necessary.

(U) Except for special-purpose, high-expense applications, this one also missed the mark.

Grade: D

Cable TV (U):

> Provides a cable into homes with a potential signal-carrying capacity more than one thousand times that of the telephone cable. It could be used for signals other than television.

(U) A good solid prediction that certainly came to be.

Grade: A

Voice Answerback (U):

> Computers can now assemble human-voice words and speak them over the telephone. This fact, coupled with the Touchtone telephone set, makes every such telephone a potential computer terminal.

(U) Largely true but who, today, wants to use a telephone handset as a computer terminal? This was, however, clearly envisioning things like voice mail, call waiting, call forwarding, etc.

Grade: A

Millimeter-wave Radio (U):

> Radio at frequencies in the band above the microwave band can relay a quantity of information greater than all other radio bands combined. Chains of closely spaced antennas will distribute these millimeter-wave signals.

(U) Except for a few limited, special-purpose applications, not in use today.

Grade: F

Pulse Code Modulation (U):

> All signals, including telephone, Picturephone, music, facsimile, and television can be converted into digital bit stream and transmitted, along with computer data, over the same digital links. Major advantages accrue from this.

(U) The author was clearly correct in predicting that PCM would have a major impact on telecommunications. Again, however, the author suffered a failure of imagination as to what this would mean. A PCM signal today can be regenerated almost without loss, making it virtually independent of distance. This makes world-spanning cables and out-of-country switching possible.

Grade: B

Computerized Switching (U):

> Computerized telephone exchanges are coming into operation, and computer-like logic can be employed for switching and "concentrating" all types of signals.

(U) Computerized switching, as the author forecast, is certainly one of the key technologies in the telecommunications today.

Grade: A

Data Banks (U):

> Electronic storage for huge quantities of information that can be manipulated and indexed by computers and that can be accessed in a fraction of a second.

(U) Again, clearly a technology that has had a impact. However, again, the author failed to follow through and link data banks with computerized switching to create today's "intelligent network."

Grade: B

(U) Of at least as much importance are the technologies which the author failed to mention but which have had a major impact on telecommunications. These would include at least

Fiber-optics (author did mention them in passing as a possibility);

Grade: D

Cellular telephone networks;

Grade: F

Packet-switched data communications. (Again, the author did discuss the technical possibility of packet-switched computer networks, but it did not make his key technologies list.)

Grade: D

(U) To sum it all up, our forecaster achieved a "grade point average" of 2.07, barely a "C." And this was at a time when almost everyone would agree the pace of technologic change was slower, the regulatory environment was simpler, and the marketplace was monopolized by national-level telecommunications providers. Obviously, our forecaster, although having much of value to tell his contemporary audience (and any SIGINT planners of the day), fell short of the accuracy needed to make decisions of where to put extremely limited R&D funds.

The Telecommunications Provider (U)

(U) A review of technology forecasts by the various large telecommunications providers is somewhat harder to undertake as they rarely make public forecasts as such. However, an admittedly less than complete review of major misjudgments in the direction of the future of telecommunications may shed some light on the subject.

(U) An example of a large, well-funded, technologically sound innovation which flopped was mentioned above: the Bell System/AT&T Picturephone. This occurred at a time when the Bell System/AT&T had an undisputed stranglehold on the supply of telecommunications equipment and services to the American public. Yet after millions of dollars spent in R&D as well as marketing, the system never entered service. One would presume that AT&T fully anticipated that this innovation would be accepted prior to investing so much of its money and reputation in it.

(U) A more recent example of telecommunications providers failing to correctly forecast can be seen with ISDN. Despite millions of dollars spent by the various regional Bell operating companies (RBOCs), as well as the long-distance carriers, ISDN has yet to be accepted on a scale which would begin to approach payback. Indeed, there is growing evidence that ISDN is being passed over by at least some potential large users who think that it would be smarter to wait for broadband ISDN. Ten years, by today's standards, is an excessively long time between initial deployment and the beginning of wide-scale acceptance. [22, 23]

(U) Other prominent failures by the Bell companies in the United States include central-office based LANs and X.25 services. These are, again, services in which large telecommunications providers invested heavily in research, deployment, and marketing.[11]

(U) A system that is presently being aggressively moved into service by the large telecommunications suppliers is the new mobile satellite systems (Iridium, ICO, Odyssey, etc.). The consortiums pushing these systems have already spent hundreds of millions of dollars to overcome major hurdles in financing, technology, and regulatory environment. It is clear that many additional millions will be spent prior to initial operating capability (IOC). Yet there is a vocal, and growing, opinion that user demand will never be sufficient to achieve a sound financial return on this investment. In short, the long-term viability of this technology, at present, is in serious doubt.

