Evaluating Intellectual Capital - Part I

C. W. (Clem) Bowman, FCIC

Abstract
Intangible assets in general, and intellectual capital specifically, are now recognized to be at least as important as tangible assets for most organizations. Intellectual capital is not simply the difference between book value and market value. The absence of reliable measurement processes has made the management of intangibles a very difficult task. Many approaches have been proposed but they have failed to bridge the gap between knowledge of the asset and the metrics needed to facilitate market place transactions.

The generation and use of intellectual capital is the lifeblood of research organizations. The development of consistent processes for selecting projects, adopting best practices and evaluating and transferring developed technologies has been the focus of attention for R&D managers for many decades. This is the first in a series of articles describing a unique made-in-Canada methodology for carrying out these functions, called ProGrid®. It is being used by many Canadian R&D entities, including the Ontario Centres of Excellence, the Canada Foundation for Innovation and a number of R&D agencies in Alberta and Ontario. The initial stage of development of the ProGrid approach was described at the R.S. Jane lecture at the 1993 Canadian Chemical Engineering Conference, with an update at the 1999 Conference.

1. Importance of Intangible Assets

In the past, tangible assets were assumed to represent the majority of the wealth of companies. These were readily amenable to accurate assessment, "bean counting" to use a somewhat derogatory expression. The accountants' view of the world has been an important feature of national and international commerce. Their metrics have provided the framework for transactions among commercial enterprises.

It has been realized in the last few decades that tangible assets were only one part of the wealth of a company or a nation. The book value of a company frequently has badly represented its strength, either by overlooking future potential or in some cases by assuming unrealistic longevity of its current manufacturing processes and products. Of the Fortune 500 companies in the first listing in 1954, 360 would not appear in a similar listing of industrial companies today.[1] Would better knowledge of the strength of their intangible assets, such as intellectual capital, have predicted their demise?

There is an important distinction between tangible assets and intellectual capital. Tangible assets have an intrinsic value independent of the observer. The value of intellectual capital, however, depends in large measure on the values, priorities and expectations of the observer. There is another distinction — a dimensional issue, one of time. Many tangible assets devalue over time. Intellectual assets often realize their value only over time.

2. Measurement Approaches

The challenge to measure intellectual assets is formidable. Various tools have been developed which have been useful for specific applications. These include:

The Risk Management Matrix of the Boston Consulting Group
This is a technique that uses four-quadrant grids for displaying performance, for example, with Relative Market Share and Growth as the two axes. As noted in the review by Millet and Honton[2], these terms represent cash generation and cash use, respectively. Thus, these two axes are not independent variables. Further, Millet and Honton note that the portfolio analyses methods, of which the Boston Consulting Group Risk Management Matrix is an example, are "not only highly judgmental, but also highly arbitrary".

The Kepner-Tregoe Decision Process[3]
This technique lays out key criteria for a selection process and uses a numerical scale to rank alternative choices. This methodology is particularly useful in problem-solving by identifying the likely cause of an undesirable event by listing and weighting potential causes. This approach illustrates the importance of having clearly defined criteria and separating them into "musts" (overarching criteria) and "wants" (desired goals that cumulatively contribute to the final decision).

The Blake Managerial Grid[4]
The Blake grid is used to optimize the balance between people-focused and production-focused human resource practices. This technique uses a grid that displays and compares different personnel behaviour practices. Although not quantitative, it shows how subjective factors can be organized into meaningful patterns.

The Myers-Briggs Personality Test[5]
This evaluation test ascertains the personality traits of individuals by the selection of preferred statements to define personality traits. It is useful in improving group dynamics by valuing different approaches to solving problems.

These methods have been useful in identifying and describing the characteristics of various components of intellectual capital, and in some cases included numerical ranking scales. However, the metrics needed to move back and forth across a transaction interface were not established. It seems that the developers of these methods stopped short of the goal — tantalizingly close, but the bridge was not made.

3. The Missing Bridge

Commercial transactions involving tangible assets are facilitated by the ability of the transferor and transferee to agree on the value of the asset, using well accepted accounting principles. However, for intangible assets the difficulty in determining the value impedes the transaction. It has been difficult to define the total value of a group of intangibles or to compare several different groupings of intangibles. In order to accomplish this, metrics must be established and agreed upon.

Consider the case of a technology that is to be transferred from an inventor to a venture capitalist. The value of the technology can be represented by a number of factors, such as the strength of the patents, the level of validation and the expected market demand. The challenge is to determine how these factors influence the value of the technology and how this compares to other technologies being considered by the venture capitalist.

The key to developing the metrics is through the establishment and calibration of a precise language to express the value of the asset under consideration (the Language Ladder in ProGrid terms).

4. Components of Intellectual Capital

The components of intellectual capital that are highly relevant to a research organization are shown in Figure 1. There are many excellent references that help in understanding this complex subject, including the book by Tom Stewart.

<table>
<tr><th colspan="4">Intellectual Capital</th></tr>
<tr><td colspan="3">Structural Capital</td><td rowspan="3">Human Capital</td></tr>
<tr><td colspan="2">Intellectual Assets</td><td rowspan="2">Systems
Processes
Relationships
Innovation</td></tr>
<tr><td>Intellectual Property</td><td>Codified Knowledge</td></tr>
</table>

Figure 1. Components of intellectual capital.

Intellectual property is comprised of legally recognized knowledge, such as patents, trademarks, copyrights, trade secrets, etc. Codified knowledge is knowledge that exists in a form that enables it to be shared with others, in the form of documents, drawings, software, etc. Intellectual assets are the sum of intellectual property and codified knowledge. Structural capital is understood to comprise intellectual assets, plus the organization's systems, processes, key relationships (such as those with customers, business partners and suppliers), and innovative capacity. The components of structural capital are sometimes referred to as customer capital, organizational capital, process capital, innovation capital, etc. The sum of structural capital, and the knowledge, skills, capabilities, and motivation of its people (often referred to as human capital) constitutes an organization's intellectual capital.

Is it possible to measure the value of each of these components of intellectual capital? Most organizations, in fact, still operate at the level of intellectual property. There are, however, a group of industry and government leaders who are active in developing both the definitions of the other elements of intellectual capital and the frameworks within which these can be measured and tracked over time.

5. Managing Intellectual Capital in R&D Organizations

As illustrated in Figure 2, R&D activities can be divided into the following three broad functions:

- selecting programs and projects;
- performing at pacesetter best practices; and
- evaluating and transferring knowledge and developed technologies.

