Mid-Term Review

of the

Intelligent Manufacturing Systems (IMS)

Program

FINAL REPORT

by

The Mid-Term Review Panel

September 2000

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Mid-Term Review Panel

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Glossary

CAG	Chairman's Advisory Group
CAM	Consolidated Annual Monitoring
CCA	Consortium Cooperation Agreements
EU	European Union
GITI	Global Industry Technology Initiative
ICP	International Coordinating Partners
IMS	Intelligent Manufacturing Systems
IPC	International Project Coordinator
IPR	Intellectual Property Regime
IRS	Inter- Regional Secretariat
ISC	International Steering Committee
MTR	Mid-Term Review
PMG	Project Management Group
RS	Regional Secretariat
RTD	Research and Technology Development
SME	Small/Medium Enterprise
ToR	Terms of Reference
TSG	Technology Steering Group

Foreword

Since the IMS Program was first conceived there have been major changes in what has been termed the 'manufacturing industry'. Rapid advances in information and communication technologies and the globalisation of industry have blurred further the distinctions between manufacturing and services. At the IMS Vision 2020 Forum[1] the implications of these changes were discussed and a future vision for manufacturing developed.

The future directions identified all supported an ongoing IMS Program, albeit one that would need to be modified to improve on past performance and accommodate to changing circumstances. The renewed role for IMS proposed would be characterised by:

- a renewed vision to address the challenges of 'new manufacturing' in a rapidly changing world;
- a proactive ideals-driven approach rather than being project driven
- an appropriate structure/organisation;
- promotion of the new manufacturing, addressing challenges of sustainable development and global equity;
- a need to broaden membership beyond OECD-like 'rich countries club', and streamline entry; and
- building on the strength of IPR framework for collaboration.

The Mid-Term Review Panel has noted these various deliberations, and welcomes the recognition of a need for change. However, the review has focussed on the actual operation and performance of the IMS Program.

Acknowledgments

The Mid-Term Review Panel would like to thank the staff of the International Regional Secretariat and the Regional Secretariats who provided support to the Panel, and responded rapidly and efficiently to the many requests for data and information.

[1] 'Vision 2020', Proceedings of the IMS Forum on Issues for Global Manufacturing to 2020, Irvine, USA, 24-25 February 2000.

Executive Summary

The Intelligent Manufacturing Systems (IMS) program was established in 1995 to promote multi-lateral collaboration between large and small companies and with researchers, particularly those in publicly funded organisations, in the development and diffusion of manufacturing technologies and systems.

It has successfully established a framework that provides the basis for cooperation across disciplines, company size, and national borders. A key aspect of that framework is the protection and use of intellectual property brought to and generated from a cooperative project.

The core of IMS is the portfolio of eighteen projects, involving a commitment of US$194 million and participation by over 350 firms and research groups across the IMS regions. However, only one of these projects has reached its scheduled completion, and hence it is not possible at this time to make a meaningful assessment of output and impact, beyond those derived from the process itself.

Nevertheless, it is quite apparent that after the initial enthusiasm, reflected in the commitment to the feasibility study and the rapid establishment of a number of projects, there is a declining interest in, and relevance of, the IMS Program. This can largely be attributed to the radical transformation in the character and environment of manufacturing since the IMS concept was mooted.

The Panel recommends the IMS continue, but with a new title and objectives that more adequately address the new challenges to manufacturing, and with a proactive approach to shaping the IMS Program and projects.

At present, the structure of IMS operations is split into two largely distinct components. The first somewhat bureaucratic component, composed of the ISC, CAG, IRS and RSs manages policy and the overall Program. The second component - the IPC and project coordinators, operate fairly independently and are largely concerned with managing the individual projects. The former addresses largely a government perspective, the latter, industry.

It is quite apparent that this structure is no longer appropriate to the needs of IMS. It is the subject to a great deal of dissatisfaction, and appears to be inconsistent with the basic aim of using the projects to underpin and validate the broader policy measures advocated to advance the cause of manufacturing.

The Panel recommends the structure, membership and decision-making procedures of the ISC be altered to allow it to function effectively as a Board, and a permanent Technology Steering Group be established to drive the proactive direction-setting processes required to shape the program effectively. At the same time, the IRS should be established at a permanent location.

In order to achieve IMS objectives, it is essential that the membership be considerably increased, and opened to a wider range and type of membership.

The Panel recommends that procedures for admission to the IMS be streamlined, and a form of associate membership be established. As part of these changes, a two-tier central funding model should be adopted.

The monitoring and evaluation processes for projects, and the overall program have clearly been inadequate. Such processes are now recognised as best practice but were not established at inception and no budget has been provided for developing, assisting and selling the process.

The Panel recommends the introduction of an appropriate project and program evaluation process.

1. Objectives and Scope of the Review

This Review is mandated by Article VIII of the IMS Terms of Reference (revised 27-1-1997) which reads:

> The participants [of the IMS] will review the principles of their cooperation five years after its launch in order to see whether it should be continued, modified or terminated.

Furthermore, the Guidelines for the Review stated:

> The mid-term assessment of IMS, both at the regional and inter-regional level, should be based on independent IMS external expertise; in other words…it should be conducted by a panel made up of high level independent experts…IMS project participants, members of the IMS management bodies and the governments/administrations supporting the initiative should be excluded from the assessment process.

The scope of the review was outlined in the Guidelines for the IMS Mid-Term Review[2] as:

(1) Assessing how the project portfolio has contributed to the IMS objectives, the effectiveness of IMS regions and IRS/ISC to contribute to the objectives in a cost efficient manner, taking into account the IMS strategic plan.
(2) Assessing major results of the project portfolio (RTD and innovation; direct and indirect impact).
(3) Assessing the efficiency of the various bodies at regional and inter-regional level managing IMS; efficiency and transparency of the program. management (marketing, communication, invitation to submit proposals, information to proposers, review and selection process, support for IPR issues; project follow-up/monitoring).
(4) Appropriateness of level of contribution to the IRS.
(5) Recommendations for the future, taking into account:
    - consistency of the selection of projects with the initial objectives of IMS;
    - extents to which selected projects are contributing to achieve the objectives of IMS;
    - progress and output of projects against the original targets set and major achievements up to now; and
    - responding to the needs of society in the light of changing circumstances.

Further guides to the scope of the review were provided by:

- the objectives of the IMS program[3]; and
- the 'Outline of the Assessment' (see Appendix 1).

[2] Doc No IMS/ISC/10/9/Annex 2, 27-10-1999
[3] pp. 3-4 in the unpaginated 'Terms of Reference for a Program for International Cooperation in Advanced Manufacturing' - the 'Blue Booklet'

In addition, in the Guidelines to the Review[4], it is noted that:

> The small number of experts and the limited time devoted to the exercise will dictate a broad analysis at the general level on the status of programme implementation (rather than in-depth project-by-response investigation). In particular, the exercise should be considered as a light and quick response to the IMS programme development and give advice on key issues. It should thus help to reinforce the establishment of best practice and identify and correct weaknesses and allow governments to base their decision on whether and how to continue IMS.

The target audience of the report is the International Steering Committee (ISC) of the IMS, and the governments signatory to the IMS initiative. The results of the assessment is required to be made accessible to all IMS stakeholders, including the IMS project coordinating partners (IPC) and the Regional Secretariats.

Given the objectives and scope of the review, the Panel concentrated its data collection and analysis on the operation and achievements of the IMS. The majority of the data were sought, in structured and semi-structured form, from participants of various kinds in the IMS Program - the members of the ISC, international project coordinators, and staff of the Inter-Regional Secretariat (IRS) and the Regional Secretariats (RS).

In addition, the Panel members carried out a series of interviews with direct and indirect stakeholders of the IMS (using an agreed pro-forma), including present and former members of the ISC, individuals involved in the IMS feasibility project, CEOs of companies involved in IMS projects, and senior figures in companies that might be expected to have a perspective on the IMS Program, its objectives and achievements.

A detailed methodology is outlined in Appendix 2.

[4] Guidelines for the IMS MTR, Annex 2, Section 3.

2. Overview of the IMS Program

2.1 Formation of IMS

In the context of the early 1990s, the changing nature of manufacturing worldwide has seen manufacturing firms focus increasingly on the global market and on their global competitiveness. The view emerged that many of the underlying technological and management challenges confronting manufacturers today can best be addressed through cooperation and, in particular, cooperation on an international scale.

Prior to the 1990s, this kind of international cooperation was generally confined to a few very large firms. The IMS initiative was established to encourage global cooperation in the development of manufacturing technologies and systems to allow manufacturing firms and nations to move ahead rapidly in a global environment while maintaining their competitive edge.

IMS grew out of an initiative from Japan proposed by Professor Yoshikawa, then President of the University of Tokyo. The vision of IMS was for a global system of industrial cooperation and technology sharing to the general benefit of mankind and the particular benefit of partners involved in cooperative projects.

The IMS proposal originally focussed on the mainstream manufacturing regions of Europe, Japan and the US. At an early stage, it was agreed that the inclusion of a small group of (then) EFTA countries, and Australia and Canada, would provide a broader perspective, particularly with regard to the engagement of SMEs. At the same time, what was referred to as a 'regulatory dimension' would be maintained by restricting membership to industrial regions.

From 1992 to 1994, nearly 100 leading firms in these regions, including Toshiba, BICC, Daimler Benz, Transtec, BHP, Inco, Nestle, ICI, BAE, Rockwell International and many smaller firms worked with governments and research groups in a feasibility study. The study was designed to test the practical benefits of working together to address common problems while retaining or enhancing their own market positions. It was, in fact, a giant experiment in the possibilities of multi-lateral cooperation. In 1994, participants in the feasibility study recommended the establishment of an industry-led framework for international R&D cooperation.

