HOW TO CREATE A BUSINESS OUT OF MANUFACTURING LINACS

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Abstract

AccSys Technology, Inc. was established in 1985 by the authors and two colleagues to design, build, and sell ion linacs based on the new linac technology that had just been developed at the Los Alamos National Laboratory. The company is now the leading manufacturer of turn-key ion linacs for several markets worldwide. This paper will describe the history of AccSys and how it has survived more than 20 years manufacturing these specialized products. The similarities of AccSys' history to that of a small electron linac manufacturer established in 1970 will also be described to provide a general concept of what is required to create a technology business manufacturing linacs.

INTRODUCTION

AccSys Technology, Inc. (AccSys) is a California corporation located in the San Francisco Bay Area. The company was incorporated in June 1985 with a technology transfer agreement from Los Alamos National Laboratory and an SBIR Phase II grant from the US National Cancer Institute to develop compact ion linear accelerators (linacs) for production of short-lived radioisotopes for Positron Emission Tomography (PET). The company has been an affiliate of Hitachi, Ltd. since May 2002 when Hitachi acquired a majority ownership of the company.

As a design and manufacturing company, AccSys specializes in the development, production, installation and servicing of ion linac systems for medical, industrial and research applications using radiofrequency quadrupole (RFQ) linacs and drift-tube linacs (DTL). AccSys has established itself as a leader in the development of turn-key ion linac systems. The company is dedicated to the design and production of high-quality, reliable systems to meet the needs of commercial applications. Since demonstrating its first prototype linac in 1987, AccSys has delivered ion linacs to research facilities and commercial customers worldwide.

Notable milestones and achievements of the company since its inception include:

- Three technology transfer and four cooperative R&D agreements with US National Laboratories.
- Strategic Defense Technology Applications Award (joint with Los Alamos National Laboratory) for commercial application of dual-use accelerator technology.
- 30 rf linac systems delivered to customers worldwide.
- Eight patents awarded on rf linac technology and applications.

TECHNOLOGY/ PRODUCTS

Using technology transferred by various means from several US national laboratories, AccSys has developed advanced rf linac concepts into three major product lines:

- The **LANSAR®** line of high flux neutron generators
- The **PULSAR®** line of proton linacs for the production of short-lived positron emitters
- The **LINSTAR™** line of proton linacs for use as synchrotron injectors.

In addition to these standard products, the company performs design studies and manufacturing of custom linacs for proton, deuteron, and heavy ion beams for research applications.

The LANSAR® linac-based neutron generators have been developed specifically to provide reliable long-term operation for non-destructive inspection applications even in harsh research and industrial environments. These systems utilize compact proton and deuteron linacs and long-lifetime, rugged neutron production targets. A broad range of configurations are available to provide outputs ranging from 10^8 to 10^{13} neutrons/second at the target for fixed or mobile applications. Key features of LANSAR® neutron generators include no use of radioactive targets, a target lifetime of many years at full neutron output and rugged units that are serviceable in the field, have low maintenance and operating costs, and are transportable in most configurations. These systems have a variable beam intensity and pulse structure. A typical small system, the Model DL-1, is shown in Fig.1.

Figure 1: Compact Model DL-1 LANSAR® linac.

PULSAR® systems are compact proton linacs designed for the cost-effective production of radiopharmaceuticals used for Positron Emission Tomography (PET) imaging applications. These systems are a proven alternative to cyclotrons for PET radiopharmaceutical production and incorporate the latest in patented and proprietary compact accelerator technology integrated with high production-yield targets and advanced chemistry process units. The combination of optimum energy and beam current, coupled with the inherent compact size, light weight and minimal shielding of these accelerators also make it possible to install a PULSAR® in a semi-trailer, as illustrated in Fig. 2, making it the only mobile system available for the routine production of FDG and other PET radiopharmaceuticals. The first unit is now undergoing factory testing and will be in use for FDG production at a customer's site in the northern USA beginning in July 2006.