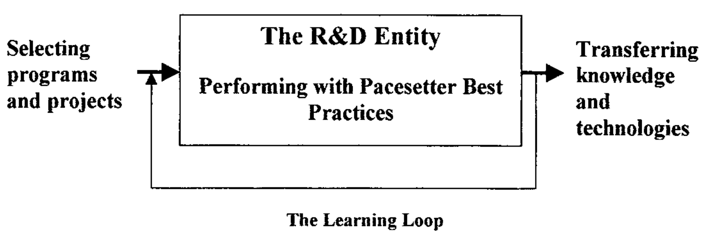

Figure 2. The R&D continuum.

Key success factors of R&D organizations bridge across this continuum, first doing the right things, then doing things right and finally getting the results to users. A key part of R&D management is to learn through this process and constantly strive to improve and profit from both successes and mistakes.

ProGrid is a non-linear two-dimensional process for tracking progress across the above R&D continuum. It assigns values to the components of intellectual capital that are selected by the evaluator, and aggregates these into usable "bites" that are plotted on a grid with axes representing two overarching criteria, again chosen by the evaluator. The ProGrid process allows the R&D organization to rank projects and select those that best fit its mission and mandate. The same process keeps track of progress through defined gates and facilitates technology transfer to the ultimate user. How the ProGrid methodology is used will be illustrated in three examples, described in the subsequent articles in this series.

Is there something fundamental about two dimensions? In many activities in life we are faced with decisions with two choices. In many cases they represent short- and long-term options, immediate gratification of needs or longer-term investment to meet future needs. Companies that fail due to the obsolescence of a dominant product have failed to provide for product replacement. They had been one-dimensional in their thinking. Thus, one of the axes in most of the ProGrid tools has a time dimension, in effect separating the current situation from an expected future state.

6. The ProGrid Family

Over the past eight years, a number of ProGrid tools have been developed for specific tasks. From left to right in Figure 3 there is a shift from a technology focus to a more market or organizational focus. Proceeding down the Figure there is a shift from screening tools to more definitive and detailed evaluation tools.

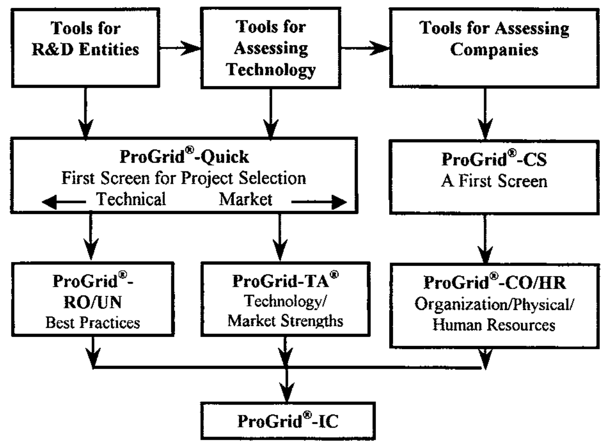

Figure 3. The ProGrid tool kit.

Some of these are set piece tools (e.g. ProGrid-RO and ProGrid-TA) and are used for benchmarking and auditing purposes. These have been employed in more than five countries and a sizable database has been established. Other ProGrid tools have been customized for specific purposes, particularly those in the ProGrid-Quick category, and are used primarily for selecting proposals or alternative courses of action.

ProGrid-IC represents a collection of processes and tools for managing intellectual capital within an organization by establishing the current and desired future positions and tracking performance trajectories. These are customized for the needs of individual organizations.

In the second article in this series, results will be presented of an international study that used the ProGrid-RO tool for assessing the internal practices of R&D organizations with respect to the vision and mission of the 'owners'. These are the processes inside the box in Figure 2.

The third article will describe examples of ProGrid tools used by many Canadian R&D entities for selecting proposals, projects and programs, (the input to the box in Figure 2). The fourth article will present the tool for assessing the technical and market readiness of developed technologies (the output from the box in Figure 2).

References

1. Loomis, Carol J., Kathleen C. Smyth, Suzanne Barlyn, 'Forty Years of the 500', *Fortune 40th Anniversary Issue*, 131:9, p. 182.
2. Millet, Stephen M. and Edward J. Honton, *A Manager's Guide to Technology Forecasting and Strategic Analysis Methods*, Battelle Press, 1991.
3. Kepner, Charles and Benjamin Tregoe, *The New Rational Manager*, Princeton Research Press, Library of Congress Number 80-84367, 1981.
4. 'The Managerial Grid', Robert R. Blake and Jane Mouton, Gulf Publishing Company, Library of Congress Number 64-14724, 1964.
5. *http://www.oise.on.ca/~cengel/coop.mbcareer.htm*

Evaluating Intellectual Capital — Part II. Best Practices for Research Organizations

C. W. (Clem) Bowman, FCIC

Abstract
This is the second in a series of articles evaluating Intellectual Capital. The first article examined the key components of Intellectual Capital and various approaches at measurement. This article examines the management of Intellectual Capital within research organizations, with emphasis on their codified capital, internal and external relationships and the all-important human capital.

The management of intellectual capital in research organizations has changed dramatically during the past thirty years. This evolution has not been linear and has involved a number of different relationships between R&D organizations and the stakeholders served. The most recent change has been the realization that to be effective, R&D must be fully integrated into the corporate strategic plan. An international benchmarking study shows how leading R&D organizations are striving to achieve a high and effective level of integration.

1. The Evolution of R&D Organizations

Many research organizations have evolved during the past thirty years from organizations focused primarily on long-term research flowing from relatively rigid missions to those that now have flexible mandates aligned to the changing needs of a variety of clients. The concept of performance measurement has changed dramatically from the time when scientific excellence was the only criterion for success.

It is useful to define two "bookend" types of organizations to illustrate the changing relationships.

Type X Organizations – Organizations whose mandate is determined solely by the current business interests of clients and who hire staff and select and monitor projects on this basis. Deliverables are closely defined and the technology is transferred under contractual relationships within a corporate envelope. Although effective at meeting the needs of clients, these organizations frequently have difficulty adding to their intellectual capital.

Type Y Organizations – Organizations whose mandate is defined by a scientific charter and who hire staff and select and monitor projects based on meeting the objectives of this charter. Specific deliverables are generally not defined and technical information is made available through publications to the broad scientific network. Although effective at creating intellectual capital, these organizations are usually not involved in the commercial use of this capital.

The evolution can be described through four phases, as illustrated in Figure 1.

