Management Information Systems for Projects and for Organizations: a Comparative Overview[1]

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SUMMARY

Traditional MIS have evolved to serve structured, functional, permanent organizations. Project information systems more recently have emerged to serve temporary, relatively short-lived, multi-functional projects. Project MIS, compared to the various organizational MIS, must handle more diverse information and be more predictive and integrative in nature over a longer time span. The result is that project MIS are generally more difficult to implement, and their implementation often reveals existing incompatibilities with and between the various organizational MIS which provide information to project systems.

Specific product and project planning and control functions and tools are identified in this paper, and the types and sources of incompatibilities are discussed. Suggested methods of minimizing the problems are briefly presented.

The underlying thesis of this discussion is that a better understanding of the differences and interfaces between project and organizational MIS will help to resolve current problems and avoid future difficulties in the implementation of information systems to serve operating project managers.

MIS IN GENERAL

In this discussion, I refer to management information systems (MIS) as identifiable sets of policies, models, procedures and files of information which operate to record, manipulate, store, retrieve, process and display information useful in managing some aspect of an organized enterprise. Such systems may depend only on rather simple mechanical devices operated directly by human hands, such as pencils, pens, ledgers, charts, and so on; or they may also depend on more complex devices and machines, such as slide rules, calculators and electronic data processing systems. They all seem to depend on paper to a great extent!

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[1] Second Editions are previously published papers that have continued relevance in today's project management world, or which were originally published in conference proceedings or in a language other than English. Original publication acknowledged; authors retain copyright. This paper was originally presented as a Keynote Address at the INTERNET 72 Third International Congress on Project Planning by Network Techniques (INTERNET became the International Project Management Association/IPMA a few years later) in Stockholm, Sweden, May 15-19, 1972. It is republished here with the author's permission.

[2] When this paper was presented in Stockholm, Russ Archibald was employed by ITT Corporation at their world headquarters in New York City.

Perhaps Moses had the first MIS when he came down the mountain with the Ten Commandments chiseled into stone tablets. At least today's reports carry more information per pound, but they are certainly no lighter to carry than the stone tablets of Moses' day.

The basic classes of primary management information systems may be identified as follows:

- General management
- Financial
- Logistics
- Business acquisition
- Resources

To which we now presume to add:

- Projects

General management information systems are concerned with the overall, integrative planning and direction of the total enterprise. They include methods of generating, recording and processing information related to:

- Strategic objectives and goals
- Financial objectives
- Business, market and product plans to achieve the objectives
- Overall performance measurement and evaluation compared to objectives.

These general management information systems depend heavily on the financial MIS, and to a lesser extent on all other types of MIS.

Financial management information systems are familiar to us all, and deal with the basic element of resource that we all understand (at least to some extent): Money. With these systems we are able to:

- Translate the strategic, market and product plans of the enterprise into the common denominator of money.
- Plan, control and account for the production, distribution and inventory of money, resulting from the basic operations of the enterprise.
- Analyze the basic operations in monetary terms.

This class includes systems for financial planning, budgeting, cash handling, accounts and financial analysis.

Logistics management information systems enable us to plan, control and account for the acquisition, inventory, processing, conversion, assembly and distribution of goods and services -- the tangible repetitious transactions or work -- which generate the outflow and inflow of money. Systems within this class include purchasing, work authorization and control, production and inventory planning and control, and product distribution.

Business acquisition management information systems include procedures

For handling information related to markets, products, capabilities, competitors, customers, proposals and selling, and orders (contracts or sales). In this class are found marketing and sales systems and procedures, such as order booking, processing and billing, collections and contract administration.

Resources management information systems deal with the basic resources of a company other than financial), including people, know-how, plant facilities, and equipment. Included here are personnel information systems, as well as those dealing with the acquisition and utilization of capital facilities, installed equipment and other types of equipment and resources required to produce the goods and services which are delivered or sold by the organization.

Project management information systems (PMIS) enable us to plan, schedule, execute and control projects -- those complex, unique efforts which cut across organizational and functional lines, and which must achieve the specifiedresults at a particular point in time and within a given cost of budget. Projects may be viewed as temporary profit centers which subcontract most if not all of the actual work required to complete them. The verb "to project," or to forecast or predict, conveys the fundamental purpose of various related PMIS: to predict how the project will come out, based on progress to date and current plans for the future.