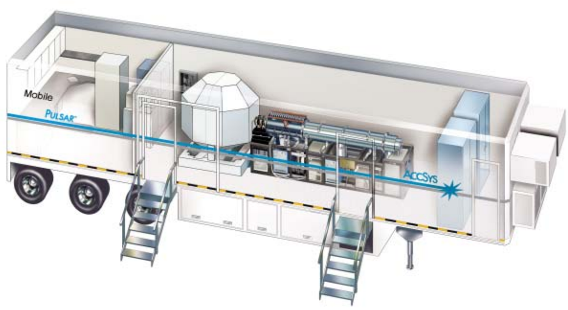

Figure 2: Cut-away view of the AccSys mobile PET radiopharmaceutical production laboratory

LINSTAR™ proton linac systems are designed to provide moderate-energy proton beams (typically 2 to 7 MeV) for injection into high energy proton synchrotrons for use in cancer therapy and physics research. A typical system consists of a combination of an RFQ linac, a drift tube linac (for injection energies above 3 MeV), AccSys' standard rf power system, a high energy beam transport system tailored to the specific requirements of the facility and an optional debuncher cavity. They can accelerate either H+ or H- ion beams and are also available for polarized H+ or H- beams. Standard LINSTAR™ units can provide pulsed beam currents up to 25 mA at pulse widths from 3 to 300 µsec. Operation at pulse repetition rates from 0.1 to 30 pulses per second have been demonstrated, including on-demand pulsing for breath-mode synchronization in proton cancer therapy.

LINSTAR™ systems are currently in use at five facilities around the world: A Model PL-2i has been operating at Loma Linda University Medical Center since 1990 as the injector to their proton synchrotron cancer treatment facility. This synchrotron system, which was built by a consortium led by Fermilab [1], operates 24 hours a day, 6 days a week. Complete proton therapy systems based on the Loma Linda installation are available from Optivus Technology, Inc. [2].

Two systems have been commissioned in Japan: a Model PL-3i is the injector for the proton synchrotron cancer treatment facility built by Mitsubishi Electric Company for the Shizouka Cancer Center; and a Model PL-7i is the injector for the proton synchrotron cancer treatment facility provided by Hitachi, Ltd. at the Tsukuba Medical Center. Another Model PL-7i injector system provided to Hitachi, Ltd. is in operation at the MD Anderson Proton Therapy Center in Houston, Texas as the injector to the Hitachi synchrotron. Another Model PL-3i injector will be installed at the South Tohoku Cancer Center by Mitsubishi early next year.

A Model PL-7i was operated at the Indiana University Cyclotron Facility for 5 years as the injector for the compact CIS synchrotron. That linac is now being converted to a high power neutron generator for neutron scattering research [3]. AccSys also designed and fabricated the Model PL-1 CW RFQ that is in use as the injector to the cyclotron complex at IUCF dedicated to proton cancer therapy [4].

AccSys has provided several custom linacs for specialized ion beam applications. These include a double-RFQ heavy ion booster for a tandem electrostatic accelerator, a high energy gamma source for high energy physics detector calibration, and the portable linac-based neutron generator system for non-destructive inspection shown in Fig.3. The latter is a rugged low-energy neutron source that fits in two cases weighing less than 80 kg each. The system can be operated in the field on a portable 2 kW generator. The maximum neutron flux is a modest 10^8 n/sec but all of the neutrons are emitted in a 90 degree forward-directed cone and have a maximum energy of less than 100 keV.

Figure 3: Portable Model PL-2 linac neutron generator.