(U) These are just some examples of the falsity of believing that the large telecommunications suppliers know best where the future is going or even that "following the money" will, ultimately, reliably lead to the future.

~~(C-CCO)~~ While private enterprise can gamble huge sums of money on telecommunications ventures that ultimately come to nothing, can the SIGINT system afford to do the same? Private industry can recoup losses from one bad guess with profits from one good guess. Indeed, if private industry succeeds in a single high-risk gamble, they can make up for a large number of losers. Unfortunately, the SIGINT R&D community is not in the same position. Our funding is fixed and unlikely to grow even incrementally. This means that the SIGINT analyst cum forecaster must be right more often than industry itself.

SOLUTIONS / POSSIBLE COPING STRATEGIES (U)

(U) While forecasting obviously has its limitations and pitfalls, to survive and prosper as an agency, we must do it. We can't just throw up our hands and say "if even technical experts and market insiders can't do it, how can we?" There are certainly many possible strategies for doing this. Two possible strategies to cope with the need to increase forecasting accuracy are outlined below.

Avoiding the Issue (U)

~~(C-CCO)~~ Possibly the best strategy is to avoid the issue to the greatest extent possible. The SIGINT system can do this by shortening the lead time for developing and fielding new systems to the greatest extent humanly possible.

~~(C-CCO)~~ This is clearly the approach with the greatest chance of success and the hardest to implement.

Advantages:

Lowest possible risk; the target is already using, or at least introducing, the technology.

No resources are wasted on technologies that are developed but never fielded.

All factors affecting success are directly under NSA control.

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Disadvantages:

Exceedingly difficult to implement; requires closely coordinated, extremely (perhaps impossibly) fast reaction times by private industry and many NSA organizations.

May be impossible to implement from a fiscal perspective; Congress is unlikely to allocate sufficient "contingency" money.

~~(C-CCO)~~ While it may be impractical, or even impossible, to use this as our sole coping strategy, definite progress in this area needs to be made. At present, technology forecasters in private industry believe that they can reliably forecast out to five years with ten years being outside the realm of possibility [11,12]. [redacted] These two realities appear to have very limited overlap.

Improving Forecasting Accuracy (U)

~~(C-CCO)~~ While technology forecasting is rife with uncertainty, it should be possible to improve the accuracy of such forecasts, at least for NSA purposes. This is the strategy that the SIGINT analyst can directly impact by a systematic look at the "how to" forecast. These could be considered "sub-strategies."

Evaluate Technology in Terms of Market Megatrends (U)

~~(C-CCO)~~ Market megatrends are things like

Ever-increasing bandwidth

Ever-lower channel/mile costs

Greater user mobility

Decreasing terminal equipment costs/increasing technical sophistication

Increasing deregulation

Internationalization of telecommunications

Ever-decreasing development timelines

Inventions and innovations which go against these trends are highly unlikely to succeed while those that advance them are likely to succeed.

(U) ISDN again provides a case which illustrates this point. In the United States, as outlined above, ISDN is almost universally regarded as a major technological flop. Meanwhile, in Germany ISDN is regarded as highly successful and enjoys high market penetration. Why? The United States, at least by comparison, is a highly deregulated telecommunications market. Germany, on the other hand, is still a highly regulated monopoly with a cozy relationship between the telecommunications provider (Deutsche Telekom) and the terminal equipment manufacturers and suppliers. In the United States all the various competing telecommunications suppliers worked against one another and never developed a common marketing strategy with each other let alone with equipment suppliers. This left the user, concerned with the (relatively) high costs of ISDN-capable terminal equipment, to decide the fate of ISDN. By contrast, in Germany Deutsche Telekom was able to declare, almost by fiat, that ISDN was the technology of the future. They then structured tariff rates to ISDN's advantage and insured that terminal equipment was available and compatible.