MIS FOR ORGANIZATIONS

Organizations of all types -- business, industrial, institutional, governmental - are structured and shaped to meet the needs of the primary purpose of each individual organization. This structure invariably results in some form of hierarchy or bureaucracy, segregating and dividing the various functions such as marketing, manufacturing, engineering, and so on.

The financial, logistics, business acquisition and resources management information systems which we have today are designed to serve the structural, hierarchical organization which has a certain permanency associated with it. Financial budgets and reports are provided for organizational sections, departments and divisions, for example. Production control systems serve the manufacturing division and have nothing to do directly with engineering. Information is provided to each functional manager concerning his limited segment of the total operation as orders are obtained and fed into production, and as the raw materials are purchased, processed and shipped to the customers.

The organization structure, portrayed by the familiar pyramidal chart of boxes and lines, forms a fairly stable skeleton on which most, perhaps all, of these management information systems are based.

EVOLUTION OF MIS FOR PROJECTS

The emergence in the past fifteen years of more numerous projects within most organizations, and the difficulties experienced in trying to plan, execute and control temporary projects using management information systems designed to serve permanent organizations, has led to the development of this new class of MIS specifically designed to manage projects.

We know that many organizations, such as the large engineering construction companies, have had some form of PMIS in operation for as long as they have been in business, because projects are essentially their only business. However, my experience indicates that these

companies typically form a pyramidal, hierarchical organization structure for each major project, and thus they are able to use the more traditional MIS, which we have seen were designed to serve such structures.

At some point, 10 to 15 years ago, we realized that we cannot always form a separate functional, self-supporting organization for each project. The large engineering-construction and aerospace firms continue this practice to a degree, but even they are finding that it is more efficient to be able to handle a number of projects within one basic organization, and to retain the functional structure to the maximum extent possible.

Other industries of many types have found it even less practical to set up project organizations for their numerous projects. To illustrate the diversity of business, industries, and governments presently concerned with managing projects, here is a breakdown of the more than 500 members of the Project Management Institute (PMI), representing 310 companies and organizations, and 15 universities located in 16 countries:

Processing/manufacturing/producing	31%
Engineer/constructor	20%
Consultant (all fields)	20%
Educational/government	11%
Instruments/computers/electronics/electrical equipment	11%
Other	7%
	100%

So the need to be able to plan, execute and control many projects as they passed through the functional, divisionalized organization forced the evolution of PMIS in support of the project management capabilities of organizations. Network planning (both the activity-event and the procedure diagram techniques) emerged as a powerful tool, if properly applied -- and as a great waste of time and effort if not properly used. This tool is one form of PMIS. From the project management viewpoint, its primary advantage is the ability to integrate the plans of many separate responsibilities and analyze both the logical sequences and the utilization of time and other resources in these plans, in terms of the total project and, in fact, many projects.

We could characterize functional management as divisive (as it divides the work along functional lines) and project management as integrative (as its prime purpose is to manage the project as a whole.) In this respect, project management is identical to general management: the former dealing in an integrative manner with each project, and the latter integrating the enterprise as a whole. Just 10 years ago, with the publication in 1962 of the U.S. Department of Defense/NASA PERT COST document, the concept of the "work breakdown structure" emerged. This followed closely the work I was involved with at Hughes Aircraft Company, where we developed an operating "PERT Cost" system in 1961[3]. PERT Cost became rather infamous in the next few years, and the concept went through a series of name changes and improvements. Presently, the general term "Performance Measurement Systems" is used in U.S. governmental programs and projects, but the essential PMIS elements that were present in PERT Cost are still evident in the current documentation.

[3]See Chapter 7, of reference I, for a description of this early system.

A key concept which has emerged from this very expensive effort with the Defense/Space industry is the systematic definition of projects – the project breakdown structure (PBS)[4]. It is through the PBS that we can create a skeleton or framework, specifically adapted to each project, which fulfills the same fundamental purpose (from the MIS viewpoint) as the organization structure. This concept of a structured, systematic subdivision of projects enables the development of truly integrative PMIS, just as the organization structure has enabled the development of organizational MIS. It is impossible to budget and control the work of a large company without subdividing it into divisions, departments and sections; similarly it is impossible to plan, budget, schedule and control a large project without subdividing it into manageable tasks. We must also be able, in both. cases, to summarize information at successively higher levels, and identify deviations from plan on an exception basis. The PBS provides this capability for PMIS.

WHAT PMIS SHOULD DO

Project managers, and the higher level multi-project managers to whom they report, must have management information systems which will enable them to:

- Plan, subdivide, estimate, integrate, forecast, evaluate and control all projects, integrating all of their life cycle phases (concept, definition, design, construction or manufacture, commissioning or commercialization, close-out).