Organizations in Phase 1 received essentially all their funding as a core "grant" from the owner, with only a general statement of expected deliverables. "Good science", supported by access to the world pool of science and technological information, was the driver for R&D programs. These organizations were generally successful in generating new intellectual capital, which frequently resulted in new processes, products or services having significant technological impact. However, the transfer of technology to clients tended to be sporadic and dependent on the personal relationships developed by senior R&D management with counterparts in the business units. Central corporate research laboratories during the 1960s had strong Type Y characteristics, as illustrated in Figure 1a.

Many owners became dissatisfied with the impact of Phase 1 organizations, and moved to an arrangement whereby R&D contracts were provided directly from the business cost centres (Phase 2, Figure 1b). The programs were approved by and in many cases almost entirely defined by these centres. R&D projects were short-term and responded to the current needs of the business, with limited attention to global technology developments. The benefits of R&D were determined through periodic audits of successful projects. These organizations, although effective at technology transfer, were less effective at

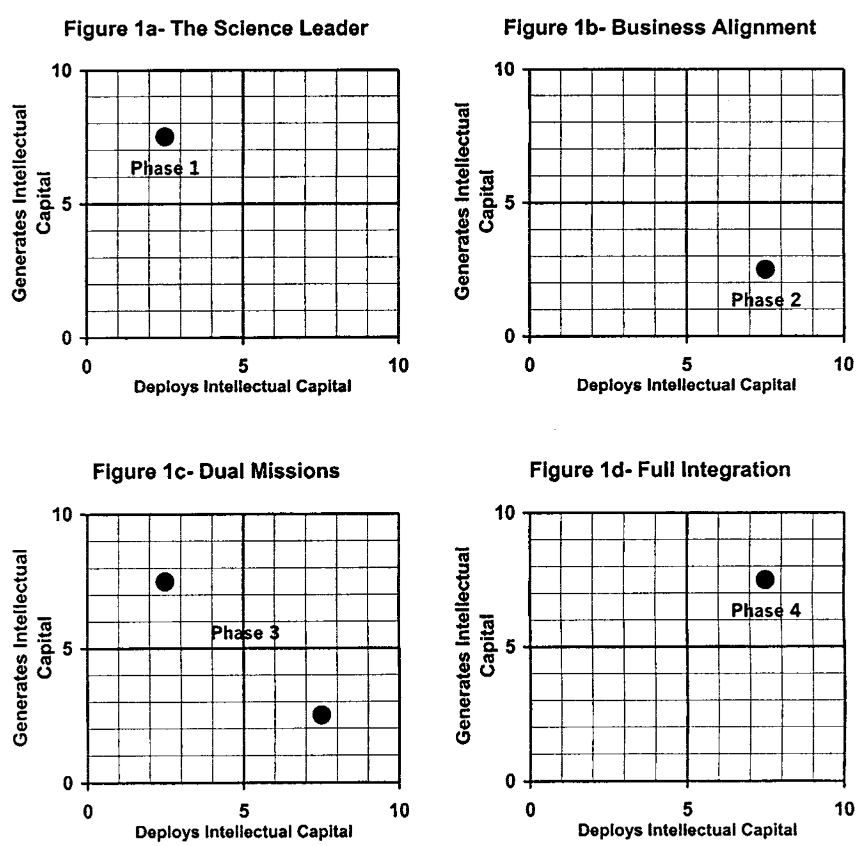

Figure 1. Evolution of R&D organizations.

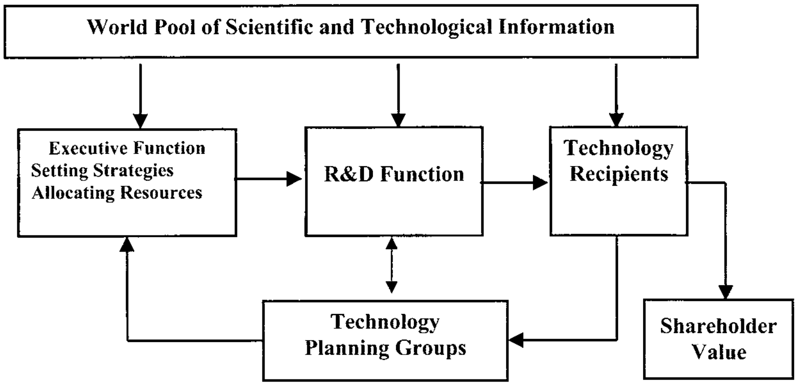

Chart 2. Achieving full integration.

replacing their depleting intellectual capacity. This situation was prevalent with many industrial research organizations during the 1970s.

Owners generally felt more comfortable with Phase 2 results, but were concerned that there were opportunities and threats not being addressed by this focus on the short-term needs of the business units. Some owners reinstated a modest level of corporate funding for longer-term R&D, with the selection of projects largely residing with the R&D organization for that component of the total budget. The business lines still provided the majority of the funding for the organization. The management process for the short- and long-term missions were not integrated (Phase 3, Figure 1c). Whether this dual mission approach was effective is debatable. It did provide research management with some discretion to initiate exploratory programs, but the capacity to expand these when successful was limited. A number of industrial research organizations adopted this strategy in the1980s.

Most companies realized in the late 1980s that they were entering a new fiercely competitive global economy in which technology would become a key strategic weapon. It became imperative that technology be fully integrated into the corporate strategic plan. It is necessary to involve senior levels of both business and research management in this process and to focus on both the short and long-term technology needs of the corporation (Phase 4, Figure 1d). An aggressive R&D management unit is needed to energize this process. Achieving this level of integration depends on the interactions of many stakeholders, as illustrated in Figure 2.

2. Establishing the Performance Criteria

A methodology was developed in the early 1990s, called ProGrid-RO, to benchmark how R&D organizations perform in each phase of evolution and to plot the route to Phase 4 where appropriate. As with all ProGrid tools, this involved establishing the criteria for measuring performance, constructing a grid with two of the criteria as the overarching performance indicators, and arranging the balance into a matrix, each cell of which represents a factor that if achieved contributes to either or both the overarching criteria.

Two of the key criteria for R&D managers, as identified in numerous surveys, are the need to balance the short- and long-term technology goals for the parent organizations. In developing the ProGrid-RO methodology, these goals have been expressed as the deployment of existing intellectual capital and the generation of new intellectual capital, and have been used as the independent overarching criteria.