Following the feasibility study, the Governments of Australia, Canada, Japan and the USA agreed to Terms of reference to establish the IMS Program and in 1995 IMS was incorporated in Canada to manage and guide operations.

Subsequently, Switzerland and the European Union joined IMS, and an application from Korea is in the final stages of approval.

The IMS initiative provides a framework for large and small companies to work together to mutual advantage. A key aspect of that framework is the protection and use of intellectual property brought to and generated from a cooperative project. This

framework provides a congenial space for cooperation across disciplines, company size, and national borders.

This provides access to a potential synergy not otherwise available to small companies which do not have the time, resources, or experience to negotiate such cooperation agreements. IMS also provides a platform to provide access to complementary technology that might not be available within a region and offers the possibility of sharing costs and risks associated with technology development. The IMS Program can complement and enhance regional programs for international cooperation, support for SMEs and globalisation.

2.2 The Project Portfolio

The core of IMS is the portfolio of projects endorsed under agreed processes and criteria. As of early 2000, sixteen projects had been endorsed and were underway, involving a commitment of US$194 million[5] and involvement of over 350 firms and research groups across the IMS regions. The projects range from highly specific activities such as the development and processing of intelligent composite materials through to long-term investigation of strategic issues confronting global manufacturing in the twenty-first century.

Details of these projects are provided in Appendix 3.1. In addition, a further 44 abstracts have been endorsed, and are in various stages of development into full proposals. (Appendix 3.2)

2.3 Objectives of the IMS Program

Nine objectives were stated for the IMS Program in its original Terms of Reference.[6]. These were to:

- enable greater sophistication in manufacturing operations;
- improve the global environment;
- improve the efficiency with which renewable and non-renewable resources are used;
- create new products and conditions which significantly improve the quality of life for users;
- improve the quality of the manufacturing environment;
- develop a recognised and respected discipline of manufacturing that will encourage the transfer of knowledge to future generations;
- respond effectively to the globalisation of manufacturing;
- enlarge and open markets around the world; and

[5] These are the official IRS figures, as of April 2001. However, a range of figures is in circulation. Other reported totals are 17 projects in 1999 worth US$191 million (Moriwaki, T., 'IMS and Future Manufacturing Systems' in Jering et al), and "about 20 active projects with an international commitment around $250 million (Jering, D., and Garello, P. (eds) *First Assessment of the IMS Scheme and IMS Projects Overview and Results- Issues in Multi-Lateral International Collaboration: Learning from the IMS Initiative*, EC, Brussels, 2000.

[6] IMS, Terms of Reference, 'Blue Booklet', October 1999 (Fourth Printing)

- advance manufacturing professionalism worldwide by providing global recognition and establishing an educational discipline for manufacturing.

These objectives are composed of a considerable mix of idealism, professional self-promotion and technical advance. This mix reflects the variety of different perspectives which different players have brought to, and sought to have embodied in, the IMS. At one end of the spectrum, the IMS is a vehicle for the pursuit of lofty human aspirations and to address major global challenges. At the other end, it is a vehicle for reaching larger markets and generating profits. It appears to have been a feature of IMS operation that these contrasts have been allowed to continue, rather than being directly addressed.

In addition to these objectives, the Blue Booklet identifies that the IMS Program should be a catalyst for:

- global manufacturing cooperation involving large and small companies, users and suppliers, universities, and governments;
- dissemination of the results of significant manufacturing improvements worldwide;
- development of global manufacturing recommendations for standards through cooperative work on pre-standardisation topics;
- assessment and selection of priorities for global cooperation in manufacturing process development; and
- dissemination, understanding, and application of consistent guidelines, provisions and model agreements that respect IPR of participants and project consortium partners.

Subsequently, through the development of a Strategic Plan, the vision for IMS is stated as:

> the leading means to shape the development of a vital international manufacturing industry contributing to the sound development of the world economy.[7]

The mission is to:

> Mobilise international industry government and research resources to drive the cooperative development and spread of manufacturing technologies and systems in a global environment of change.[8]

The objectives were somewhat revised and broadened in this Strategic Plan. Perhaps more significantly, five key results areas were identified which represent desired outcomes which are explicit or implicit in the Vision, Mission, Objectives and Goals of the IMS. These were:

1. Increased resource commitment to IMS.
2. Effective and broad diffusion of manufacturing technology.
3. Enhanced standing of manufacturing as a profession.
4. Active globalisation of manufacturing operations and recognition of the role of IMS in globalisation.

[7] IMS Strategic Plan, 1998.
[8] Ibid

5. Effective and efficient management of IMS.

As a further guide to the Program, and in particular project applicants, five technical themes and associated sub-themes were developed[9]:

1. Total product life cycle issues
   - future general models of manufacturing systems;
   - intelligent communication network systems for information processes in manufacturing;
   - environment protection, minimum use of energy and materials;
   - recyclability and refurbishment;
   - economic justification methods.

2. Process issues
   - clean manufacturing processes that can minimise effects on environment;
   - minimum consumption of energy;
   - technology innovation in manufacturing processes;
   - improvements in the flexibility and autonomy of processing modules;
   - improvement in interaction or harmony among various components and functions of manufacturing.

3. Strategy/Planning/Design tools

4. Human/Organisation/Social issues
   - promotion and development projects for improved image of engineering;
   - improved capability of manufacturing workforce education/training;
   - autonomous offshore plants;
   - corporate technical memory;
   - appropriate performance measures for new paradigms.

5. Virtual Extended Enterprise issues

The variety, breadth and variation of these objectives and goals pose a considerable challenge to the conduct of an assessment of IMS performance.

[9] Blue Booklet, Appendix III.1

3. Achievements of the IMS Program

One earlier attempt, described as a "First Assessment of the IMS Scheme"[10], is based on summarised contributions to a Workshop held in Helsinki on 24 November 1999. It addresses strategic issues for manufacturing, progress on almost all IMS projects, intellectual property rights (IPR) issues, and provides a summary of a roundtable discussion on the future of IMS.

This paper is useful and contains a number of insights. As it is in the main descriptive and written by participants it does not represent itself as an independent assessment

However, the contribution of one author[11] provides a glimpse of just how the IMS Program is perceived as having a potentially major impact:

> It is expected that the key breakthrough technology to solve current problems of the manufacturing sector will be an autonomous distributed manufacturing system assisted by advanced IT, which will be realised by the IMS.

3.1 Program Achievements

With regard to the broad objectives of the 'Blue Book', the MTR Panel finds it difficult to identify more than a modest contribution. Even at US$200 million, the IMS Program represents a minuscule fraction of global trade, or even investment in technology development. Indeed, single companies like Ford and GE have larger technology development budgets.

Consequently, the extent of the contribution of the IMS Program to "improving the global environment" or "the efficiency with which renewable and non-renewable resources are used" could only be very small in practical terms. That the IMS Program has only been operating for five years renders any such contribution immeasurable.

The Panel concludes that objectives of this kind are essentially rhetorical, and intended to be inspirational. As such, they may serve an appropriate purpose. However, they need to be supplemented by operational goals against which progress can be assessed.

To some extent the objectives of the Strategic Plan, such as "effective, equitable and beneficial global cooperation in manufacturing R&D" and "to enlarge and open markets around the world" are of the same rhetorical, and hence immeasurable kind.

However, the MTR Panel is of the view that with regard to a number of these objectives, even after only five years of operation, there is evidence of some achievement, and much promise.

[10] Jering and Garello, op cit, ref. 5.
[11] Moriwaki, T, op cit, ref 5, p.15.

Thus, the number of project participants, the extent of their interaction, and the generally positive comments of participants about their experience[12], provides prima facie evidence of substantially increased and valuable cooperation in manufacturing R&D between large and small companies, users and suppliers, universities and research institutes. To some extent, mostly implicitly, this can be extended to governments.

With regard to 'the dissemination, understanding and application of consistent guidelines and provisions which allow for equitable management of IPR', the evidence of participants, independent analysis, and the extent of imitation by other Schemes, indicates the IMS has been highly successful against this objective. Indeed there is a common assertion that the IMS IPR Provisions "are the most significant and successful aspects of the IMS Program".[13]

Given that IPR issues are commonly a major challenge in inter-firm agreements, and in particular, a key barrier in multi-lateral negotiations, to provide a widely accepted, and relatively low transaction cost, framework, is a considerable achievement. Some associated with the program did however caution that the IP provisions had not been severely tested at this stage.

However, the Panel notes, and draws the ISC attention to, the claim that the IMS should move beyond its present example agreement to produce a standard model agreement.[14]

With regard to the objective of greater sophistication in manufacturing operations, the continuing evolution of appropriate technology development projects, and most importantly, application and diffusion of their findings and outputs, offers the possibility of a significant contribution.

While the emphasis of the IMS Program has been thus far on the generation of new projects, with one project completed and others approaching their termination date, *it is appropriate that the ISC direct greater attention to issues of dissemination and diffusion.*

With regard to the "advancement of manufacturing professionalism worldwide" and "developing a globally recognised, respected and relevant discipline", some small progress has been made through an IMS project to develop a model curriculum for an undergraduate degree in Manufacturing Management, and to trial it in one institution in each region. However, it is the MTR Panel's view that this represents only modest progress towards what are seen as central objectives.

[12] Some typical comments from project coordinators (IPC) are: "international exposure to different styles of conducting business", "extended exchange of expertise at inter-regional level", "incorporation of a larger background of knowledge", "active participation of both large corporations and SMEs", "commitment to continue the project through additional work packages", "establishing a powerful common platform architecture".