- Integrate action plans, schedules, and resources (money, manpower, machines, etc.), all identified by PBS element and organizational responsibilities; and including estimates, budgets, actual expenditures, physical progress and forecasts of time and cost to complete and at completion.

- Allocate resources over multiple projects, or reschedule activities to utilize available resources in the most productive manner.

These capabilities are not extraordinarily complex or unique, in principle. For example, consider an engineer in charge of a complex engineering design task. We can think of this as a small project, although it is probably a portion of a larger project. The engineer does all the things I have mentioned above -possibly on the back of an envelope -- for his task. In most engineering organizations, the chief engineer or technical director has procedures for performing these management functions on all the engineering tasks which form the workload for his department. He will probably make use of certain organizational MIS in the process.

However, if we now consider the multi-functional projects which exist in the same organization, and include the marketing, manufacturing, field operations and other tasks in addition to the related engineering tasks for each project, carrying out the planning and control functions becomes a much more complex situation. The basic ideas and needs have not changed, but the information complexities are increased considerably, and the organizational MIS, by themselves, will not do the job. The large amount of inter-dependent information almost forces us to use computer-based systems in typical multi-project situations.

[4]I prefer this term to "work breakdown structure," as the PBS usually contains other elements besides work. The concept is described in some detail in Chapter 1 of reference 1.

I do not intend to describe such systems in detail, but I am sure you will find a great deal of current information about them in the proceedings of this conference, and of course in the general literature on the subject.

COMPARISON OF ORGANIZATIONAL AND PROJECT MIS

The key differences between project and organizational MIS may be summarized as follows:

ORGANIZATIONAL MIS	PROJECT MIS
Purpose: to manage permanent, slow-changing organizations.	Purpose: to manage temporary, rapidly-changing projects.
Type of information handled: Each separate MIS deals with specific information of primary interest to one part of the functional organization.	Type of information handled: Many types of information affecting several functional areas contributing to each project.
Time horizon: Usually limited to annual budget cycle.	Time horizon: Reflects the duration of each total project and each life cycle phase therein; therefore must be flexible; usually extends beyond the annual budget cycle.
Predictive capacity: Limited to budget period, maximum usually one year.	Predictive capacity: Must have strong predictive capacity reaching to the end of each project, usually beyond one year.
Integrative capacity: Limited, since each MIS deals with one specific type of information -- with the exception of general management information systems, which must have the same or even greater integrative capacity as PMIS.	Integrative capacity: High, since information dealing with action plans, time, cost, resources, logistics and business acquisition must be interrelated and summarized for each project and each affected functional organization.
Ease of implementation: of new procedures: High, if a modular approach is used, since new procedures can be introduced for a limited segment within a function, and since the integrative capacity requirement is limited.	Ease of implementation: Low, since system effectiveness is directly related to the degree of integration, and since PMIS depend heavily on many organizational MIS which frequently have inherent inconsistencies in procedure and data (different numbering schemes, cut-off dates, cycle times, etc.)

INTERDEPENDENCIES BETWEEN ORGANIZATIONAL AND PROJECT MIS

In order to discuss the interdependencies between these different classes of MIS, we must first view the information needs of the overall function of project management. Then perhaps we can differentiate between the various systems which are basically organizational but which also serve project managers, and those systems which are specifically designed to handle project information. In the process of doing this, the interdependencies should be revealed.

Product vs. Project Planning and Control

It is beneficial to recognize the differences between the product (or results being produced by the project) and the project itself (or the process by which this product is being created).

Figure 1 illustrates a conceptual model of a large business program, and shows the separation of product-related and project-related information. Even though such information is somewhat separated, the project manager assures its proper integration for evaluation and direction of his project. This partially illustrates a long-range concept of future organizations which, in the words of the managing director of one of the largest ITT Corp. houses, "will consist of a permanent site (works) management staff, with responsibility for the plant and its engineering and production staff, and a more mobile, flexible project or contract management staff which will handle the task for conceiving, planning, coordinating and directing the various projects which are to be executed using the site facilities and people."