Several variations of the matrix have been used depending on the particular nature of the R&D organization, as shown in Figure 3. Public sector organizations

A R&D Inputs	B The Connectors	C Benefits/Impact
Vision/Mission	Business Alignment	Corporate Impact
Program Management	Technology Transfer	Industry Impact
Human Resources	Performance Measurement	Social Impact

Figure 3. Matrix for measuring R&D performance.

tend to have mandates that impact on societal issues such as creation of new enterprises and training. The areas of impact of private sector organizations tend to be more internal to the corporation. Some R&D organizations have limited internal capability and contract out much of their activity. Nevertheless, they all can be measured by how well they fulfill the short and long term expectations of their owners and key stakeholders.

3. Establishing Current and Future Position

Some of the sub-criteria are not performance related but rather indicate the Type X/Type Y nature of the organization. These include:

- Organization Mandate
- Budget Sources
- Hiring Strategy
- Selecting R&D Projects
- Monitoring R&D Projects
- Staff Deliverables
- Technology Transfer
- Networking

These criteria enable an organization, either through self-assessment or with the aid of an external evaluator, to establish a current and desired future X/Y trajectory, as shown in Figure 4. This defines the balance the organization has chosen between building and deploying intellectual capital. This is a real case where the organization currently has dominant Type Y characteristics and plans to become a strong Type X organization.

Once the trajectories are defined, the remaining criteria can be used to defined current and future performance levels along these trajectories. The ProGrid methodology involves the use of Language Ladder statements to select the current and future state. As an example, the Language Ladder statements for a criteria on alignment of the R&D objectives with client business plans would be:

a) The R&D objectives been developed with general reference to the needs of the key clients.
b) Consideration of the needs of the key clients has been taken into account in developing the R&D objectives. The objectives are reviewed with the clients to obtain comments and suggestions.
c) The R&D objectives have been developed collaboratively with the key clients and are well aligned with their business needs.
d) The R&D objectives are fully integrated into the business objectives of the owner and key clients and represent key components of the overall corporate strategic plan.

Through aggregation of all criteria, the current and future grid positions can be established. The positions in Figure 4 indicate that the organization has identified the need to make major changes in its performance. Having defined the Language Ladder statements for each criteria, the actions needed to move from one level to another are apparent and form the basis for future actions.

4. Benchmarking a Group of Organizations

Approximately 30 R&D organizations have participated in various benchmarking projects that have used the ProGrid-RO assessment process. Five types of organizations have been involved:

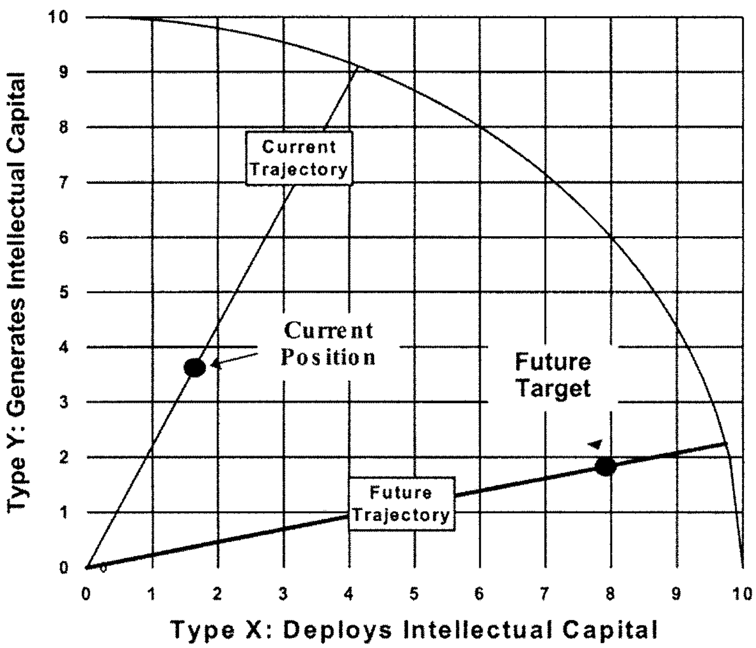

Figure 4. Establishing current and future position.

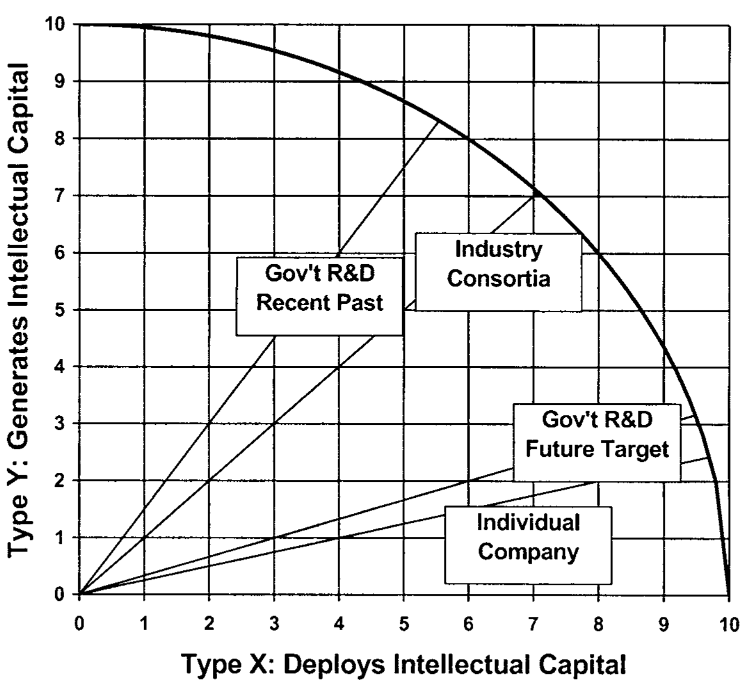

Figure 5. Moving to preferred future states.

1. Private Sector – Single Company
2. Private Sector – Consortia
3. Government Laboratories – Industrial Sector Related
4. Government Laboratories – General Industrial Support
5. Government Laboratories- Science/Technology Focused

Although the results are proprietary to the specific organizations involved, one major conclusion was reached that can be more broadly shared. This is illustrated in Figure 5. Many government R&D organizations currently position themselves in a zone where they put more emphasis on the generation of intellectual capital than on its use. Individual companies place themselves more strongly in a zone where the use of intellectual capital is the more dominant focus.

