Financing the Standards Development Process*

Michael B. Spring and Martin B.H. Weiss

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Introduction

In the decade since scholarly work on standards began, the basic dynamics of standards in the marketplace have been reasonably well described (see [11], [15] and [30] for surveys of this literature). Some empirical studies have been performed to examine the actual behavior of the marketplace and of committees [12, 25, 33] (even though this sampling is far short of what is necessary to fully understand standards), and preliminary attention has been paid to modelling the standards development process [8, 18]. Much anecdotal literature exists addressing changes in the standards process [6], although little has been done to quantify this (see [5, 31] for attempts at quantification). The properties, attributes, and related marketplace behavior of different kinds of standards, such as software standards *vs.* hardware standards, have not yet been researched.

The question of how to finance the standards process was been raised by the Office of Technology Assessment report [29] Global Standards: Building Blocks for the Future. Weiss and Spring [34] began to address selected issues of financing in the context of intellectual property issues. This paper provides a broad analytic framework for addressing financing issues through an examination of the specific, detailed pattern of costs and benefits of standards.

This kind of study is pertinent in light of the numerous discussions that have occurred in recent years on restructuring the U.S. standards process. Several different kinds of standards are developed in the United States under the auspices of a multitude of professional and industrial organizations [6, 29]. Garcia [14] shows that this approach developed in the early part of this century because of a policy preference for private enterprise over government-directed activity[1]. As a result, numerous Standards Development Organizations (SDOs) emerged, none with a clear, centralized authority. The situation is compounded today by the growing popularity of consortia [32] and the increasing use of public specifications developed by dominant producers such as Microsoft. Each SDO, consortium, and industrial organization has different rules, procedures, and motivations for developing standards.

*The authors welcome comments. They may be reached via the internet (spring@pitt.edu and mbw@pitt.edu) or at the Department of Information Science and the Telecommunications Program at the University of Pittsburgh, Pittsburgh, PA 15260.

[1]Garcia points out that the early predecessor to the National Institutes of Standards and Technology (NIST) was financially and politically crippled in the face of active lobbying and concern over government meddling in this "commercial" activity.

The OTA report [29] suggests that the lack of a single authoritative SDO hampers United States efforts in the international standards arena. The report was critical of the market driven, decentralized process that is in place, particularly given the planned and organized approach used by our major trading partners. While there has been increased support for chartering the American National Standards Institute to serve as the official United States voice on standards, it is difficult to see how such a charter will improve the fundamental problems of funding the development of high quality standards that serve the interests of both the nation's industrial and commercial sectors and the nation as a whole. Even without considering the issue of external pressure, Weiss and Toyofuku [36] have raised questions about the sustainability of the current process in light of "free riders."

In terms of funding, the situation in the United States generally mirrors the situation internationally. In the International Telecommunications Union Telecommunications Standardization Sector (ITU-T),

> each organization bears the direct cost of participation of its experts in ITU-T meetings, including travel, hotel accommodations, etc. Such costs are quite substantial, particularly if one considers the costs arising from preparatory work (developing proposals, harmonizing them on a national and regional level, drafting the contributions, etc.). All this work prior to a meeting costs money, to be spent by each participating organization.
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> The costs incurred by TSB [Telecommunications Standardization Board] for providing logistical support, for translation, interpretation, printing, and mailing all paperwork, for salaries of TSB staff, etc., are covered by financial contributions by Administrations and other organizations admitted to take part in ITU-T activities[17]

Private financing is not the only funding strategy. The European Telecommunications Standards Institute (ETSI) pays some standards developers in order to accelerate their work [3, 24]. Colleen Preston, Deputy Undersecretary of Defense for Acquisition Reform, reported at the National Research Council Conference on Standards and Trade that as a part of acquisitions reform, DOD will be looking to pay for the development of public standards where none exist as an alternative to Milspecs and Milstds. Similarly, the very high costs associated with some consortia may be viewed as upfront costs by the corporate sponsors to accelerate the standards development process. Even though the free market approach seems to be gaining favor in Europe, there remain numerous examples of standards development that is more heavily government supported than is the case in the United States. While the private sector has resisted increased government involvement, even that limited to funding, there have been recent signs of a willingness on the part of some to accept government support so long as it does not imply increased regulation and bureaucracy [22]. However, no analysis exists that provides a grounded explanation of what funding *should* be provided. In order to do that, one needs an analytic framework that articulates the costs and benefits accruing to the various stakeholders.