[13] For example, Amarego, P. R., 'IMS Intellectual Property Provisions - Background and Essential Elements', in Jering and Garello, op cit, ref 5, p.145.

[14] Ibid, p.147.

The 'five key results areas' provide more specific and operational goals against which the performance of the IMS program can be assessed.

1. Increased resource commitment to IMS. There is no evidence of substantial progress towards this objective. The rate of new project formation has declined, though it may be that the large number of abstracts emerging from the EU region may be transformed into projects over the next year or two (although this imbalance is also a cause for concern). Nor has there been much progress in minimising barriers to joining IMS or IMS projects, identified as a key strategy in the Strategic Plan.

2. Effective and broad diffusion of manufacturing technology. Given that the Program has only been operating for five years, has attracted projects with an average life of four years, and only one project is completed, there is little evidence of achievement of this objective. Of greater concern, it is not apparent that the IMS has processes in place to promote such diffusion other than through normal market mechanisms.

3. Enhanced standing of manufacturing as a profession. As noted above, little direct progress has been made towards achievement of this objective.

4. Active globalisation of manufacturing operations and recognition of the role of IMS in globalisation. With regard to the first component, the globalisation of manufacturing, and other industries, would appear to be occurring at such a pace, and be so strongly driven by competitive pressures, that there is little scope for a relatively small scheme like the IMS to play a significant role. Indeed, the IMS Program itself is as much under pressure from globalisation and its consequences as the manufacturing industry it is directed towards.

With regard to the second component - establishing recognition of IMS - there has been a considerable effort on this matter by the IRS and the various RS. A website has been established, brochures published and distributed, explanatory/marketing documents written, and a variety of information sessions and presentations made at regional and international conferences.

Despite this effort, the view of many participants, and associated government officials, is that the IMS has not succeeded in establishing an 'identifiable brand' ie that relatively few of the stakeholders in manufacturing are aware of the IMS Program. This view is confirmed by enquiries made by the MTR Panel members. A variety of explanations have been offered, including lack of a coordinated international marketing effort, and the very name itself.[15] These issues will be addressed in Chapter Five.

5. Effective and efficient management of IMS. This will be addressed in Chapter 4.

[15] 'Intelligent Manufacturing' is apparently seen by many technology development researchers as not connected with their interests, and probably highly constraining; in addition, the key words intelligent and manufacturing are so broad that an Internet search is unlikely to locate the IMS Program.

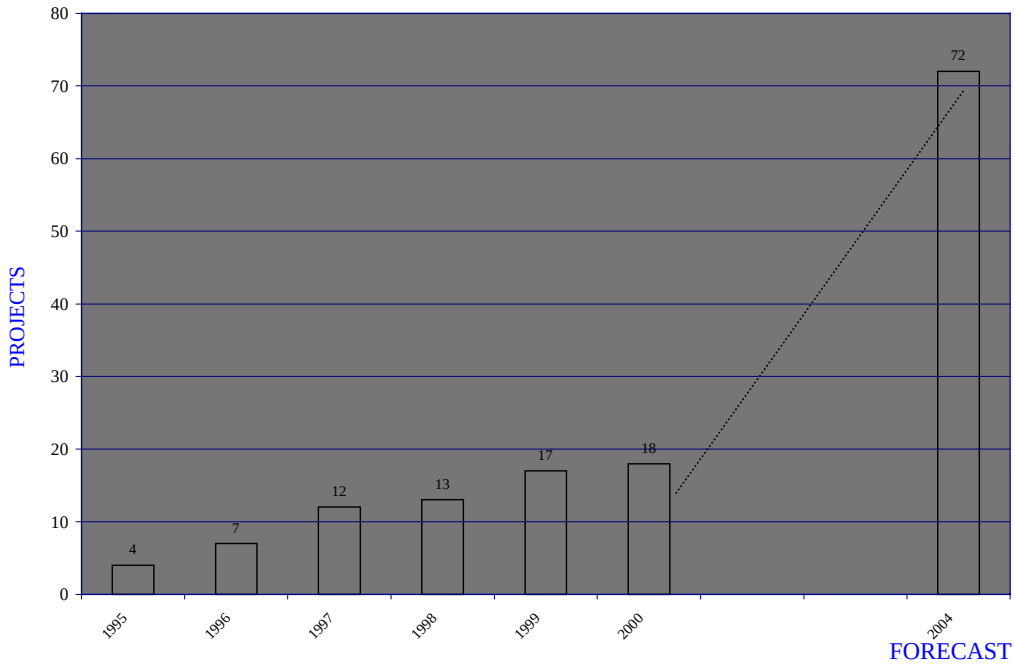
3.2 Project Achievements

In 1999, IMS established a project monitoring system based on a three-component data collection exercise. This was based on annual and 'annual summary' reports from each project, and the project report to the 'Binarra' database. A 'Consolidated Annual Monitoring (CAM) Report' was produced for the December 1999 ISC meeting, based on the Annual Summary Reports. This has been used as the major input into assessment of the project portfolio.

One issue that is not addressed in the CAM Report is the quality of the projects. However, the engagement of such a wide and experienced range of participants, in most cases committing their own resources, and comments Panel members have received from a wide range of sources, indicate a high level of agreement about the generally high quality of the projects. This also suggests that the selection processes are working effectively, in terms of ensuring quality.

Another issue is the rate of generation of suitable new projects. The relevant data are presented in Figure 1.[16] These data give a clear indication that new project formation has plateaued over the past 3-4 years, and there must be very real doubt that the target of a total of 72 projects for 2004 will be reached. This alone is a strong indication that IMS is not meeting its objectives, and may be diminishing in influence.

Figure 1
Cumulative IMS Projects



This directs attention to the effectiveness of the marketing of IMS and the efficiency of the process of proposal approval. The MTR Panel concludes, on the basis of evidence from participants and officials, that both may present problems. In

[16] These data are drawn from Moriwaki, op cit, ref 5.

particular, the complex and often lengthy approval process[17] may act as a deterrent for project and consortium formation.

In principle, the elapsed time between submission of an abstract and proposal endorsement is five months. In practice, this has been up to one year (and in a few cases, longer), arising from the requirement for all proposals to obtain approval from all regions regardless of whether there is a partner from that region, different interpretation of guidelines in different regions, discussions over CCA issues, etc.

In the MTR Panel's view, the degree of complexity in the approval process is unnecessary to maintain quality, and probably acts as a deterrent. Simplified procedures need to be developed.

With regard to the 18 endorsed projects, 14 provided data for the 1999 CAM Report.[18] The following analysis is based on their responses.

The total number of partners in these projects is reported as 334, with an almost exact 50/50 split between companies (169) and research organisations (165). Of the companies 63% were large and 37% SMEs. These proportions also generally apply at the regional level.

There is considerable disparity in the level of involvement of the regions. The EU (123) and Japan (100) provide by far the largest number of partners. They are followed by the US (50), Australia (20), Canada (18) and Switzerland (13). This disparity is reflected of the extent of the financial contribution to projects from each region. Thus Japan contributes 38% of these funds and the EU 36% - together three-quarters of the total budget. The next biggest contributor is the US with about 15%. The remainder contributes between 2 and 4% each.[19]

In terms of performance, the indicators reveal a performance highly biased towards the research stage, with very little commercialisation. Thus, in total, ten patent applications have been lodged and two granted. No copyright or licensing agreements are reported. In contrast, there have been 203 presentations and 119 publications. These results may to some extent be a reflection of the early stages of many projects. However given that the projects are represented as industry-led, and the speed of technological advance, there is reason for concern that there is an insufficient orientation towards commercial outcomes.[20]

The five technical themes designed to guide the IMS Program (Section 3.3) do not in practice to have had much direct effect on either proposal formulation or approval. One set of data[21] indicates that the projects are concentrated in three of the five

[17] The phrase most commonly used was "tedious and unnecessary".
[18] The other four had only recently been initiated.
[19] Though, as a proportion of GDP, the contributions from each member are largely comparable.
[20] It may be that a major route for achieving commercial returns from the project will arise from direct application of results by partners in their businesses; the results from Globeman 21support this view. However no data are available to support this. It should also be noted that there is a view that the responses under-report outcomes, for commercial reasons and a resistance to external assessment when partners are investing their own resources.
[21] Presentation by E. van Leeuwen at the Irvine Forum.

themes: process manufacturing, product life cycles and virtual extended enterprises. Another report[22] offers the following classification, and number of projects:

Virtual Manufacturing	5
Monitoring and Control	2
New Materials	1
Knowledge Systematisation	2
Processing and Assembling	4
Design Technologies	3
Computer and Communication	1

Regardless of which data set is used, it is apparent firstly that the five themes are not operating as a practical shaper of the IMS Program, and that areas like human, organisational and social issues are apparently being neglected.

With regard to the value of the IMS project framework, the major response was in terms of availability of opportunities to exchange or share technical information among partners. Communication between partners across the regions was generally rated as positive.

Only one project has been completed - Globeman 21. The Final Report points to three areas of impact of the results. First, the conceptual and theoretical models are seen as helping companies to understand the critical issues in the global environment and implement appropriate structures, companies and consortia to deal with distributed global manufacturing challenges.

Second, the direct business impact, via fourteen industrial demonstration projects, is seen in operating systems already in use by some partners, and being planned by others. Examples provided are:

- changes in the way companies are contacting and supporting their customers;
- a shift from a 'travelling serviceman' to a 'remote help desk' service concept;
- changes in approaches to collaboration;
- agility based on distributed business practices provide strong competitive advantages by reducing time to delivery and market;
- recognition of new business opportunities especially in added knowledge-based services.