Neither of these entities is entirely satisfied with its current position. Many companies have coalesced around R&D consortia in order to achieve a better balance in short- and long-term activities, as shown by the Industry Consortia position. Government laboratories, on the other hand, are attempting to become more responsive to the needs of clients and to identify as a target a position closer to the current position of individual companies. It is unlikely that government laboratories can put in place the necessary tight linkages among a broad range of clients to achieve this position. More importantly, it raises the question as to whether they will so weaken their position for generating intellectual capital that they will cease to perform the mission for which they were established.

5. Applications

The ProGrid-RO methodology can be employed by an R&D organization in a number of different ways:

- to set the stage for a major change in R&D strategy;
- to compare different R&D units within a corporate structure;
- to prepare the baseline for an ongoing organization improvement program;
- to benchmark itself against other similar ogranizations;
- to strengthen its interactions with key clients; or
- to assess the extent of buy-in of its strategic plans and processes throughout the organization.

The uniqueness of the method its that it defines the standards for performance, measures the organization against these standards, and then converts these into comparable metrics. The metrics can be translated back into the actions needed to move from a current to a future state, and to track progress.

Clem Bowman, FCIC, has had an extensive R&D management career with Imperial Oil and the Alberta Research Council. Nine years with the Alberta Oil Sands Technology and Research Authority provided experience in funding technology-intensive ventures, which led to his interest in providing tools for R&D funders and venture capitalists.

Evaluating Intellectual Capital — III. Evaluating Investment Opportunities

C. W. (Clem) Bowman

Abstract

This is the third in a series of articles evaluating intellectual capital. The first article examined the key components of intellectual capital and various approaches at measurement. The second examined the management of intellectual capital within research organizations, with emphasis on their codified capital, internal and external relationships and the all-important human capital. This article describes a methodology for selecting projects or ventures that best match the objectives of the organization.

1. Assessing Prospects

The author was involved in a technology investment program in which over 1,000 proposals were submitted, all of which had merit . The difficulty in selecting the most prospective of these proposals was an awesome task, which required balancing competing objectives, such as capturing an opportunity for an early commercial project versus laying the foundation for a more complete understanding of the fundamental nature of the resource and markets. This experience, and that obtained by several colleagues working in different industrial sectors, led to the development of a more consistent and transparent evaluation methodology, called ProGrid-Quick. This is a screening tool to serve as the threshold for more detailed due diligence processes.

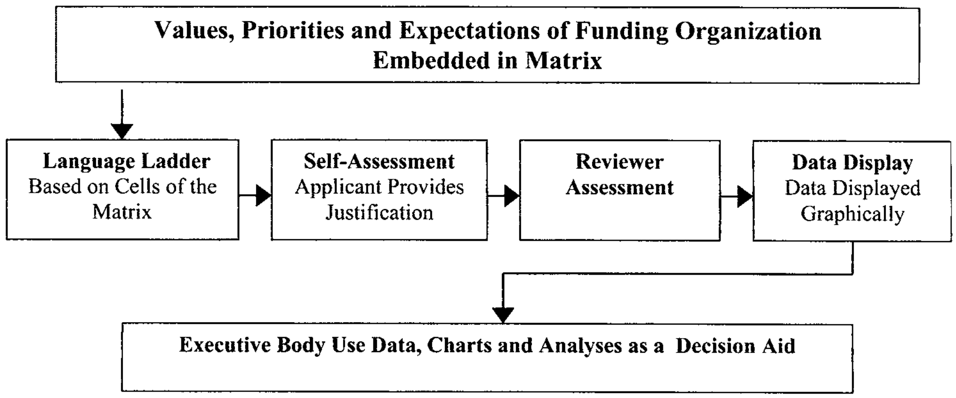

Figure 1. The decision process.

2. Developing the Assessment Process

Funding and investing organizations that use the ProGrid methodology embed their values, priorities and expectations into an application form. These values, priorities and expectations are first assembled in the form of a matrix of performance factors. A set of calibrated performance levels is established for each performance factor. The application form includes a self-assessment section in which the applicant selects performance levels that represent the current status of the undertaking for which investment is being sought. As a key part of this process, the applicant provides justification for the selections. The completed applications are normally submitted to a review group of up to eight reviewers. The reviewers will select their own ratings for the undertaking, based on the justifications provided by the applicant and their own knowledge and experience.

The applicant's and the reviewers' assessments are input into the appropriate ProGrid software for analysis. The software provides an automatic output report, containing key evaluation information. The management team responsible for making funding/investment decisions uses the output charts and text as a decision-assist, as illustrated in the process in Figure 1.

3. The Evaluation Matrix

Every customized ProGrid-Quick tool has a distinctive evaluation matrix, reflecting the values, priorities and expectations of the funding or investment organization. However, the same general factors appear in most matrices, and therefore it is possible to construct a list of cells that have similar characteristics, as shown in Figure 2.

There is a specific structure that has been found to be effective in developing the matrix. The left hand column should group factors that describe the concept (the "input"). The right column should group factors that describe the expected benefits (the "output"). The middle column should group factors that connect the input to the output.

The 20 cells shown are typical of those that have been used to date. Normally only seven to twelve are employed in a specific customized tool. For the assessment of proposals where scientific merit and the qualifications of the principal investigators are the major selection criteria, the cells will mainly be those shown in the first two columns, which, in turn, would be developed in a three column format (e.g., the impact for some users will be the connector for others). For the assessment of proposals where market impact is the ultimate goal, the cells in the right-hand column would have increased importance.

4. Language Ladder Statements

There are many versions of Language Ladder statement sets that apply for any of the cells in the evaluation matrix. The specific language used reflects the values, priorities and expectations of the funding or investment organization. The following is a typical Language Ladder statement set for the criteria on "validation" of a new concept:

The Concept	The Connectors	The Benefits
The Advance	HQP/Skills	Technology Transfer
The Team	Collaboration	Market Impact
Facilities	Industry Involvement	Competition
Capacity	Intellectual Property	Rate of Return
Project Management	Commercial Readiness	Strategic Fit
Business Plan	Receptor Capacity	Societal Impact
Validation	Financing	

Figure 2. Candidate cells for evaluation markets.

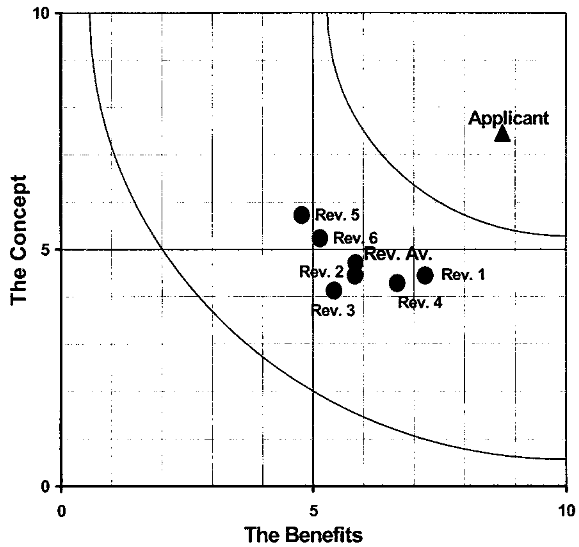

Figure 3. Proposal grid.