Framework for Analysis

At a global level, it is difficult to compare the costs and benefits of the 3.5 inch floppy disk standard with the costs and benefits of the TCP/IP standard. Even closely related standards

such as IEEE 802.3 (Ethernet) and IEEE 802.3*i* (10BaseT) vary significantly in complexity, time required for development, cost of related product development, and length of use. All of these are factors in the cost of standardization. On the benefits side, the situation is equally complex. There are both direct and indirect benefits to the developers and users of a standard. This section provides a framework for the analysis of the costs and benefits of standards.

While any number of different dimensions might be selected as the basis for cost analysis, three stand out in the literature.

1. The type of standard
2. The nature of the development process
3. The scope of the standard

Types of Standards David [10] suggests that standards might be classified as behavioral or technical, and within these classes further typed as basic measurement, quality assurance, or compatibility standards. While it is a sound general classification scheme, it fails to adequately discriminate among the many information technology (IT) standards that fall into the technical compatibility group. Bonino and Spring [4] and Bonino [5] identify two broad subclasses of technical compatibility standards: traditional and anticipatory. Traditional standards are those based upon products or prototypes that have been tested in the laboratory or marketplace, while anticipatory standards are those that are developed before products exist.

Cargill [6] identifies standards as conceptual or implementation and product or process. Spring and Bearman [27] describe two possible subclassification schemes for IT standards: standards may be grouped into the information technology function they perform (interconnection, interface, interchange [of data], or interoperability) or they may be grouped into the information process they relate to (creation, dissemination, storage, or access). Spring [26] has also suggested that standards may be classified as reference models, base standards, syntax standards, or implementation/derivative standards:

1. Reference models serve to organize an area and serve to constrain and focus other standards. They are not implemented directly, but through the base standards they call for. Perhaps the most famous reference standard is International Standards Organization (ISO) 7498, The Open Systems Interconnection Reference Model.
2. Base standards form a measurable and implementable product or process description. These form the majority of the standards developed by traditional SDOs. IEEE 802.3 would be an example of such a standard.
3. Syntax standards specify a language or procedure that may be used to develop other standards. Thus while a computer language standard is a base standard (because programs developed in the language are not themselves standards), a standard such as ISO 8879 – Standard Generalized Markup Language (SGML) is intended to spawn implementations of the language that are themselves standards, such as CALS or Z39.59[2].

[2]ISO 8824 – ASN.1 would be another example of a syntax standard.

4. Implementation or derivative standards are standards developed from syntax standards or those with a significant dependence on a base standard. Clearly Z39.59 is an implementation of SGML. 10BaseT may be defined as a derivative standard of 802.3, i.e. it is critically dependent on 802.3.

The costs (and benefits) of developing a standard before products are developed will be different–in distribution if not magnitude–from the costs of developing a standard based on existing products. Similarly, there are different costs and cost distributions for reference, base, syntax, and implementation standards. While different, the anticipatory–traditional and reference-base-syntax-implementation dimensions are not fully orthogonal. Reference models are almost always anticipatory. Similarly, derivative standards are frequently based on successful products. In contrast, base or syntax standards may be anticipatory (ISDN) or traditional (Ethernet). The qualified marriage of these two dimensions yields the following classification for standards by type:

1. Reference
2. Anticipatory Syntax
3. Traditional Syntax
4. Anticipatory Base
5. Traditional Base
6. Implementation

We would suggest that costs and benefits will be significantly different for each of these types of standards. Analyses that do not factor out the different costs and benefits will not provide a fair picture.

Jumping ahead in the analysis, it is not hard to imagine that it might be possible to justify government support for reference models more easily than it would be to justify it for implementation standards. Considering the long period of time involved in development of a reference standard, it is easy to see that a reference model that has heavy upfront costs might require a different funding strategy than an implementation standard. In addition, it is reasonable to expect that those who invest in a standard for the long term will have to expect a higher rate of return if the benefits do not accrue until ten years after the investment has been made. Since the benefits accruing from implementation standards will be realized more quickly than those accruing from the development of a reference standard, private funding is easier to justify. In order to see how these costs are arrayed, we suggest that the costs be determined for each of the major phases in the life cycle of a standard.