The third impact arose from the comprehensive and comparative analysis of currently available commercial tools.

The MTR Panel concludes that at this stage, direct and documentable achievements of the IMS program are somewhat limited, with benefits confined largely to the participants. While many of the projects could only be expected to have a long-term impact, there is a need to pay greater attention to achieving, and demonstrating widespread benefits.

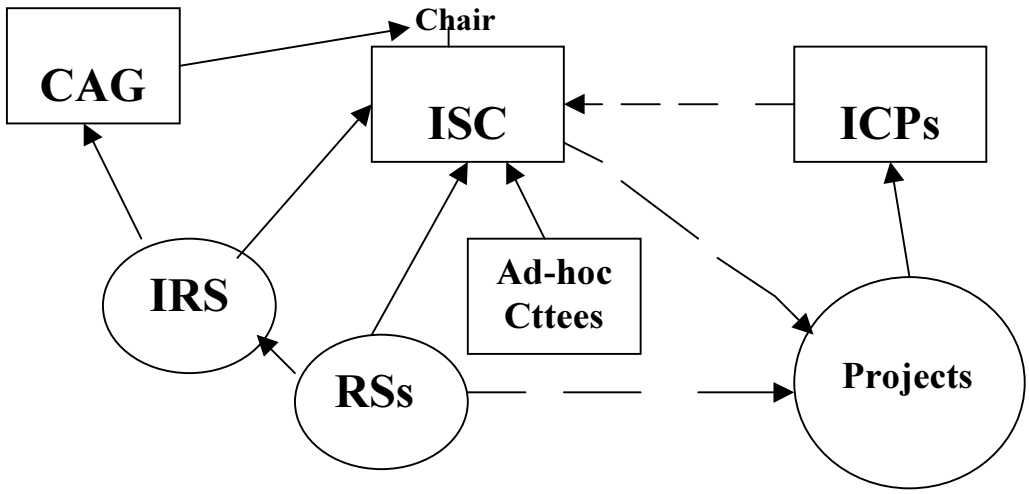
[22] Moriwaki, op cit. ref 5, p. 17.

4. Operations of the IMS

4.1 Structure

The structural elements of the IMS organisation are outlined in Figure 2 below.

Figure 2
Current Structure of IMS



Currently, the executive decision-making body is the ISC, which meets bi-annually. Its membership is currently a maximum of twelve, but with the inclusion of Regional observers, representation of IRS and RS, observer Regions and project partners, meetings have commonly had more than 50 participants. This has undoubtedly made it difficult for the ISC to operate effectively in a Board-like manner.

A Chairman's Advisory Group was established in 1997 to provide a mechanism for more direct and frank input of advice to the Chairman out of ISC session. This would seem largely to be a response to the limitations of the ISC, the frequency of its meetings (twice per year) and the challenges of international communication.

The ISC and the CAG are serviced by the IRS, which has primary responsibility for the provision of logistics and support for the governing body. In addition each member region has a Regional Secretariat, of various forms, to provide regional logistics and support.

In addition, the International Coordinating Partners (ICP) of each project have met on four occasions to discuss common issues, but have had relatively limited contact with the ISC. The extent of interaction between the ISC and the project partners is extremely limited, taking the form of ISC endorsement of proposals, and a somewhat perfunctory reporting of a set of projects to each ISC meeting.

In summary, the structure of IMS operations is split into two largely distinct components. The first somewhat bureaucratic component, composed of the ISC, CAG, IRS and RSs manages policy and the overall Program. The second component - the IPC and project coordinators, operate fairly independently and are largely

concerned with managing the individual projects. The former address largely a government perspective, the latter, industry.

It is quite apparent that this structure is no longer appropriate to the needs of IMS. It is the subject to a great deal of dissatisfaction, and appears to be inconsistent with the basic aim of using the projects to underpin and validate the broader policy measures advocated to advance the cause of manufacturing. Recommendations for a radical restructuring are made to overcome the bifurcation noted above, and to increase the effectiveness of the governance of IMS.

4.2 Decision-Making within the IMS

The Terms of Reference for the IMS (the Blue Booklet) state that the "ISC will reach decisions by consensus of its members". This has been practiced as unanimous consensus, largely to ensure that all the interests and requirements of the regional members are recognised and taken account of. While this may seem an appropriately cautious approach to managing the considerable challenge of a multi-lateral program, it has provided a considerable barrier to speedy decision-making, and a burden to the ISC decision-making processes. With five years of accumulated experience, and considerable development of practices and understanding, now may be the time to move toward a more effective basis for decision-making.

4.3 Location of the IRS

The present principle of shifting the IMS Inter-Regional Secretariat every 2-3 years, designed to ensure acknowledgment of the multi-lateral nature of the IMS Program, apparently contributes little to this objective, and is highly wasteful and inefficient. The potential for virtual operation now available by use of Internet-based communications further weakens the case for shifting physical location. Hence, identification of a suitable location for the IRS should be a matter of priority.

One of the original justifications for the regular relocation of the IRS was that the ISC Chairman position rotates amongst member regions and that there would be efficiencies arising from co-location. No evidence has been forthcoming that any such efficiencies exist.

4.4 Program Formulation.

It has already been noted that the five technical themes have not apparently operated as a strong shaper of the project focus of the IMS Program. Its development has been largely a 'bottom-up' process, driven by the interests and enthusiasms of the would-be participants, and in particular the ambitions of researchers in these fields. It is important to maintain a mechanism whereby researchers and companies can pursue new objectives as they emerge in the marketplace or through the advance of knowledge.

However, in order to achieve its objectives, and demonstrate its relevance in the rapidly evolving era of 'new manufacturing', there is a counterbalancing need to provide strong 'top-down' leadership by identifying issues or fields of high

significance and promoting appropriate proposals to address these issues. This would require the IMS to move to a far more proactive style and stance.

4.5 Membership and Funding of IMS

The present conditions for application and approval for new membership of the IMS are lengthy and cumbersome and in all likelihood have served to deter new members from seeking to join the IMS. In addition, the current 'standard' fee, used to support the IRS, is inequitable. Both the conditions of membership and fee structure need to be reviewed.

4.6 Membership of the ISC

Current arrangements provide no limitation of term for members of the ISC. Indeed, members have been encouraged to extend their membership, because of their valuable knowledge and experience of the development and operation of IMS. While this may have been appropriate in the formative stages, the MTR Panel believes it is now timely, and necessary, to bring 'new blood' into the IMS decision-making processes. A recommendation for such a change is made.

5. Recommendations

5.1 The Future of the IMS

The IMS Program has been responsible for a range of significant achievements in the five years of its operation. It remains the only mechanism to promote multi-lateral collaboration in research and technology development and diffusion between industry and researchers (with the exception of the special case of the Framework Programs within the European Union). As such it has pioneered a number of mechanisms to promote and effectively manage international collaboration.

However, after the initial enthusiasm, reflected in the commitment to the feasibility study, and the rapid establishment of a number of projects, there is evidence of declining interest, and perhaps relevance, of the IMS Program:

- interest from companies in Canada, Australia and the US has remained small, or marginal; in these members also, the commitment of the sponsoring Government also appears to be waning with the lack of public funding of projects contributing to the lack of enthusiasm from companies;
- a substantial drop-off has occurred in new project proposals and establishment, such that performance is now well below the target set;
- some loss of commitment among initial promoters and supporters;
- there is a view among many participants that the organisation is ageing, has become excessively bureaucratic, and its mission may no longer be appropriate;
- a degree of disparity, even confusion, over whether the IMS Program is, or should be, characterised as industry-led, or an industry government partnership;
- considerable disparity between participants over whether the major objective of the IMS is collaboration *per se*, or the output arising from collaborative projects and its subsequent commercialisation; consequently, criteria for assessment are unclear;
- relatively limited progress on some of the broader objectives of the IMS (eg improving the global environment, enlarging and opening markets).

Government support varies greatly between regions and while most have programs to support research and international collaboration the fact that IMS represents itself as 'industry led' makes it difficult to attract government financial support in some places. Redefining the program as a government/industry partnership may allay some of the concerns that funding IMS could be regarded as 'corporate welfare'.

Notwithstanding these many difficulties, the MTR Panel has reached the view that the actual, and more importantly the potential achievements of the IMS Program are considerable. The challenge is to assert its relevance through a reinvention which will enable it to more effectively address the many challenges of 'new manufacturing'.

Recommendation 1.1 **The IMS should continue for the remaining five years initially agreed, but it should be substantially reconfigured to address the new challenges of manufacturing, and to increase its effectiveness and impact.**

The character and environment of manufacturing has been radically transformed since the IMS concept was mooted some seven years ago, through a range of inter-connected developments:

- rapid advances in technology,
- globalisation,
- the emergence of the knowledge economy,
- the commercial establishment of the Internet,
- growth in outsourcing;
- the refocus of resources, by large multinational companies, away from manufacturing and towards supply chain management and product life-cycle reduction;
- privatisation of government owned enterprises;
- a new emphasis on supply chain management;
- the growing importance of, and pressure about, environmental consequences;
- the pressures arising from continuing, and in some cases growing, international economic imbalance.

An option that has been canvassed is that the concept, and label, of manufacturing be radically extended to incorporate these new aspects. However it is the view of the MTR Panel that the term 'manufacturing' is so deeply established, at least in the English-speaking nations, that such a transformation is beyond the capability of the IMS.

Alternatively, a new, more appropriate name should be established for the Program. The costs of such a change are not very large, because the IMS has not established a strong 'brand recognition' and any confusion can be overcome by using, as others have in similar circumstances, a positioning statement such as 'incorporating the IMS Program'.