A. The concept has had a limited level of testing.
B. Key elements of the concept have been confirmed but an integrated system, model or prototype has not yet been developed.
C. An integrated system, model or prototype has been developed and has been tested.
D. An integrated system, model, or prototype has been developed and the product, process or service has been successfully tested under a full range of commercially relevant conditions.

These statements should be constructed to be clearly distinguishable and as uniformly separated as possible. The progress from "limited testing" to an "integrated prototype tested under commercial conditions" takes place over four well-defined steps, that should be justifiable by the applicant and readily verified by reviewers.

5. Using the Charts

The management team will have standard ProGrid charts to assist in its review of the submitted applications. Figure 3 shows an example of a proposal on a grid with the concept and the benefits as the axes. This chart displays the spread among the assessments carried out by the reviewers and the position as determined by the applicant. Figure 4 shows a profile of strengths and weaknesses of the application with respect to the performance factors in the original evaluation matrix.

An effective technique is to use the positioning grid and an R-value rating table (the R-value is a measure of the distance to travel to the upper right hand corner of the positioning grid), to divide the applications into three groups:

Group 1 – Highly rated applications
Group 2 – Applications that border on the budgetary cut-point
Group 3 – Applications that are significantly below the budgetary cut-point

There is no single method for making the final decisions and recommendations, but the following is one approach where the number of applications is large and where funds are limiting.

Group 1 applications are considered in order of the R-value ranking, determining if there are any significant differences among the reviewers in any performance factor. If not, budgetary or other concerns of any committee member can be raised and considered. After this process, a consensus should be sought about funding.

Group 2 applications may require more effort. As for Group 1, differences among reviewers should be identified and discussed. In addition, the sensitivity (potential for future changes) in the project should be assessed. The likelihood that current weaknesses can be readily corrected should be addressed. Any fatal flaws should be identified. After this discussion, it should be feasible to either confirm the current relative position of the application or to shift it upwards or downward in the seriatim.

Group 3 applications can be considered in an open discussion, in which a reviewer may challenge the weak position and present views contrary to the average reviewer assessment. Examples that fall in this category would be applications that have singular strengths that would warrant funding on a "prospective" basis.

The reviewers have selected the performance levels that best define the current position of the application. In some cases, there is an expectation that the position will improve as development proceeds. Some of the improvements are largely within the control of the applicant and would be key factors to address in the continuing development program. Other factors are largely outside the control of the applicant and reflect external conditions. Similarly, there is the potential for a slippage in the current position if some of the controllable development expectations are not successful or if some of the external factors adversely affect future prospects. The ProGrid assessment methodology includes an expert system that predicts possible upsides and downsides based on the current position and experience with similar applications.

6. Advantages to the Methodology

Organizations who provide funds for scientific projects in a formal competition typically use a peer review process to select winning projects. This is a time-honoured process that has served the scientific community well in the past and will continue to be a mainstay of project selection. Applications normally will consist of detailed descriptions of the research plan in rigorous detail. Copies of papers describing previous related research will frequently be included along with full curriculum vitae of the principal investigators. The documentation would be equivalent to a complete business plan for a commercial venture. Those involved in the review process are normally other researchers with experience in the area involved. For most of the reviewers, participating in such reviews is part of the normally accepted workload, and it is feasible for each of them to commit several days to a formalized review and selection process.

Peer review as described above has limitations in certain situations. When the volume of applications is large, when there is a near-term business implication requiring a wider spectrum of experience of the reviewers, when there is a need for a high level of transparency in the review process and when a more consistent basis of providing feedback to applicants is required (successful and unsuccessful), the standard peer review process requires modification.

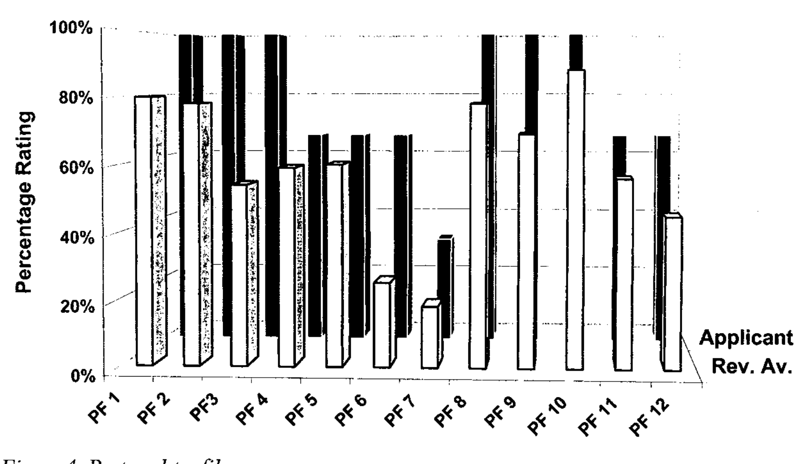

Figure 4. Proposal profile.

The ProGrid methodology is a form of peer review in that selected reviewers assess a submitted application form. However, the high focus of the applications on well-defined criteria selected by the funding body, the self-assessment by the applicants, and the ease of validation by reviewers leads to a review process that meets the requirements of competitions where conventional peer review has been found to be less suitable. ●

Clem Bowman, FCIC, has had an extensive R&D management career with Imperial Oil and the Alberta Research Council. Nine years with the Alberta Oil Sands Technology and Research Authority provided experience in funding technology-intensive ventures, which led to his interest in providing tools for R&D funders and venture capitalists.

Evaluating Intellectual Capital – Part IV. Tracking Investments

C. W. (Clem) Bowman, FCIC

Abstract

This is the fourth and final article in the series evaluating Intellectual Capital (IC). The first three articles examined the components of IC, the management of IC within research organizations, and the evaluation of IC investment opportunities. This fourth article describes a methodology for tracking the technical and market readiness of new IC.