HISTORY OF ACCSYS

The First Ten Years

There are a number of ways to fund the startup and growth of a technology company in the U.S. as can be seen in Table 1. The original concept for a technology spin-off company (that would eventually become AccSys) was proposed by the author in 1980 while a staff member in the Accelerator Technology Division at the Los Alamos National Laboratory (LANL) where he was involved, among other things, in the development of the first proof-of-principal RFQ in the western world [5] and the linac for the PIGMI project [6]. After being told by the laboratory management that pursuing his original concept of a technology-transfer design company using key LANL people as consultants would probably cost him his job, he left the laboratory to join a cyclotron manufacturing company in California as Vice President of R&D where he was told he could potentially pursue development of the compact linac technology from LANL for commercial applications. Unfortunately, that company went into bankruptcy within two years of his joining it and the company that purchased the cyclotron technology had no interest in the linac technology.

Table 1. Funding Sources for Startup and Growth

Type	Characteristics or Requirements
Venture Capital	• Typical deal > $5M • Limited number deals/year • Large market, explosive growth or quick IPO/acquisition • Loss of control
Corporate Sponsor	• Joint venture, partnership, strategic alliance • Proprietary or patented technology required • Good fit with corporate interests and markets • Limited control
Angel or "Patient" Capital	• Typical deal $.25M to $5M • Hard to find Angel groups • Mainly located in high technology areas • Retain some control
Bank or small business agency loans	• Limited $ not suitable for high-tech business needs • Risk averse – must pledge personal assets as collateral
Self-funded - "Bootstrap"	• Seed money from founders, family, friends and associates • May require initial capital from savings, personal loans, second mortgages • Raise additional growth capital from private sources and bank debt financing • Retain control but at personal financial risk

Undaunted by this set-back, he accepted a position at Varian Medical Corporation as Manager of R&D and continued his pursuit of a way to utilize the LANL linac technology for medical isotope production and industrial applications. Upon hearing of a new U.S. government initiative, the Small Business Innovative Research (SBIR) program [7], to fund small high technology companies to develop and commercialize innovative technology he joined the co-author's technical software consulting business and, along with her and several colleagues still at LANL, submitted a proposal to the U.S. National Institutes of Health for a design study for a compact proton linac for the production of PET isotopes. The completion of this first Phase I SBIR grant, an official technology transfer agreement with LANL, and the imminent award of the Phase II grant to construct a prototype finally led to the incorporation of AccSys in June 1985.

Because the technology and the proposed marketplace were neither one proven as commercially viable, the company could not obtain venture capital funding so the startup funds came from the four founders at an initial investment of $10,000 each. Fortunately for AccSys during the first few years of operations, its technology and the know-how of the founders were in high demand by the defense industry for design studies and hardware development under the U.S. Strategic Defense Initiative, which generated both revenue and cash flow to augment the SBIR funding.

After several years of operation, some "angel investor" funding was obtained through a private stock offering to help finance the company's growth. However, most of the growth had to be accomplished using the "bootstrap" method by which the technology R&D and product development was funded through grants and contracts with the government, universities and private industry and the profits were used to fund further growth of the business. During the first ten years in business, AccSys had received more than $6.5 million in SBIR contracts, including 12 of the 20 Phase I awards for which it applied, 8 of the 10 Phase II awards it sought, and a large Phase III contract for one of its linac systems.

By 1990 AccSys was already recognized as a leading designer and manufacturer of proton linacs and in 1991, it was awarded a ~$6million contract to design and fabricate the 70 MeV DTL stage for the Superconducting Super Collider (SSC) linac injector. In order to handle this job, the company expanded in size to more than 40 employees and doubled its manufacturing space. However, when the SSC project was cancelled by the U.S. congress in 1993 the company was forced to layoff a third of the staff immediately and eventually shrunk back to only 7 employees before it started to recover. Around the same time, two of the four founders left the company.

AccSys finally settled its cancellation claims with the U.S. DOE two years later, but not before it was within a few weeks of having to declare bankruptcy. The management then decided to concentrate on developing commercial markets for its products. The history of the company during this first ten years, including all of its ups and downs, was featured in a lengthy Philadelphia Enquirer newspaper article in June 1995 [8].