Phases of Standardization Over the last several years, there have been several efforts to better define the steps in the standards development process. Weiss and Spring [35] suggest specification, distribution, and implementation as important phases for examining issues of intellectual property rights. The X3 Strategic Planning Committee [28] defined a five step life cycle, consisting of the following phases

1. Initial requirements
2. Base standards development
3. Profiles/product development
4. Testing
5. User implementation/feedback

In a similar fashion, Committee T1 [23] has identified five stages:

1. An initial set of requirements for a standards project is developed based on inputs from users, manufacturers, service providers, etc.
2. Base standards are developed.[3]
3. Standards are implemented through two related activities:
   (a) Within the committee process, user profiles and implementation agreements are developed.
   (b) Products are developed based on the base standard and the user profiles.
4. Products are tested for conformance to the standard and profile.
5. Products are delivered to users.

For purposes of this analysis, none of the models described provides the scope and detail required. The T1 model provides reasonable scope and the X3 model a reasonable level of detail within the traditional SDO process. However, both tend to ignore the increasing importance of conformance test development and certification. Similarly, they tend not to address issues such as the need for registration agencies for implementation standards. With these concerns in mind, we suggest the following phases of standards development:

1. Requirements analysis
2. Document development
   (a) Objective setting
   (b) Development
   (c) Specification:
      i. of interface, characteristics, etc.
      ii. of conformance requirements
3. Standard approval

[3] T1 defines a base standard as "a minimum set of requirements for interworking and interoperability that provides an opportunity for individual manufacturers and service providers to innovate in providing price, performance and additional features to attract and satisfy users." [23]

4. Document dissemination
5. Implementation:
   (a) of products
   (b) of conformance tests
   (c) of derivations of the base standards
6. Management
   (a) Maintenance of the standard
   (b) Establishment of certification procedures
   (c) Development of registry agents and conventions
7. Certification of products and registration of standards

Three points need to be made about this model. First, the phases are not necessarily linear. The use of formal description techniques (FDTs) in the specification phase may obviate the need for, or significantly reduce the cost of, the development of test suites in the implementation phase. At the same time, the use of an FDT is likely to increase the cost of the specification phase. Second, the expanded model defines a scope that spans organizational boundaries as they exist today. Third, not all phases apply to all standards types or to all the standards within a type. For example, it is generally meaningless to talk about conformance to a reference model. Standards that can generate conformance tests based on FDTs and that are subject to self certification will not have steps for review and certification of testing agencies. Similarly, a registration facility is only necessary where it is required by a base standard.[4]

Scope Assigning costs to the phases of standardization, while useful, is not complete. Other factors must be considered that can impact the cost of a standard. These are perhaps best described by defining the scope of a standard. There are a number of hints in the literature as to how the scope of a standard might be defined:

1. Cargill [6] defines one of the characteristics of a standard as its importance – "measured by the dollar impact in both the users' and providers' world . . . For the users it is the cost of time *before* implementation of the standard; for the providers it is the cost of implementation itself." (p27) To operationalize Cargill's definition, one needs to define the providers and users. The provider side is accounted for in the previous two sections, but the user assessment of cost is more difficult. At a first level of analysis, we argue that the size of the user community provides one measure of scope. For instance, the users of a standard like ISDN–the owners of phones–are likely a much larger group than the users of a standard such as SCSI–the manufactures of computers and peripherals. With this in mind, it may

[4]For example, since ISO8879–Standards Generalized Markup Language (SGML) assumes the development of shared Document Type Definitions (DTDs), it was necessary to specify Registration Procedures for Public Text Owner Identifiers–ISO 9070 to allow for the registry and availability of DTDs, which are in essence derivative standards or conventions.

be possible to assess the costs associated with lost opportunity given the time to develop one or another standard. From the provider perspective, one might look at the financial impact a standard is likely to have. A change in the DOS operating system will have a far more significant financial impact than a change in SCSI.