(U) Contrast this with a case study of TCP/IP and the Internet. It is interesting to note that both TCP/IP and ISDN were debuted in the United States in 1987. While ISDN was introduced with a fanfare of publicity by the major U.S. telecommunications providers all across the country, TCP/IP appeared at a fledgling trade show that attracted 675 attendees [11]. That trade show grew to be INTEROP, attracting tens of thousands of attendees annually to different venues here and abroad. The Internet, based on TCP/IP, has grown beyond all projections continuing to double in size every year. The Internet, by contrast, began as an American phenomenon and then spread to the rest of the world. While successful in Germany, it is still not nearly as widespread as in the United States. Why the difference? The emergence of the Internet was driven by users and, until very recently, was almost universally ignored by U.S. telecommunications providers. (In January of 1996 MCI became the first major U.S. telecommunications provider to offer Internet access.) In summary, in a highly regulated environment the more successful implementation was top down, while in the deregulated environment it was bottom up.

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(U) Ironically, the Internet, and its growing sophistication, may be the saviour of ISDN in the United States. Users are increasingly demanding ISDN to satisfy the bandwidth-hungry demands of home pages and other graphics-oriented phenomena appearing on the Internet. [6]

(U) It is also interesting to note that the Internet is beginning to enter the "overhyped" stage common to "FAILURE TO FORECAST MARKET CONSTRAINTS." For the first time in 1995, a market survey found the number of Internet users in the U.S. below projections. New users, who tend to be less technically sophisticated, are increasingly complaining about things such as the extremely long down-load times for graphics and the difficulty of finding information they want on-line via the Internet. [14,15]

~~(C-CCO)~~ Even larger general societal trends can be of assistance to the SIGINT forecaster. For example, there is a rapidly growing number of "telecommuters" in this country who are performing work for an office or firm from personal computers in their homes. This is adding major impetus to the growth of ISDN. [redacted]

Understand the Accuracy of Information about an Innovation and How It Changes over Time (U)

(U) The various forecasting failures outlined above can be arranged into a reasonably consistent timeline. Almost all technology innovations go through a predictable cycle of acceptance and entry into the marketplace where actual demand and anticipated demand are not in agreement. The Internet example above is an illustration of this idea. This concept is illustrated in figure 2.

~~(C-CCO)~~ This conceptual view illustrates the stages that a new technology innovation goes through during its life cycle. Also indicated are the various corresponding categories of forecasting failure as discussed above. Forecasting of an innovation's market impact is most accurate during the mid-cycle years of the innovations life cycle when its actual demand growth is most linear. [redacted]

~~(C-CCO)~~ Of course not all technology innovations are successful. Note that the point in time when an innovation most typically fails is at the very point at which its anticipated success is greatest.