The problems experienced by AccSys during this period are quite common for technology startup companies in general and the "slump" that can occur after the initial successes and ramp-up is often referred to by entrepreneurs as "the valley of death". Even if the company survives this phase, the steep climb to a healthy, profitable enterprise with sustainable products and markets can be tough. In fact, in the U.S. only about 20% of small technology startup businesses survive beyond five years.

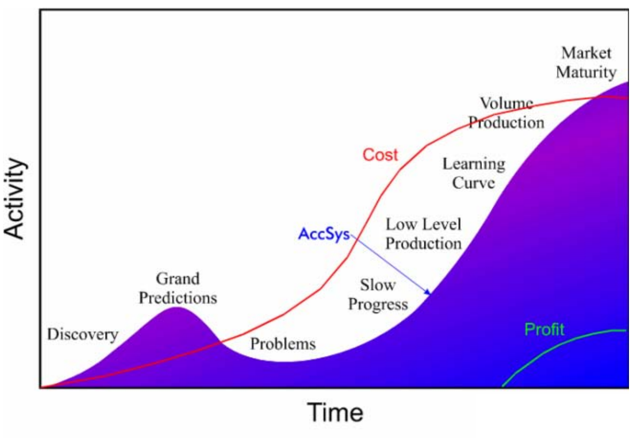

Figure 4: Growth stages for a technology company [9].

Becoming a Commercial Linac Business

AccSys was quite successful in using the SBIR program and other R&D contracts during its first ten years to bootstrap the development of its products and advance the state of its technology. Research projects included the study of superconducting RFQ technology and the design and low-power modeling of interdigital and other advanced accelerator structures. Major collaborative R&D programs with U.S. national laboratories such as Fermilab, Argonne, Los Alamos, Brookhaven, and Lawrence Livermore supplemented the company's expertise in accelerator technology.

After the SSC experience, company management made the decision to discontinue actively seeking government contracts and pursue markets for commercial linacs for medical and industrial applications using the technology and products it had already developed. The business began another period of steady growth, but the default of a Japanese customer on a large contract for multiple PULSAR® systems for the Japanese market in 1998 resulted in another major set-back and brought the company again to the brink of bankruptcy. At one point, the authors even decided to sell their home and use the equity to keep the company in operation. They then began an active program of seeking a large corporate partner and after several failed attempts, a deal was struck in 2001 with Hitachi, Ltd. Power and Industrial Division for them to acquire a majority stake in the company.

In May 2002 AccSys officially became an affiliate of Hitachi, Ltd. with the closing of a tender offer by Hitachi for a majority of the shares of the company. With the help of the resulting financial backing, AccSys began the full transformation to a world class manufacturing company. Although the linac sales and production capacity are still somewhat limited due to the challenges of breaking into the medical market with what is perceived to be a "new" technology product (cyclotrons still dominate the PET isotope production equipment market), the growth in these areas has been steadily increasing.

SCHONBERG RESEARCH CORPORATION

Lest one believe that AccSys is a unique startup company that has grown through bootstrapping, one only needs to consider the history of Schonberg Research Corporation (SRC), another small company in northern California that developed a unique commercial X-band electron linac system that has now found widespread use in non-destructive examination (security) and medical treatment. [10]

After a brief career at Lawrence Livermore National Laboratory doing accelerator research and development, Russ Schonberg entered the electron linac business world and worked at two linac companies (Varian & Applied Radiation Corporation). He then co-founded another accelerator company (SHM Nuclear Corporation) before starting his own business with his wife in 1970.

After many years of successfully representing other companies in the NDT field, he was funded in 1978 by EPRI (Electric Power Research Institute) to develop a miniature 6 MeV electron linac for radiographic inspections in nuclear power plants. This first system was demonstrated late in 1979 and this led to more orders for these systems in 1984. After successfully working with a vendor to develop a variable frequency magnetron appropriate for this linac and expanding the business, Schonberg was approached in 1989 by a medical doctor at Stanford University to develop a version of the linac for "X-ray surgery" and in 1991 a spin-off company called AccuRay was formed to develop these systems.