2. Another aspect of scope has to do with the percentage of the total community involved. For example, while the United States commercial sector might well be satisfied with a POSIX standard with a strong bias toward Unix and C, it is not acceptable to the U.S. military community or the broader European community. In this wider operating system community, it is more critical that an expanded array of operating system features (security, real time functions) and language bindings (ADA, FORTRAN) be specified. Often it will be possible to meaningfully define this aspect of scope in terms of whether the standard is intended for an industry grouping or enterprise, a nation, a region, or a global community.

3. Finally, one might examine the expected temporal scope of a given standard. A standard that is intended as a temporary fix can, or should, be developed more quickly than one requiring a commitment of many years. Similarly, developers may expect a longer period of return on their investment. As with the issue of cost to users, there are issues related to lock-in costs for standards that have longevity. David [9] has discussed the costs of lock-in for the QWERTY keyboard standard.

The scope of a standard, then, involves three measures. We operationalize them as follows:

1. Community impacted:
   (a) General population–all or a large segment of the population
   (b) Population segment–only one group within the population, such as the publishing community, or the service sector
   (c) Development segment–a population segment that includes only the kinds of individuals involved in developing the standard
   (d) Developers–the standard affects only that group directly involved in the development of the standard

2. Scope of Agreement:
   (a) Industry or enterprise group defines the scope of agreement
   (b) National bounds define the scope of the agreement
   (c) A regional group of nations defines the scope of agreement
   (d) The global community defines the scope of agreement

3. Period of commitment:
   (a) The commitment is temporary for either political or technical reasons
   (b) The commitment is indeterminant, and while expiration is anticipated, no fixed time period is set

	Reference	**Syntax**		**Base**		**Implmnt.**
		Anticip.	Trad.	Anticip.	Trad.	
Analysis						
Development *design* *specification*						
Approval						
Dissemination						
Implementation *products* *tests* *derivations*						
Management *maintenance* *certification* *registration*						
Certification						

Table 1: Cost Breakdown by Type of Standard

(c) The commitment is considered to be indefinite, and no change is anticipated, or the commitment is made to observe the standard for a long period of time–more than 10 years from adoption, even if change might be desired

Assignment of Costs Table 1 provides a framework within which to assign costs for each kind of standard. This table crosses type of standard with phase of standardization. It is reasonable to expect that different costs can be expected in different phases for the different types. Areas of high cost will require careful examination and elaboration while areas of low or no cost may generally be ignored. Added to this analysis will be additional lost opportunity costs based upon an assessment of the scope of the standard. For limited scope standards, the costs are simply those of development. For standards that have significant scope in terms of impact, community, or period, additional direct costs or indirect costs must be added. The indirect costs will include lost opportunity, compromise, and commitment costs.

To develop accurate cost analysis, costs must be attributed to each cell shown in Table 1. To obtain the direct costs for even a single step can be a daunting task. For example, in a detailed examination of the development process, one needs to account for different costs for different categories of participants. Weiss and Toyofuku [36] define five categories of individuals involved with standards: developers, Type 1 free riders, Type 2 free riders, observers, and interested parties[5].

[5] "Free Riders" are firms that benefit from standards but do not contribute to their development; hence they get a "free ride" from the developers of the standard. To be a free rider, a firm sells compatible products after the standard is developed. Type 1 free riders are firms that wait until the standard is complete before developing compatible products. Thus, they make *no* investment in the development of the standard. Type 2 free riders attend standards committee meetings, thereby incurring costs, and gain advance information on the standard. Observers are firms or individuals who have an interest in the development process of a particular standard but who have no

Participants	*Costs*
Developers	Time and Travel
	General R&D
	Product R&D
	Conformance/Interoperability Tests
Type 2 Free Riders	Time and Travel
	Product R&D
	Conformance/Interoperability Tests
Type 1 Free Riders	Product R&D
	Conformance/Interoperability Tests
Observers	Time and Travel
Interested Parties	Time and Travel

Table 2: Costs by Types of Participant

While all of these groups benefit from standards, Type 1 free riders incur no significant costs related to the development of the standard, as delineated in Table 2. Beyond these direct costs to participants, SDOs must also pay for various administrative support costs such as photocopying, mailing, meeting rooms, preparation of minutes, procedural support, and verification.