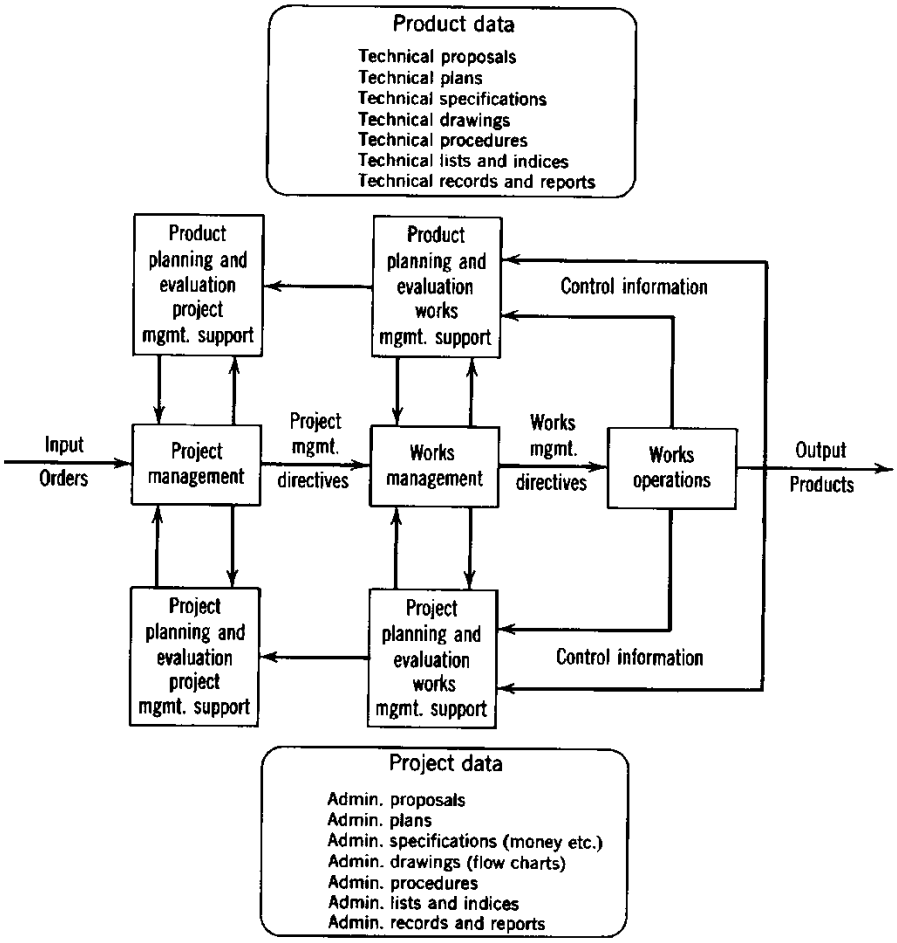

Figure 1. Large Business Program Model (Source: Frank Little, Boeing Company)[5]

[5]Reference 1, page 27

One of the project manager's most important -- and most difficult -- tasks is to interrelate the technical and the administrative aspects of his project. Most PMIS efforts to date are limited to administrative planning and control information, and considerable difficulty has been encountered in tying this to the technical information in a systematic way. This division of information is frequently aggravated by a similar division in the assignment of project management responsibilities, and in fact many project managers who come out of the technical area feel it is demeaning to get involved with mundane matters concerning schedules and costs.

Planning and Control Functions and Tools

Various methods, procedures, systems and practices -- management tools -- exist to accomplish the planning and control functions for both the product and the project. These are summarized as follows:

Product Planning and Control Functions and Tools

These concern what the end results of the project will be, and encompass all information relating to the physical performance and economic characteristics of the product (whether it be goods, services, information or change). In the following list, the tools which are identified relate primarily to a manufacturing environment. Equivalent tools will usually be found in organizations and projects producing other kinds of results.

PRODUCT PLANNING & CONTROL FUNCTIONS	EXAMPLES OF THE TOOLS
Establishing and controlling the product characteristics.	Product plans Market analysis Specifications, drawings and diagrams Analytical techniques, tests and reports Design review procedures Models, work-ups and prototypes Product cost estimating procedures Value engineering procedures Project evaluation meetings.
Controlling product configuration.	Drawing release procedures Design review procedures Configuration management practices Change order control procedures Change control boards Production control systems Technical supervision
Establishing and controlling product quality.	Quality control procedures Product assurance (reliability and maintainability) procedures Technical supervision Design review procedures Project evaluation meetings

Project Planning and Control Functions and Tools

These concern how the end results of the project will be achieved and encompass all information relating to project objectives and definition; action plans; resource plans, budget forecasts and expenditures; progress to date; and similar non-technical matters. They include the following:

FUNCTIONS	EXAMPLES OF THE TOOLS
Establishing and controlling project plans and objectives.	*Product plans *Proposals to customers *Contracts with customers *Project Authorization Requests *R&D Case documents *The Project File Contract administration procedures *Project evaluation procedures
Defining the project.	**Systematic planning techniques such as the Project Breakdown Structure
Planning the work (tasks).	**Project Breakdown Structure **Work control package definition procedures **Network systems (PERT/CPM/PDM) **Resource allocation procedures **Bar charts
Scheduling the work.	**Network systems **Resource allocation procedures **Bar charts **Milestone charts
Estimating required resources (manpower, money, material, facilities) .	**Work planning procedures (listed above) Manpower and material estimating procedures Cost estimating and pricing procedures
Budgeting resources	**Planning, scheduling and estimating procedures (listed above) Budgeting procedures
Work assignment and authorization: Internal External	 Work authorization and control procedures Subcontracting and purchasing procedures
Evaluating progress: Physical	 **Reporting procedures **Network systems **Project management systems

Cost Manpower	Financial information systems (accounting, budgeting, etc.) Contract administration procedures **Project management systems Manpower reporting procedures **Project management systems Contract change procedures **Project management systems
Schedule and Cost Control	Budgeting procedures Work order procedures
Integrated evaluation of time, cost and technical performance.	*Project evaluation procedures and practices, using information produced by all the above tools.

The items marked with an asterisk (*) or a double asterisk (**) in this list relate primarily to projects, and in most cases have been specially developed to meet project management needs. The items marked with a double asterisk (**) may be considered as individual PMIS, or they may be combined in one or more groups to form more complex PMIS.

The remaining items on the list are organizational MIS or related procedures, which are used by the project management function with suitable planning of coding schemes to enable the project information to be produced.

Incompatibilities with Organizational MIS Used for Projects

The specific organizational MIS which are used for project purposes as indicated on the above list include:

- Contract administration
- Manpower and material estimating
- Cost estimating and pricing
- Budgeting
- Work authorization and control
- Subcontracting and purchasing
- Cost accounting
- Manpower reporting

Each of these systems has usually been developed within the functional organizations to satisfy management needs, without specific regard for project considerations. When project requirements emerge within the organization, the managers and specialists responsible for developing, implementing and operating PMIS must have a good understanding of the workings of these existing systems. This is necessary so that the project systems to be introduced will be compatible with and take full advantage of the existing systems.

In some cases, introduction of project systems calls attention to known deficiencies in the existing systems, or identifies the absence of certain important procedures. For example, a good work authorization and control system is vital to good control of project tasks in a functional organization. Yet frequently we find that the only existing system of this type is used only for plant maintenance and repair. In other words, you can't get the lock fixed on your office

door without a formal work order in many companies, but you can arrange to have 15 engineers assigned to a new product idea by making a couple of phone calls. Usually, we can use such existing work order systems to authorize and control all project work, with minor changes.

Introduction of project systems will almost always reveal various types of incompatibilities with and between these organizational MIS. Some of these incompatibilities are extremely difficult to overcome. This should not be surprising, considering the basic differences in the two types of systems previously discussed and the fact that the various organization MIS generally have evolved over long periods of time, each one under varying circumstances.

Since the primary purpose of project MIS is to integrate various types of information relating to work being performed within various types of functional organizations, introduction of such integrative systems has a uniquely powerful revelation effect in regard to incompatibilities. There is often a tendency to blame "project management" or "project MIS" for creating problems with systems which were thought to be perfectly good. Perhaps some of you have had the same feeling as I have at times, that introduction of improved project systems is an unending series of unfortunate discoveries -- each of which causes some pain, diverts some effort and delays the desired results until the incompatibility has been overcome.

The causes of these incompatibilities include:

Differences in time units - hours, shifts, calendar days, working days, calendar weeks, production weeks, calendar months, accounting months, calendar years, and fiscal years are all used in various systems.

Differences in cutoff dates - various reports or data are available as of a certain day of week, weekend, bi-weekly, bi-monthly, monthly, quarterly, etc.

Differences in cycle time - some systems produce reports within hours of the cutoff date, and others require several weeks.

Functional vs. product vs. project orientation - some information is related only to the type of work function , while other information relates to a product or project.

Manual vs. machine systems - some systems will be totally manual, others fully automated. It is debatable which is the easier to change in order to adapt a new system.

Identification and coding of information - codes used in one system may be meaningless in another; the same code (for example, "contract number"), may be inadvertently duplicated in other parts of an organization, or used for different purposes and with a different significance.