A number of options were considered by the MTR. With the shift in emphasis of 'new manufacturing', global industry technology appeared most appropriate. Phrases such as scheme, program and collaboration were considered and rejected. In the Panel's view, 'initiative' more appropriately reflected the special challenges to be addressed, and served to place a greater emphasis on outputs.

Recommendation 1.2 **The IMS be relaunched with a new, more appropriate title: Global Industry Technology Initiative (GITI) is proposed.**

To meet these new challenges, the objectives of the IMS require substantial revision.

Recommendation 1.3 **The ISC redraft the objectives of IMS to more adequately address the new challenges to, and context of, manufacturing.**

In addition, it is apparent from many responses, and from the MTR Panel's analysis, that the 'technical themes' developed to guide the IMS program have neither been an effective guide to project development, nor are appropriate to the new and future state of technology and manufacturing. However, any new set of static themes would rapidly face the same problem. The answer is to establish a process whereby the IMS provides continuing, dynamic, and proactive leadership and guidance in important areas of focus.

The process should be structured so industry, governments and researchers see it as **the** definitive strategy determining exercise for different segments of the manufacturing industry. The requirement is not only to identify key technological blockages and opportunities, but also to forecast their time of realisation. If this status can be achieved the exercise may even become self-funding, particularly if it can be held in association with a recognised international industry meeting that already attracts the major participants. Managed carefully the 'road-maps' produced by this process can become a major output from the IMS Program, to be used more widely than just guiding and evaluating research programs.

Further thought needs to be given as to the nature, number, scope and frequency of these strategy exercises. Conferences are typically the way industry agreement is sought on broad strategic directions but expert panels, consultants, surveys or other means could also be considered. Realistically IMS could probably manage no more than two such initiatives each year and given that they would need to be repeated every two or three years in each sector it would seem no more than about five focus areas could be accommodated at any one time.

The options for the scope for each strategy initiative would appear to be sectoral – automotive, electronics, aerospace, pharmaceuticals, etc. or technological – machining, materials, IT application, recycling etc. A process would need to be established to select these, taking into consideration views of members and giving some attention to the spread of project proposals. (See Recommendations 2.2 and 2.3)

Recommendation 1.4 **The ISC scrap its present set of technical themes, and establish a proactive approach to shaping the IMS program and projects through a continuing series of 'road-mapping' exercises designed to identify key areas of technology development for the future.**

5.2 Restructuring of IMS

In order to meet the new challenges of manufacturing, to transform the IMS so that it can effectively address these challenges, and to reduce the management and administration blockages that have developed, a substantial restructuring of the management structure, responsibilities and operations are required.

It is apparent that the International Steering Committee (ISC), while providing a forum for exploration of the many issues relevant to the IMS, and for exchange of views between representatives of the participant regions, has been limited in the effectiveness and efficiency of its operation. ISC meetings commonly have about 50 participants, with various interests. That a smaller Chairman's Advisory Group (CAG) was established (in effect replacing the previous Executive Committee but with advisory powers only) to overcome the limitations of the ISC, is itself evidence of a failing of the ISC, and the need to establish effective management processes.

Rather than operating around the ISC, the MTR Panel regards it as essential to revise the ISC so that it can provide effective 'Board-like' governance and strategic leadership.

In addition, the views of regional governments may be presented more effectively if far more attention is devoted to appropriate selection and briefing of representatives. There should be a significant emphasis on these representatives understanding their roles, and being held accountable for the views they present.

Ideally areas of difference between members would have been addressed and resolved before coming to the ISC by informal discussion and ad hoc Working Groups. With such a change the CAG, which is a subject of some criticism due to perceptions of a lack of transparency in its discussions, should not be necessary.

Recommendation 2.1 **The composition of the ISC be revised, with membership reduced to one representative from each member, with allowance for a standing alternate.**

Membership should be limited to a three-year term, with only one possible term of reappointment.

Present conditions for appointment of the Chair should continue.

Decision-making should be by consensus, with provision for majority decisions if necessary, abstention on issues which are not supported (but which have no significant impact on a particular member) or a veto where the approval of a matter would create a domestic legal or policy problem for a member (which must be able to be justified to other ISC members).

In order to establish a proactive process for guiding and encouraging proposal development, to facilitate project development and approval, to maintain effective contact with project teams, to manage the project monitoring and evaluation process, and to evaluate the impact of a 'suite' of projects, it is necessary to establish mechanisms and management processes at a more specific level than that appropriate to the ISC. The current practice of every member being required to evaluate and approve every project is inefficient and unnecessary.

Recommendation 2.2 **A Technology Steering Group (TSG) be established as a permanent committee of the ISC.**

The TSG should have responsibility for identifying key technology/sectors which should be the subject of road-mapping exercises, promoting project formulation, providing final approval of all projects, monitoring and evaluation of projects, and impact evaluation.

Membership should be determined, on advice, by the ISC. [23]

The Chairman/Convenor of the TSG should be appointed by the ISC and should be a member of the ISC.

Decision-making should be by consensus, with provision for majority decisions if necessary.

However, there is a need for detailed expertise, management and guidance at the specified technology/sector level. This may be best provided through an *ad hoc*, project-oriented group that operates for the lifetime of the family of projects. Membership need not be region based, although efforts would be made to involve all members to the extent that expertise is available. The arrangement would have the further advantage of overcoming the different approach to evaluation and the varying degrees of technological competence that has delayed project approvals in the past.

Recommendation 2.3 **For each key area identified by the TSG, an ad hoc Project Management Group (PMG) should be established, with membership of 4-6, based on technological and industry expertise.**

The PMG reports to the TSG; ideally each PMG should have at least one TSG member who would act as the Convenor.

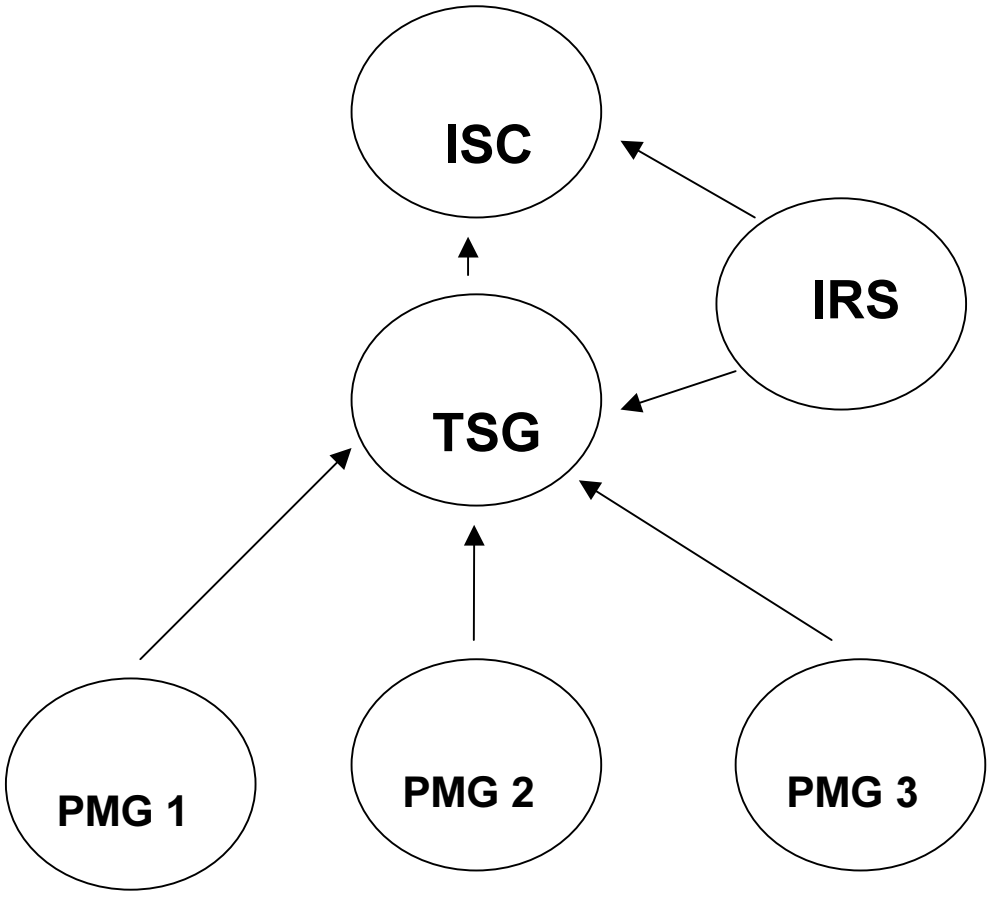
The role of each PMG is to organise and conduct a road mapping exercise, building on existing studies, solicit and assist in developing project proposals, preliminary project approval, and project monitoring.

[23] Each IMS member should be requested to provide up to two nominations for the TSG each year. The ISC would establish an evaluation process to select candidates to fill vacancies from the combined list, based on demonstrated expertise and a need to ensure a balance of skills and backgrounds within the total Group. As a working committee, it might be expected to have a membership of about eight for a single 3-year term, with one-third rotation every year.

It is envisaged that the majority of projects would arise from those solicited as a result of the road-mapping exercises which would identify and assess technology gaps. However, but companies and research institutions would continue to be encouraged to submit proposals outside these priority areas. Submissions would be received by the IRS and referred to the most appropriate PMG for evaluation.