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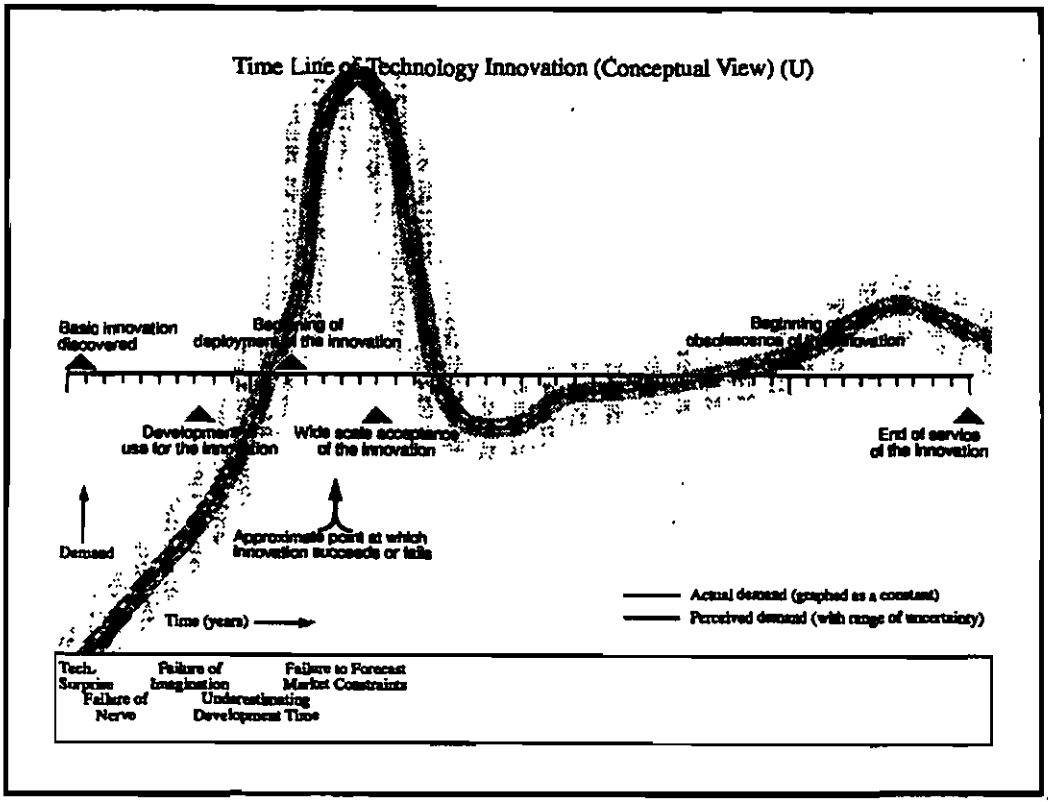

Timeline of technology innovation (conceptual view) (U)

~~(C-CCO)~~ This chart is not meant to be numerically accurate but rather to provide the SIGINT forecaster with a guide to evaluate information about a new technology innovation. It should also be noted that while all innovations go through a similar life cycle, the total length of the timeline can vary widely from one innovation to another.

Anticipate the Interplay of New Technologies (U)

(U) Further complicating the forecaster's job is that many such technological innovations are impacting the marketplace simultaneously each at a different point on this development timeline. They can often interact in ways that are overlooked by industry, which tends to look at one technology at a time. Indeed, as pointed out above regarding cellular telephones, it is this very interplay that actually leads to a new telecommunications development entering the marketplace.

(U) A near future example to watch for is a new telecommunications development based on ever more powerful hand-held computers presently called "personal digital assistants" (PDAs). The increasing sophistication of these devices coupled with an increasing number of cellular providers allowing their networks to be used as wireless access points for these PDAs is putting the technology suite in place to make these extremely useful devices. This development also couples nicely with the megatrend we are seeing in society of more and more people working out of their homes and other non-traditional work settings. Additionally, a set of standards which will make this possible, TCP/IP, is also already in place and capable of supporting this technology. Key areas that will have to be improved before this development will have a major and lasting impact on the marketplace are improvements in user interface and portable power sources. [16, 17, 18, 19]

~~(FOUO)~~ The interplay of all these various developments and trends can become very complicated. [redacted] As illustrated by the ISDN versus TCP/IP example above, conditions in a target area do not always match those in the United States or in the international telecommunications marketplace.

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CONCLUSION (U)

~~(C-CCO)~~ While clearly far from perfect, technology forecasting has become essential to the long-term survival of the SIGINT system. The limitations and pitfalls of technology forecasts must be accepted and assessed honestly or they are of no use. At the present time, forecasts should focus on about five years from the present. New tools and software should be developed to improve forecasting. [redacted] Forecasts should be used and acted upon as quickly as possible and not used as a reason for delaying crucial decisions pending more certain information. There will always be a forecast about yet another new technology "just around the corner."

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~~(C-CCO)~~ The surest predictor of the telecommunications of tomorrow will always be the telecommunications of today. Legacy and in-place systems will always be the foundation for future telecommunications. The better the SIGINT system can cope with today, the better it can cope with tomorrow.

~~(C-CCO)~~ Technological forecasting has become a crucial component of the SIGINT business. The systematic accumulation and transference of knowledge in this field must also become an ongoing effort by the SIGINT community. This article is offered as the beginning of a dialogue about such an effort.

[redacted]

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