Similarly, conformance testing costs have to be calculated. The "classical" method for conducting a conformance test is to build an apparatus to which implementations of the standard (typically referred to as the Implementation Under Test, or IUT) are attached. The apparatus stimulates or "exercises" the IUT and observes its responses. The responses and their timing are measured by the conformance test apparatus and compared to those specified in the standard (see Linn [19, 20] for a more detailed discussion of conformance testing). Alternatively, manufacturers can connect their implementations to existing implementations (normally from other vendors) in the marketplace. If they interoperate properly, then the new implementation is thought to conform to the standard[6]. This approach is sometimes called *interoperability testing* to distinguish it from conformance testing, since it focusses on product interoperability instead of conformance to the standard. This is arguably what end users want. Finally, there is *self certification* as a conformance test process. Here, vendors conduct their own conformance tests instead of relying on a third party to conduct them. An end user may challenge the conformance to the standard, and only at that time does the vendor have to produce the conformance test results. In each case, *any* organization that manufactures products conforming to the standard incurs these costs, regardless of the organization's participation strategy. Type 1 free riders must build conformant products even if they did not participate in the development process. Thus, this cost is relatively evenly distributed. There are some costs that might be borne by an SDO if it is involved in administering the conformance test. It is assumed here that the development of the conformance test was part of the standards development process.

intention of developing products that conform to the standard. Finally, interested parties are all others who attend meetings.

[6] Actually, the implementation conforms to those implementations of the standard. If an implementation of the standard is different from the standard but dominates the market, a *de facto* implementation of the standard could well emerge that may not conform to the actual standard.

	Reference	**Syntax**		**Base**		**Implmnt.**
		Anticip.	Trad.	Anticip.	Trad.	
Analysis	High	High	Medium	High	Low	N/A
Development						
design	High	High	Medium	High	Medium	Low
specification	High	High	Low or High	High	Medium	Low
Approval	High	High	Medium	High	Medium	Low
Dissemination	Low	Low	Low	Low	Low	Low
Implementation						
products	N/A	N/A	N/A	High	Medium	Low
tests	N/A	High	High	Medium	Medium	Low
derivations	N/A	High	High	N/A	N/A	N/A
Management						
maintenance	Low	Low	Low	Medium	Medium	Low or High
certification	N/A	Low	Low	Low	Low	Low
registration	N/A	High	High	N/A	N/A	Medium
Certification	N/A	N/A	N/A	High	Medium	Medium

Table 3: Development Cost Estimates by Type of Standard

To estimate the cost by phase for classes of standards without hard data from many cases is a difficult task. Nonetheless, Table 3 is an attempt to characterize these costs based on our observations and anecdotal data about the standards process. These assignments represent research hypotheses that must be tested. The rationale for the cost assignments are outlined below:

Reference Reference standards are usually designed to be applicable over long periods of time. As a result, the development of such a standard requires that the developers have good foresight about technical capabilities and market demand. As this kind of projection in a committee forum comes as the result of extensive discussion and debate, we label the analysis and development as high cost activities. Since the standard will affect the relevant markets for a long time, it is expected that approval will also be time consuming, hence a high cost activity. The remaining phases of the standards life cycle are not applicable with the exception of maintenance, which is low cost. Note that it does not make sense to consider the implementation, certification, or registration of reference standards.

Anticipatory Syntax Like reference standards, anticipatory standards lead the market, which requires market and engineering foresight on the part of the developers, making the first several phases high cost activities. Syntax standards, by definition, require derivative standards and tests to certify the derivative standards, thus these costs are high. They also

require the development and maintenance of a registry. As a result, all of these are high cost phases as well. Since syntax standards (both anticipatory and traditional) are not directly implemented in products, it is not appropriate to consider the product implementation or certification costs associated with these types of standards. The standard serves as the absolute reference for the development of tests for the derivative/implementation standards based on it.

Traditional Syntax Traditional standards are developed after the marketplace has been involved, so the development costs are generally lower. One significant exception to this is specification in the presence of competing standards in the marketplace. Finding a technical position palatable to all (or a majority of) participants is sometimes quite challenging. One example of this problem may be the development of standard mail note formats where there is currently competition between X.400 syntax specification and SMTP/MIME specification. Thus, the table shows the development costs being either low or high, with the actual cost being dependent on whether this is a single dominating standard or one of multiple competing standards. The remaining costs of syntax standards mirror the costs of the anticipatory syntax standards.