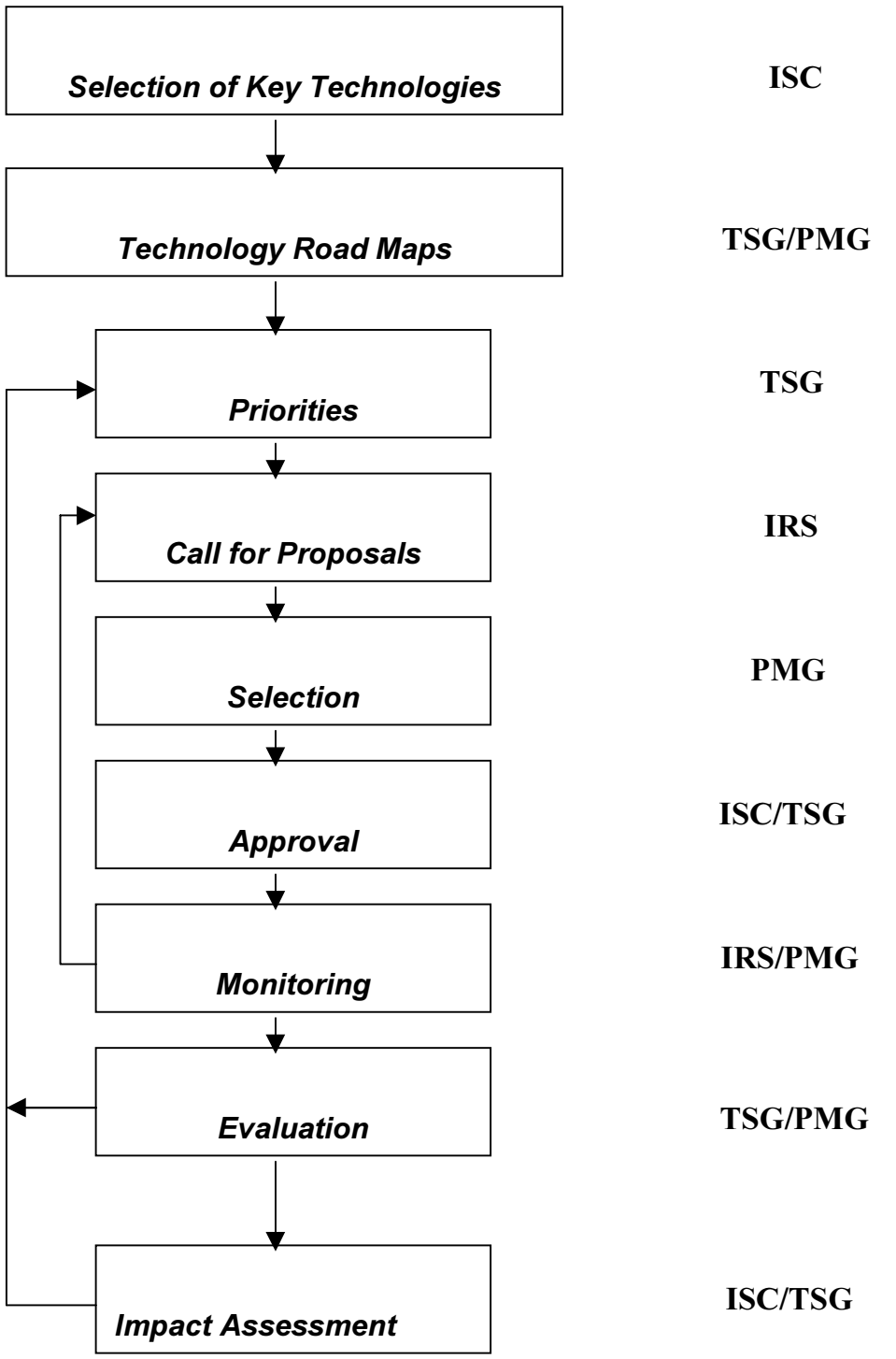
Figure 3 outlines the proposed structure for governance and operation of the IMS Program.

Figure 3
Proposed Structure for IMS Management



The various stages of the management process for developing new projects are outlined in Figure 4.

Figure 4
The Project Process



In order to support this restructured operation, the IRS needs to be both streamlined and strengthened.

Recommendation 2.4 **The IRS be located at a permanent location** (to be decided against criteria of cost, tax arrangements, access, neutrality, etc).

The IRS be led by a CEO with substantial experience and standing, who should be an ex-officio member of the ISC.

The IRS should remain small, operating as much as possible as a virtual organisation, contracting services and expertise from the member regions as required. The budget should recognise this, but present levels are probably adequate.

Under this new structure, the role of Regional Secretariats will be significantly changed, as a large part of the current function will transfer to the TSC and PMGs. RSs already vary considerably in size and influence between the members. In some they are seen as playing a crucial role in promotion, facilitation and proposal development. In others, their role is largely administrative, in support of the governance structure.

Given this variance, it seems inappropriate and unnecessary for the roles and objectives of the Regional Secretariats to be prescribed as at present. It would also be best left for each region to determine the level of support it considers appropriate. However, there is a strong case for a minimal level of support for 'local' activities of the ISC member(s), the TSC and the PMGs. Member Governments may need to be requested to make arrangements within their relevant Departments for long term support to be provided.

In addition, each region may need to appoint an experienced consultant, ideally someone with previous experience as an ICP for an IMS project, to assist with industry contacts, proposal preparation and trouble shooting.

Recommendation 2.5 **Member regions should provide adequate local secretariat support for their ISC, TSG and PMG members, and to promote and facilitate the IMS Program.**

The MTR Panel observed that interest from companies in becoming involved in IMS was greatest where government funding support was available, or at least assistance in negotiating partnership arrangements. While different member regions have different support mechanisms in place for industrial research, the success of the IMS would be underpinned if, at the very least, the initial costs of investigating the benefits of participation could be subsidised by member governments**.**

Recommendation 2.6 **Member governments should be requested to make available a small budget allocation to subsidise expenses incurred by organisations negotiating initial participation in an IMS project.**

5.3 IMS Membership

There is wide agreement among IMS participants and others that the process for entry to the organisation is unnecessarily lengthy and cumbersome. While negotiation of MOUs between governments and international organisations inevitably requires diligence and caution, current processes seem to be designed to deter all but the most able and committed.

Recommendation 3.1 **Procedures for application and approval of IMS membership should be streamlined so that, under normal circumstances, admission of a new member should take less than one year.**

However, the levels of competence and commitment required for full access to IMS will inevitably be found only in the industrialised nations. In order to achieve its objectives, there is a need for the IMS to develop mechanisms to provide a form of access and involvement for nations or regions[24] that have not as yet developed these strengths. A form of membership with minimal or no fees, but self-funding for costs, and with access only to generic IMS technology/IP, may be appropriate.

Recommendation 3.2 **The ISC examine, as a matter of urgency, the establishment of a form of associated membership, on a minimal or fee-free basis, for countries that cannot meet the full membership requirements, and establish special programs to give this associate membership value.**

5.4 Funding for IMS

There has already been an examination of the present basis for central funding of IMS operations. The case appears to be strong that the present standard fee model has some inequity, and may inhibit new entrants. The basis for a two-tier model with a fixed component and a variable contribution relating to size or level of activity, has been extensively examined, and would appear to be the most appropriate.

Recommendation 4 **The ISC seek to move to an appropriate two-tier central funding model as soon as possible.**

[24] For example, ASEAN, Mercosur, ILAFA, etc.

5.5 Monitoring and Evaluation

The monitoring and evaluation processes for projects, and the overall program have clearly been inadequate. Such processes are now recognised best practice but they were not established at inception and no budget has been provided for developing, assisting and selling the process. There is a need for the assessment process to be embedded in overall project performance and management.

Indeed, the promotion of effective project management and evaluation could be another objective appropriate to the IMS program. Methods for effective project and program evaluation of multi-lateral projects have been pioneered in Europe, particularly in the EUREKA program where a ‘best practice' framework has been developed. (Appendix 4). Evaluation criteria might include impact on business and profit growth, evidence of technology deployment, impact, etc.

The continuation of the IMS Program after its scheduled 10 years is likely to be very dependent on all participants, but governments in particular, being convinced that the outcomes achieved are sufficient to justify ongoing support.

Recommendation 5 **The ISC develop and institute an appropriate project and program evaluation process, as an embedded technical and cultural component of the program, as a matter of urgency.**

Appendices

Appendix 1 Outline of the Assessment

Regional assessment should cover the following, in accordance with a previously agreed scope, methodology and reply structure:

- contributions of IMS project portfolio from a point of view of Regional Co-ordinating Partners to achieve IMS objectives (as set out in ToR);
- achievements including direct and indirect impacts;
- effectiveness of the IMS IPR provisions;
- efficiency of Regional Secretariat from a point of view of International Co-ordinating Partners (eg. marketing, addressing the potential project participants; consortia formation and other activities related to the international implementation);
- effectiveness of the regional contributions to IMS objectives (as set out in ToR);
- relevance of the IMS objectives against evolving issues of manufacturing from the region's point of view (optional); and,
- added value of the IMS scheme in relation to regional schemes for manufacturing (optional).

Inter-regional assessment should synthesise, compare the regional assessments and additionally assess:

- effectiveness of project portfolio to achieve IMS objectives; major trends of portfolio (type of projects, participants, SME involvement etc);
- achievements including direct and indirect impacts (significant results, success stories; added value in relation to regional co-operation);
- effectiveness of the IMS IPR Provisions;
- effectiveness of ISC activities in achieving the IMS objectives;
- efficiency of IRS including regional secretariats;
- appropriateness of current system of regional contributions to IRS; and,
- relevance of IMS objectives against evolving economies and RTD in the different regions and new global issues (optional).