In 1994 another spin-off company, IntraOp, was formed to commercialize this small linac for performing irradiations during surgery after an SBIR grant was completed with a radiation oncologist at the University of California – San Francisco. Finally, the technology and underlying patents for this X-band system were sold to American Science and Engineering in 1998 for use in security applications. During its existence, SRC delivered 25 linac systems and reached a maximum size of 35 employees, but the two spin-off companies are both much larger and both are quite active in their medical equipments fields. AccuRay has delivered 110 systems to date and IntraOp has delivered 12 systems.

STARTUP BUSINESS REALITIES

AccSys and Schonberg have both proven to be a financial and technological "success" for their respective entrepreneurial founders and both companies have shown that you can make a business out of manufacturing linacs. However, neither company has had the success that Varian Medical Corporation or Siemens Medical Corporation has had in their fields. But each of these companies has had to face the same basic challenges and must satisfy the same key requirements that must be addressed by any new accelerator company:

- Adequate funding – The more money put into the startup, the quicker the growth and return of profits will be, as illustrated in Fig. 5.
- An identified market – Emerging or niche markets are easier and less costly to penetrate.
- Technical expertise – Usually developed at a national laboratory or large corporation.
- Well prepared business plan – Must include legal agreements and documents for "what-if" scenarios.
- Business support – Hire good people or consultants to take care of the business part of the business. Technologists do not always make good businesspeople!
- Location, location, location – An accelerator manufacturer is not likely to afford to be vertically integrated, so it will need access to lot of outside fabrication and technical support services. Even more key is access to skilled workers and business services (accountants, lawyers, etc.).

As an example of the latter, there have been at least 10 linac companies formed in the San Francisco Bay Area, including AccSys and Schonberg. These include Varian Medical, Applied Radiation Corporation (eventually became Siemens Medical), the two spin-off companies from Schonberg Research Corporation, several companies started by other ex-employees of Varian (SHM, JM Corp. and Haimson Research), and HESCO.

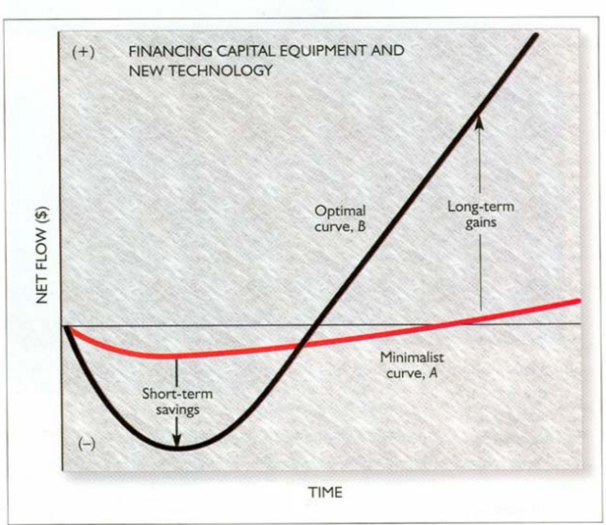

Figure 5: Cash flow needs of a startup technology company [11].

CONCLUSION

Starting a new business in the accelerator field is not for everyone, but for those who have considered this path, the authors' advice from their business experiences can be summarized as follows:

- If making an obscene amount of money in a short period of time is your primary motivation, you'd better find something else to do.
- Enjoy what you are doing and believe in your product!
- Be aware of new opportunities that may arise in a commercial market using technology in your field of expertise.
- Be prepared to work tirelessly at getting a business started (> 60 hours/week).
- Be prepared to continue to work tirelessly to make it a success.
- Be prepared to "lose it all". True entrepreneurs are not reckless risk takers. They take carefully calculated risks but none-the-less they are risks.
- Pay careful attention to legal and financial matters associated with your business. Better still, hire experts you can implicitly trust to deal with such matters.

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