As noted in the first article in this series, the value of intellectual capital, unlike tangible assets, is subjective and based on the ability of the owner or user to extract commercial value. The challenge for technology-intensive companies is to maintain their pool of intellectual capital through the development of new processes, products and services. A methodology called ProGrid-TA® has been developed to assist research organizations and their sponsors to track their investments in new technology, from inception to commercialization.

A ***Technical Strength***	*B* ***Connecting Factors***	*C* ***Commercial Potential***
Technical Framework	*Commercial Readiness*	*Market Characteristics*
Level of Verification	*Proprietary Strength*	*Margin and Profit Potential*
Excellence of Project Team	*Technological Durability*	*Commercialization Channels*

Figure 1. The evaluation matrix.

1. Evaluating Technologies

The ProGrid-TA methodology was developed in 1993 to assess the technical and market readiness of new technologies. It has now been used to assess approximately 300 new processes, products and services and has been upgraded progressively based on the experience of a wide range of users. As with all ProGrid tools, the methodology involves a sequence of steps; establishing criteria for measuring progress, constructing a grid with two of the criteria as key indicators of performance, and grouping the balance of the criteria into a matrix, each cell of which represent a factor which if achieved contributes to either of the two over-arching criteria.

The matrix used in the ProGrid-TA assessment is shown in Figure 1. The columns in this matrix represent a progression from factors that largely influence the technical strength of the project in Column A, to those that largely influence its commercial strength in Column C and those that are necessary factors to connect the technology to the market place in Column B. The headings for Column A and C (Technical Strength and Commercial Potential) are the two over-arching criteria and are used as the axes of the positioning grid, shown in Figure 2.

2. Establishing the Metrics

Performance levels must be established for the criteria embedded in the above matrix to provide the metrics for the ProGrid-TA calculations. This is facilitated through the development of Language Ladder statements for thirty-seven criteria. For example, one of the criteria in the Technical Framework cell is Advance on Prior Art. The following statements cover the expected range of performance:

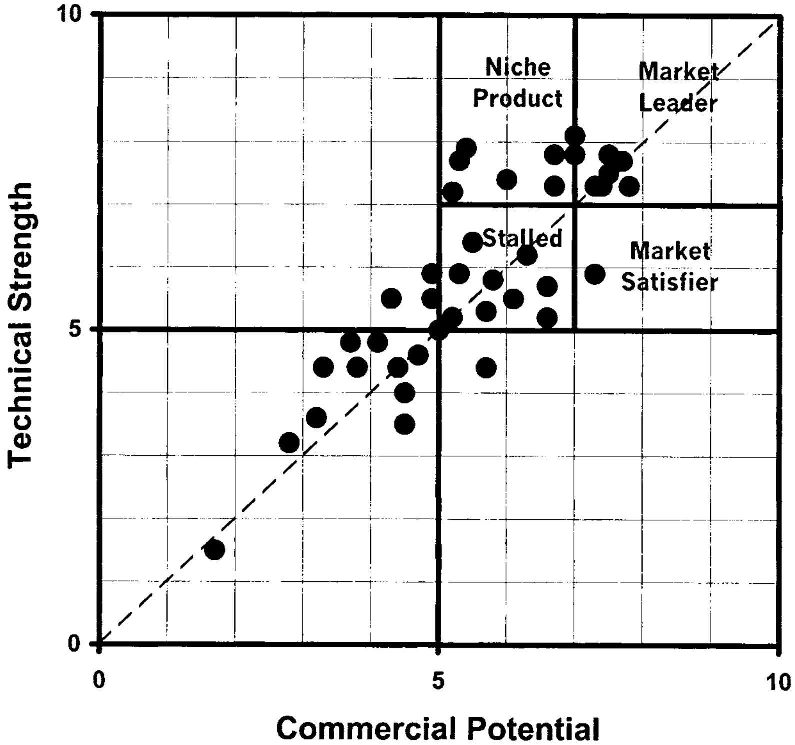

Figure 2. Positioning grid.

A. a relatively small advance on the prior art that would not be apparent to most users;
B. a definable and measurable extension of the prior art that will be discerned by discriminating users;
C. a significant and readily recognizable improvement over the prior art, but the basic scientific and technical principles are similar; and
D. a major advance on the prior art and embodies significantly different principles.

An example of a market-oriented criterion is Market Acceptance, for which the expected range of performance is covered by the following statements:

A. There is no evidence at this time of customer acceptance.
B. Preliminary market studies indicate positive customer acceptance.
C. Specific customers have been identified who have indicated their intention to place orders.
D. Current or new customers have given firm orders today.

Values are assigned to each performance level to provide the core metrics for the ProGrid-TA calculations.

3. Positioning Grid

Once a technical asset has been evaluated using the ProGrid-TA methodology, its position can be represented on the positioning grid shown in Figure 2, depending on its state of technical strength and commercial potential. The data in this chart represent technology/market pairs that were evaluated to the end of 1997.

At the inception of a new idea, its location on this grid will likely be close to the origin. As the idea matures into a bona fide technology, it will follow a specific trajectory. If the technical and market developments proceed in parallel, the trajectory will follow the 45 degree diagonal. If the market develops faster than the technology, or if the technical content is relatively low, the trajectory will lie closer to the x-axis. Conversely, if technical progress proceeds faster than market development, or if the technical content is very high, the trajectory will lie closer to the y-axis. Where the trajectory ends will determine the overall merits of the technology.

The division of the upper right quadrant into four zones illustrates the characteristics of technologies that fall within those zones. Niche products are those that have high technical strengths but with limited market reach; specialized analytical equipment would normally be in this zone. Market Satisfiers are products that have limited technical content but have large and sustainable markets. Market Leaders are those that have both high technical content and large market reach and these are the targets for most Venture Capital pools. The stalled zone represents an important area of the grid: technologies may pass through this zone on transition to a higher performance state. However, if they fail to make the transition after an appropriate period of development time, it may be an indication that the technology lacks the singular strengths to move beyond a "stalled" situation. There may be considerable further development effort but with limited true progress.

4. Technology Profile

A second and important output of the ProGrid methodology is the Technology Profile bar chart with the bars representing the strength of each cell of the matrix previously described. Profiles for two technologies are shown in Figure 3, one having strength on the left side of the chart (technical factors) and the other having strength on the right side (commercial factors). These are frequently referred to as Technology Push and Market-Pull technologies. The previously mentioned Stalled technology will have no commanding strengths and no major weaknesses, i.e., a flat profile. This is typical of a mature technology that has been involved in several commercial launch attempts where the obvious weaknesses have been corrected but no outstanding strengths have emerged.