Appendix 2 Methodology

Timetable for MTR

		2000
Meeting 1	Teleconference to establish project	17 January
Meeting 2	Detailed planning meeting, Lisbon	11 March
	Minutes of Planning Meeting	20 March
	Responses from Panel Members	27 March
	Draft Instruments	24 March
	Responses	31 March
	Data collection/survey/interviews	1 April – 22 May
	All data delivered to Rapporteur	29 May
	Data analysis & outline report to MTR Panel	16 June
Meeting 3	Zurich	26 June
	Further data collection and preparation of draft report by Rapporteur	27 June – 31 July
	Evaluation of draft report by Panel members and comments back to Rapporteur	14 August
Meeting 4	Teleconference to review draft report	17 August
	Preparation of revised draft report by Rapporteur	31 August
Meeting 5	Approval of Final Report by teleconference	15 September
	Submission of Final report	18 September

Data Collection

A preliminary analysis condensed the various issues raised into a single consolidated list. Against each item initial sources of data and experience were identified.

Issue	**Source of Information/Judgement**
1. Assessing how the project portfolio has contributed to IMS objectives: • greater sophistication in mfg operations • improved global environment • improved efficiency of use of renewable and non-renewable resources • creation of new products and conditions which improve quality of life for users • improved quality of the mfg environment • development of a respected discipline of mfg to transfer knowledge to future • effective response to the globalisation of mfg • enlargement and opening of markets • advanced mfg professionalism/ establish	Regional Delegations (RD) International Coordinating Partners (ICP) Expert individuals and organisations outside IMS International Steering Committee (ISC) Government Representatives

educational discipline for mfg *and as a catalytic agent for*: • global mfg cooperation • dissemination of results worldwide • development of global mfg recommendations for standards • assessment and selection of priorities for global cooperation in mfg process development • effective IPR processes	
2. Effectiveness of the regions in contributing to the IMS objectives	Regional Secretariats(RS), Inter-regional Secretariat (IRS), ICP, RD
3. Effectiveness of the IRS in contributing to the IMS objectives	RS, IRS, ICP, RD, ISC
4. Effectiveness of ISC in contributing to the IMS objectives	RS, IRS, ICP, RD
5. Major results of the project portfolio • RTD and innovation • direct and indirect impact – significant results, success stories, perceived and expected benefits, added value in relation to regional cooperation in each of the five technical themes - total product life cycle - process issues - strategy/planning/design tools - human/organisational/social issues - virtual/extended enterprises	Monitoring Reports for each project ICP, RD, consortia members (CM - industry, research), expert individuals/ organisations outside IMS
6. Efficiency of the various management bodies	RD, IRS, RS, ICP
7. Appropriateness of level of contribution to IRS	RS, IRS, Government reps
8. Effectiveness of the IMS IPR provisions	RD, CM, RS, IRS
9. Consistency of selection of projects with IMS objectives	IRS, RD, project data
10. Added value of IMS to regional schemes	RD, Governments, IRS
11. Relevance of IMS objectives to evolving economies/changing needs	RD, IRS, RS

The following sets of data were collected:

- Submissions from IRS & RS addressing Terms of Reference;
- Names and contact details from project leaders and regional project coordinators of 3-5 actual or potential customers for their project (poor response);
- Interviews by Panel members (against a proforma prepared by the Rapporteur as a guide);

- Submissions from RS about their performance against responsibilities VIC, Blue Booklet;
- Submission from IRS about performance against responsibilities VIA4, Blue Booklet;
- Submission from national delegation to ISC members addressing performance against responsibilities VIA4, Blue Booklet (limited response);
- Annual project monitoring reports;
- Submissions from IRS and RS on additionality of IMS;
- Evidence of visibility of IMS brand image;
- Response by international and regional project coordinators to evaluation questionnaire.

Development, Application and Evaluation of Research Tools

Professor Luke Georghiou of PREST, University of Manchester, a recognised expert in program evaluation, was appointed adviser to ACIIC (the Rapporteur's centre) to assist in development of evaluation mechanisms.

A four-phase research methodology was developed:

Phase 1 – March 2000
- Collection and analysis of 'best practice' mechanisms for evaluation of technology development and diffusion programs.
- Development of a framework methodology for the first (Lisbon) meeting of the MTR Panel.

Phase 2 – April 2000
- Analysis of the appropriateness and effectiveness of the survey instrument used to produce the consolidated Annual Monitoring Report.
- Development of a structured pro-forma to guide interviews of respondents to be carried out by MTR Panel members.
- Development of a survey instrument and process to obtain submissions and responses from the ISS the IRS and Regional Secretariats.
- Preliminary analysis of the responses.

Phase 3 – May - June 2000
- Compilation and detailed analysis of all data collected.
- Assessment of the adequacy of the various measurement tools.
- Identification of key gaps in available information and development of possible research tools to fill them.
- Review of data and measurement tools at MTR Zurich meeting (26 June).

Phase 4 – July - September 2000
- Refinement of research tools.
- Collection of further data.
- Evaluation of research methods and tools.
- Design of an evaluation scheme for IMS.
- Presentation to final MTR Panel Meeting (15 September).

Appendix 3.1 Approved Projects

1. **Globeman** Enterprise Integration for Global Manufacturing for the 21^{s} Century
   - Commenced 1996
   - Commitments US $13.4m
   - Regions involved Australia, Canada, EU, Japan, USA
   - Number of partners 35

2. **NGMS** Next Generation Manufacturing Systems
   - Commenced 1996
   - Commitments US $27.0m
   - Regions involved EU, Japan, USA
   - Number of partners 36

3. **HMS** Holonic Manufacturing Systems
   - Commenced 1996
   - Commitments US $19.0m
   - Regions involved Australia, Canada, EU, Japan, USA
   - Number of partners 29

4. **GNOSIS** Knowledge Systematisation:Configuration Systems for Design and Manufacturing
   - Commenced 1996
   - Commitments US $8.5m
   - Regions involved Canada, EU, Japan, Switzerland
   - Number of partners 28

5. **SIMON** Sensor Fused Intelligent Monitoring Systems for Machining
   - Commenced 2000
   - Commitments US $8.7m
   - Regions involved Canada, Japan, EU, Switzerland, USA
   - Number of partners 19

6. **MMWS** Metamorphic Material Handling System
   - Commenced 1998
   - Commitments US $9.9m
   - Regions involved Canada, EU, Japan, Switzerland, USA
   - Number of partners 25

7. **HUMACS** Organisational Aspects of Human-Machine Co-existing Systems
   - Commenced 1997
   - Commitments US $1.5m
   - Regions involved Canada, EU, Japan, Switzerland, USA
   - Number of partners 38

8. **3DS** Digital Die Design Systems
   - Commenced 1997
   - Commitment US $20.7m
   - Regions involved Canada, EU, Japan
   - Number of partners 22

9. **RPD** Rapid Product Development
   - Commenced 1997
   - Commitment US $16.7m
   - Regions involved Australia, Canada, EU, Japan, USA
   - Number of partners 25

10. **INCOMPRO** Intelligent Composite Products
    - Commenced 1998
    - Commitment US $8.2m
    - Regions involved Canada, EU, Switzerland
    - Number of partners 13

11. **IF7** Innovative Intelligent Field Factory
    - Commenced 1998
    - Commitment US $7.0m
    - Regions involved Canada, EU, Japan
    - Number of partners 25

12. **MISSION** Modelling and Simulation Environments for Design Planning and Operation of Globally Distributed Enterprises
    - Commenced 1998
    - Commitment US $10.0m
    - Regions involved Australia, EU, Japan, USA
    - Number of partners 39

13. **HUTOP** Human Sensory Factors for Total Product Life-Cycle
    - Commenced 1998
    - Commitment US $4.0m
    - Regions involved EU, Japan, Switzerland
    - Number of partners 23

14. **HARMONY** Coping with the Complexity of Business Innovation
    - Commenced 1998
    - Commitment US $9.6m
    - Region involved Australia, EU, Switzerland, USA
    - Number of partners 18

15. **HIPARMS** Highly Productive and Reconfigurable Manufacturing Systems
    - Commenced 2000
    - Commitment US $4.2m

Region involved EU, Japan, USA
Number of partners 18

16. **INTELIWD** Intelligent Manufacturing of Wood Products
Commenced 2000
Commitment US $7.7m
Region involved Australia, EU, USA
Number of partners 15

17. **ROBUST** Systematisation of Quality Engineering and Development of Software for its Application
Commenced 2000
Commitment US $0.4m
Region involved EU, Japan, USA
Number of partners 11

Appendix 3.2 Endorsed Abstracts

ADWELTEC	Adhesive Bonding and Welding Techniques for Composite Structures
AIREFIT	Advanced Repair and Quality Inspection Processes for Jet Engine Components
AMSS	Autonomous Manufacturing Support System
ASTFOMAN	Advanced Sensing Technologies for Food Manufacture
BLADE	Interactive Blank Determination
CATALYST	Virtual Enterprise Catalyst
CLENEF	Intelligent Temperature Monitoring and Control for Clean and Energy Efficient Combustion Processes
COMET	Corporate Memory Technology
COSIPMAP	Control Systems for Industrial Plasma Manufacturing Processes
DELPHI	Intelligent Approach to Machine Diagnostics, Prognostics, Maintenance and Reconfiguration Control
DIFFICUT	High Speed Machining Technologies for Difficult-To-Cut Materials
DIRECT	Direct Modelling of Forging Processes
GCO	Global Cape-Open
GLOBE	Global Design to Manufacturing Process-Development of a Single, Completely Descriptive Design to Manufacturing
ICT-TAD	Low Frictional Wear Coatings made out of Nanocrystalline Diamond by Carbon Plasma Deposition
IDEPEC	Integrated Design of Electronic Products and Environment Considerations
INTELMAN	Intelligent Manufacturing of Structural Parts by Liquid Composite Moulding (LCM)
IREMAR	Intelligent Remote Diagnosis and Maintenance of Automation and Robotics Systems
ITEX	Development of an Effective Approach for Inter-Organisational Collaboration within the Supplier-Producer-Customer Supply Chain
LIFELONG	IMS Lifelong Learning: Global-Class
MATERIAL EYE	Development of a Time-Resolved Imaging Spectrometer for Improvement of Manufacturing Process-Material Eye
MEQUI	Measurement and Quality Feature Integration in Product Design Process Planning and Manufacturing
MIDAS	Enhanced Computer Based Design and Manufacturing of Mini-Hydraulic Products for Domotic Applications
MULTICAL	Multivariate Calibration in Industrial Quality Measurement and Process Control
OCMMM	Optical Characterisation Methods for MEMS Manufacturing
POEM-DESC	Progressive Object-Oriented Engineering Methodology; Design for Environment, Safety and Conservation