By anticipating such incompatibilities and planning our way around them, we can avoid many surprises and achieve the operational results we desire at an earlier time.

Methods of Minimizing the Problems

In developing and introducing new or improved project management information systems, I would recommend using the following methods to minimize the problems and difficulties which will be encountered.

Define Objectives

A clear statement of the reasons for introducing the new system, and the objectives expected to be achieved, is essential. Yet we frequently see substantial efforts under way which do not have well-defined objectives.

Give Operating Management the Responsibility

Only when the appropriate operating manager has the clear responsibility for success or failure of the system will it achieve its true potential.

Use the Task Force Approach

Each affected part of the organization, and each related system, should be represented on the task force or team introducing the new or revised system, so that the capabilities, needs and weaknesses of each department and system will be known.

Design for Environment

The system to be introduced must be adapted to reflect the strengths and deficiencies of the existing, related organizational systems, as well as the capabilities of the managers to understand and use the new system.

Avoid Technical Pitfalls

Any new system is based on certain techniques or procedures. In PMIS we now have reasonable experience concerning technical pitfalls -- many of which are no doubt described in these proceedings. If any particular technique gets in the way of useful results, the technique should be reexamined carefully, and revised or discarded.

Educate All Affected Persons

Failure to recognize the need for indoctrination, training and development of all affected managers and specialists -- both project people and functional contributors -- is a primary source of unnecessary difficulty. We can expect people to resist any change or new procedure which they do not understand and therefore do not trust. Change implies criticism of the old way, and this must be offset by proper education regarding the need for the change and the expected results.

CONCLUSION

Understanding of the differences between organizational and project MIS, and of the interrelations between the various information systems, will help in the design, development and implementation of more effective systems for project management. We must never lose sight of the fact that all information systems must satisfy a real operating need in a practical manner. The project systems which are the main concern of this INTERNET 72 meeting are intended to help plan and execute projects so that they achieve their technical, schedule and financial objectives: "to specification, on time, within budget." In short, they are intended to serve

operating managers, and not to provide intellectually fascinating opportunities for systems people to spend a lifetime talking to each other.

As we participate in the remainder of this conference, I suggest that each of us keep this point in mind. For if we do not serve operating managers, our efforts and our jobs will quickly disappear.

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Now 93, with careers spanning more than 70 years, Russ Archibald has had broad international experiences in piloting and designing aircraft, corporate engineering, operations, and program and project management. His three project management related careers have been *Military/Aerospace (19 years), Corporate Engineer & Executive (17 years)*, and *Management Consultant (34 years to date)*. Russ has consulted to a wide variety of large and small organizations in 16 countries, has trained thousands of people in project management, and has resided in the USA, France, Mexico, Venezuela, Panama Canal Zone, and Peru with Marion, his wife of 70 years. For the past 23 years they have resided in San Miguel de Allende, Guanajuato, Mexico.

Russ is founding member number 6 of the Project Management Institute/PMI. After presenting the first PMI paper in 1969 he was President of the PMI Southern California Chapter in 1991-2, founding member of the PMI Mexico City Chapter in 1996, and in 2006 was awarded the PMI *Jim O'Brien Lifetime Achievement Award.* A PMI Fellow and Certified Project Management Professional, he co-authored with Prof. Dr. Jean-Pierre Debourse the 2011 PMI research report *Project Managers as Senior Executives*. He was also a founding member in 1970 and is an Honorary Fellow of the Association of Project Management (APM/IPMA-UK).In 1967 he was co-author (with Richard Villoria) of *Network Based Management Information Systems (PERT/CPM)*,Wiley, one of the first books to appear on project management.

Russ is co-author with his grandson Shane Archibald of *Leading and Managing Innovation-What Every Executive Team Must Know about Project, Program & Portfolio Management*(2nd edition CRC Press 2015, 1st edition 2013 also published in Italian, Portuguese and Spanish); author of *Managing High Technology Programs and Projects* (3rd edition Wiley 2003, also published in Italian, Russian, and Chinese), has contributed chapters to 15 books edited by others, and presented 88 papers at many PMI, IPMA and other conferences in many countries. He holds BS (U. of Missouri 1948) and MS (U. of Texas 1956) degrees in Mechanical Engineering. Russ was awarded an honorary Ph.D. in *Strategy, Program, and Project Management* from the *Ecole Superieure de Commerce de Lille* in Lille, France in 2005. See russarchibald.com. Russ can be contacted at russell_archibald@yahoo.com