5. Advanced Features

Future Position – An expert system has been added to the ProGrid methodology that provides an estimate of the future position as development proceeds. Each of the 37 criteria has four levels of performance, resulting in a total number of 148 current performance states. The likelihood of advancing from these states has been estimated based on each language ladder statement. This feature allows progress to be measured against the attainable future state. An example of the potential trajectory of a technology calculated by the expert system is shown in Figure 4.

Commercialization – Additional modules (ProGrid CS, ProGrid-CO; see Part 1 of this series, p. 24, January 2001, *ACCN*) can be added to ProGrid-TA to assess the capability of the company who will commercialize the technology. Venture Capital companies have historically placed pre-eminent importance on the quality of the management team in start-up companies. They have learned to make accurate judgements about the capability of the commercializing team based on a few observations — essentially a "gut feel" about the quality and commitment of the principals. The ProGrid-TA approach uses a different sequence; if the technical assets are strong and a viable market exists, then the venture deserves closer examination regardless of the current strengths and weaknesses of the commercializing organization. This approach provides the opportunity to add value by facilitating the addition of the missing components. If the ProGrid-TA assessment is encouraging, the companion modules can be employed to determine the strengths and weaknesses of the company.

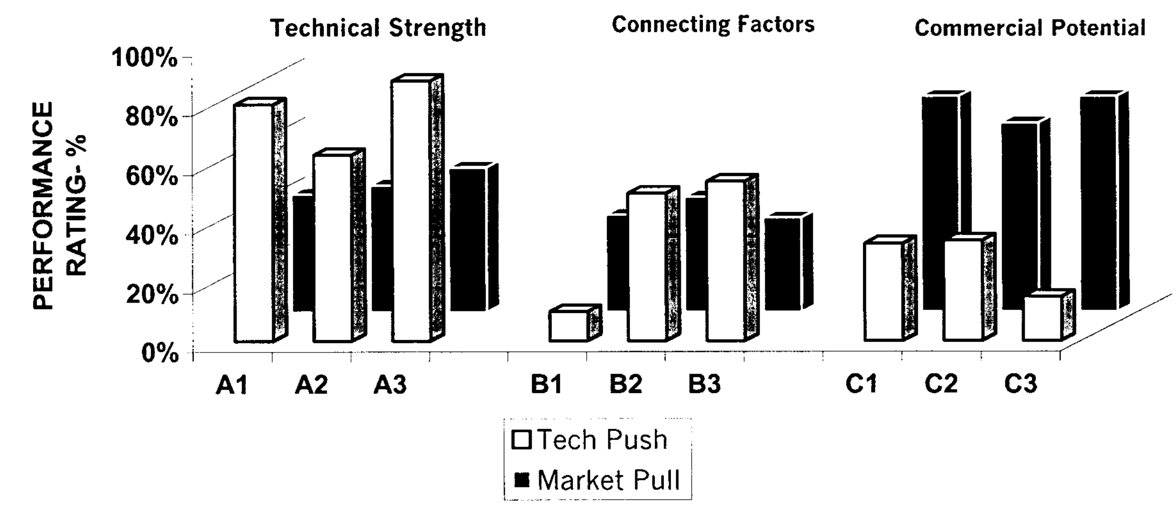

Figure 3. The technology profile.

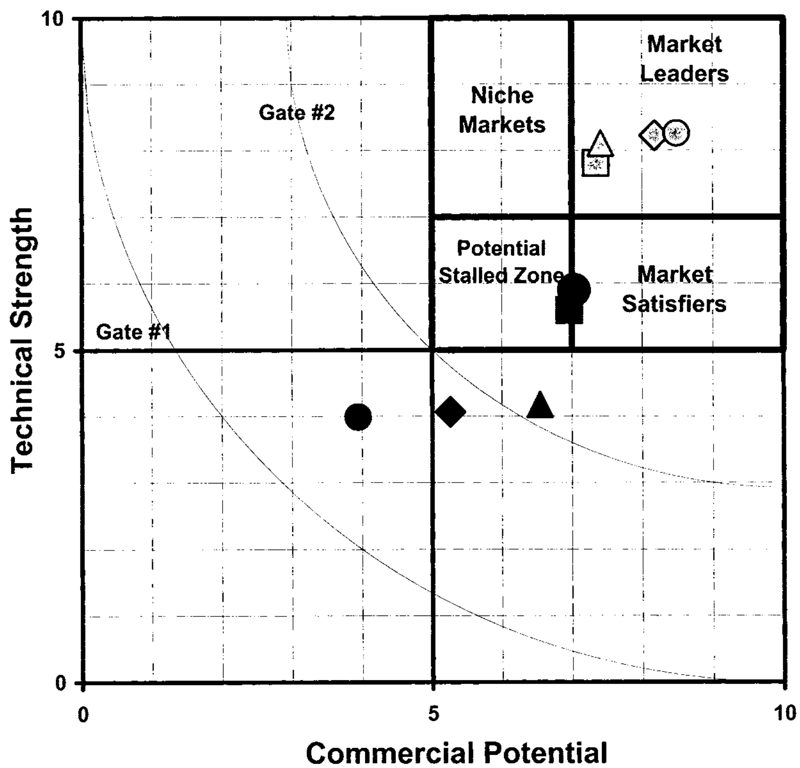

Figure 4. Future trajectory.

6. The Assessment Process

The ProGrid-TA technology assessment procedure should be carried out by a panel of people knowledgeable about the technology/market to be assessed. This normally will include individuals representing the technology developers, the commercialization team, and preferably one or two individuals who are not part of these two groups but whose participation will add credibility to the process. A trained facilitator adds considerable value to the assessment by ensuring that the assessment decisions are consistent and well supported. The facilitator ensures that consensus is reached on each of the 37 ProGrid-TA criteria. In addition to assessing the technical and market readiness of a new technology, the ProGrid-TA assessment also serve as a mentoring session to help the entrepreneur define the actions needed to enhance the probability of commercial success. ⬢

Acknowledgements

The author has worked with many experienced technology managers in developing best practices of research management and the various ProGrid tools, which have been described in the four articles in this series. Three individuals in particular played a very large role, J.R. (Ron) McCullough, G.B. (Gerry) Dyer, and J.W. (John) Kramers.

Clem Bowman, FCIC, has had an extensive R&D management career with Imperial Oil and the Alberta Research Council. Nine years with the Alberta Oil Sands Technology and Research Authority provided experience in funding technology-intensive ventures, which led to his interest in providing tools for R&D funders and venture capitalists.