POLYALOY	Intelligent Control of Structure Formation and Processing of Polymer Alloy by Computer-Aided Methods
RPIMP	Development and Integration of Rapid Prototyping Technology for Manufacturing and Adjusting of the Surgery Prosthesis
RUBACON	Airformed Cerashell Construction- An Intelligent Way to Manufacture Affordable Housing
SiSiBon	Advanced Wafer Bonding for Low-Cost Reliable Micromechanical Products and Processes
SLAPS	Self-Tuning and User-Independent Laser Material Processing Units
STEP-NC	STEP-Compliant Data Interface for Numeric Controls
TES	Recycle System for Composite Material Waste; Thermal Elutriation System
VP	Extended Environment for Virtual Prototype Based on Virtual Factory Scheme
WWTPSC	World Wide Textile Production and Supply Chain

Appendix 4 Best Practice in the Evaluation of Multi-Party, Multi-Nation Research and Technology Development Projects

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Introduction

This Appendix reviews practice in the evaluation of international, collaborative, research and technological development (RTD) programmes as a contribution to the IMS Review. In practice, most of the relevant experience comes from European programmes, though many of the methods used are held in common with national or bilateral programmes in similar areas. The other programme with inter-continental participation, the International Human Frontier Science Program, is concerned with basic science in the fields of molecular biology and brain. Consequently, its reviews have been concerned mainly with issues of scientific quality and peer review procedures[25]. The main focus here is on lessons from the European Union's Framework Programme and from the EUREKA Initiative. Conclusions are drawn about elements for a monitoring and evaluation system for IMS.

Evaluation Frameworks and Issues

Evaluation Issues

Typically, programme evaluations are concerned with three types of issues:

- Efficiency of implementation – concerning the processes involved in setting agendas, soliciting and selecting projects, monitoring and management of projects, financial procedures etc.;
- Effectiveness of achievement – including scientific/technical quality and increasingly concerned with the socio-economic outputs and effects arising from projects and the programme; and
- Appropriateness of objectives and rationale – the wider strategic issues, for example whether the programme was conceived in the right scale, whether it targeted the right technical and market areas, additionality of public funding.

In the past, evaluations, normally carried out by panels of experts, had little difficulty in engaging with implementation issues and scientific quality. To some extent they were also able to comment on appropriateness issues by drawing upon their own knowledge of the wider context for the programme. The obvious gap, highlighted by many panels, has been the ability to engage systematically with measurement of outputs and impacts beyond the most immediate such as scientific publications or patents. Yet, even new or improved products and processes are still only outputs from the innovation process, effects do not occur until these outputs interact with the economy or society –for example in terms of increased sales, reduced costs or improved social welfare through a new standard or regulation. In recognition of this,

[25] The first review of HFSP was carried out jointly by ARA and PREST in 1996 and was combined with a report by a scientific review panel. Probably the most relevant finding for IMS was that there were genuine benefits to all partners from the different insights they received when put in contact with research teams in other continents. ARA (now KPMG) and PREST, with a Japanese partner, are midway through a follow-up review. The bulk of the work is concerned with following up past fellowship and grantholders, and bibliometric examination of publications.

there has been a growing emphasis in evaluation design towards creating systems which systematically capture and where possible quantify effects.

There are many barriers to be overcome in the collection of information on effects, including those of timing (there may be a long delay before effects come to fruition), attribution (effects frequently draw upon a wide range of inputs including other R&D and other aspects of the innovation process) and appropriability, whereby those performing the research may not be the main beneficiaries.[26]

Evaluation Frameworks
Evaluation methodology can be conveniently divided into techniques for *collection of data* (surveys, use of statistics etc), techniques for *analysing data* (eg testing hypotheses through assembling case-studies, using econometric analysis or constructing indicators) and a third category – *framework methods*. The existence of this latter category is the distinguishing characteristic of evaluation in that it provides for a context in which judgement of value can be made. Normally a framework involves comparison (eg before-after, participants vs. non-participants, or outcomes against expectations). A framework can also be used to investigate the contribution of public funding, for example to test whether it was the case that private returns were insufficient for the work to proceed but the sum of social and private returns provided a good case for investment and hence public support.

In the case of IMS, the comparison is likely to be with what could have been achieved in private, national or regional RTD as opposed to global cooperation.

Lessons from European Experiences[27]

Evaluation practice for the European Union's Framework Programme (which operates as a succession of programmes, so far First to Fifth) is based upon a system of panels of independent experts reaching judgement on individual sub-programmes, with a further panel carrying out an assessment of the Framework Programme as a whole. Present practice is to address the problem of timing referred to above by giving the panels a five-year frame of reference covering, the effects of the previous programme, the outputs and early effects of the programme just completed and the management and strategy of the current programme. Panels, and in particular the high-level overall panel normally also comment strategically on the future. Annual monitoring exercises supplement this system with the intention of providing a quick response system. The present Fifth Framework Programme has placed a much higher emphasis than its predecessors upon wide-ranging socio-economic targets and hence there is much pressure for evaluation to be refocussed on impact assessment. A review panel recently recommended significant enhancements to the present system, including an upgrading of supporting studies and automatic collection of information of effects

[26] A full review of the difficulties encountered and progress made in this area is found in Georghiou L and Roessner D., 'Evaluating technology programme: tools and methods', *Research Policy* 29 (2000) 657-678
[27] For a more detailed description and analysis of evaluation of the Framework Programme and EUREKA Initiative see Georghiou L, 'Socio-economic effects of collaborative R&D – European experiences, *Journal of Technology Transfer* 24: 69-79, 1999

after completion of projects.[28] In the present round panels have made substantial use of existing *ad hoc* impact studies in their areas which had been commissioned for management and dissemination purposes.

One further issue in the evaluation of the Framework Programme is of particular relevance to IMS. One of the criteria for support of projects is that they should contribute to "European value-added". In other words they should be only be supported if they were most efficiently pursued at European Community level as opposed to national level or below. Examples of this include creating a critical mass of human and financial resources, supporting Community policies or dealing with trans-national needs, standardisation or development. Linking to the conclusion of Section 2 above, the analogous evaluation issue for IMS is its "Global value-added".

The EUREKA Initiative, a separate intergovernmental scheme not operated by the Commission, has been evaluated frequently in the past fifteen years. However, since 1996, there has been in place a system for 'continuous and systematic evaluation' (CSE). This, as its name implies, collects information systematically each year by sending a standardised questionnaire to all projects which finish in that year. This four-page questionnaire replaced the requirement for a final report. All projects that indicate expectations of impact are sent a short (2-page) market impact questionnaire one, three and five years after the end of the project. The results are interpreted by an independent panel, which also carries out more detailed semi-structured interviews with a sub-set of participants.

Results are presented to EUREKA's Ministerial conference through an Annual Impact Report. The database is cumulative in its analytical power and provides the stakeholders with a fast and easily comprehensible form of feedback. A significant point for IMS is that EUREKA is principally an industrial collaboration scheme and many of its participants do not receive government funding. Nonetheless, response rates to the CSE have been consistently high, with national administrations assisting in collecting them. An evaluation system of this kind has its limitations and it has been supplemented by more targeted exercises on management issues and on broader strategy for the initiative. However, the Strategic Review was able to proceed without the need to repeat any of the data collection activity and the CSE system has generally avoided the problems of tracing old contacts that often inhibit evaluations.

A similar approach has been adopted by COST, Europe's third general scientific cooperation scheme, and is also being considered by the Human Frontier Science Program.

Conclusions

In this brief review some important pointers emerge for monitoring and evaluation of IMS. These may be summarised as follows:

- a well-articulated and operated monitoring and evaluation system is an important tool for maintaining the confidence of stakeholders in a programme

[28] Airaghi et al, Options and Limits for Assessing the Socio-Economic Impact of European RTD Programmes, Report of Independent Reflection Group, European Commission, ETAN Paper, January 1999

and for demonstrating its benefits more broadly to prospective participants (at the level of company or nation);

- The trend is towards evaluation systems which focus upon impacts and effects of RTD. The most reliable way to collect this information is through an ongoing process which maintains contact with former participants;
- To work, a system of this type needs to be as light as possible, working with short and simple surveys supplemented by a limited number of case-studies;
- The distributed nature of international cooperation means that all members will need to cooperate in ensuring effective data collection;
- The broader framework for the evaluation of IMS should concentrate on the ways in which global cooperation has facilitated or enhanced the achievement of project goals, and any broader social benefits;
- A reporting system for monitoring and evaluation which ensures that its results are debated at high-level, and are properly disseminated to stakeholders, is an essential element;
- An impact focus will not meet all needs. From time-to-time a more strategic evaluation will be needed to assess changing circumstances. However, the existence of a continuous system will ensure a common knowledge base for the debate.