Anticipatory Base Like anticipatory syntax standards, the analysis, development, and approval phases of anticipatory base standards are high cost phases. Unlike anticipatory syntax standards, there are no registration costs, but instead there are product testing costs that will be high as product developers work to implement the standard specification. These costs are high because to date vendors have found anticipatory standards to be critically ambiguous, thus increasing development time and cost. Note that base standards typically do not require registration, and that derivative standards are typically base standards in their own right (such as the relationship between 10Base5, 10Base2, and 10BaseT Ethernet), so these are labelled as not applicable (N/A) in the table.

Traditional Base As with traditional syntax standards, traditional base standard have lower analysis, development, and approval costs, in general, than their anticipatory counterparts, largely because their definition occurs after compatible products enter the marketplace. One example of this is the development of a standard page description language in the face of three significant market standards–HPGL, PostScript, and Interpress. Also due to the marketplace presence, these standards may be subject to lower product testing costs because the testing may be an informal interoperability assessment rather than a formal conformance test.

Implementation The overall costs for these standards are low, because they are implementations or derivatives of other types of standards. Since implementation standards are based on another standard, there is minimal analysis required and development is rather straight forward. Derivative standards may have low or high maintenance costs. On the one hand, derivative standards may simply replace them. On the other hand, implementation standards may involve obtaining agreement from a large user community. Thus, maintenance of Milstd 28001(CALS) or Z39.59–both based on SGML, will be high because large numbers of users must be involved in the revision and respecification process. Consequently, the maintenance costs of the new standard should be low *or* high.

Analysis of Benefits

While any number of different dimensions might be selected as the basis for benefit analysis, we suggest that as with costs, benefits differ based on three factors. As with costs, benefits differ based on the type of standard and the scope of the standard. Rather that assigning benefits by development phase, however, benefits are best analyzed by examining the groups to which the benefits accrue.

Three groups benefit from the development of a standard: the developers, the SDOs, and the users. Each of these groups may be further subdivided as shown below.

1. Developers
   (a) Active developers
   (b) Type 1 free riders
   (c) Type 2 free riders
2. Standards Development Organizations
   (a) Sponsoring SDO
   (b) Liaison SDO
3. Users
   (a) Producer users
   (b) Consumer users
   (c) Nation states

While it is theoretically straightforward, even if practically difficult[7], to attribute monetary costs for standards developers, it is more difficult to evaluate benefits. For developers, net revenues (it i.e., revenues beyond the cost of developing the standard and developing, producing, and certifying the subsequent product) may be a reasonable metric of benefits[8]. For SDOs, gross revenues may be a better metric[9]. For users, at the level of the nation state, the *existence* of a standard may meet some social goal and benefits may not be directly measurable in monetary terms.

Developers Developers have three major avenues for recovering their investment in the standards development process:

1. Profits from products based on the standard

[7]Studies by Weiss, Bonino, Toyofuku, have encountered tremendous difficulties in quantifying the costs associated with participation in the standardization process.

[8]Gross revenues may be inappropriate because it is difficult to consider revenues that do not meet or exceed a product's total development costs a benefit.

[9]SDOs are frequently not-for-profit corporations, so gross revenues may be more appropriate. Shortfalls in gross revenues with respect to costs may be made up via other sources, such as membership dues, as long as the goals of the membership are satisfied.

Organization	*% Revenues*
American National Standards Institute	28%
American Society for Testing and Materials	80%
National Fire Protection Association	66%

Source: United States Congress, Office of Technology Assessment [29]

Table 4: Revenue from Sales for Selected SDOs

2. Consulting with other companies based on the expertise they developed in the development process

3. Royalties and licensing fees based on intellectual property owned by the developer that was incorporated into the standard[10].

In addition, developers may receive an indirect benefit associated with the prestige and industry leadership associated with active standards participation. There may also be some strategic benefits to actively participating even if the developer does not intend to manufacture and produce products conforming to the standard [31].

From a marketing standpoint, active developers must be able to recover their investment in the standard by being an early entrant to the market for compatible products, by building subcomponents (such as integrated circuits) that other product developers would likely use[11], or through other means. If the standard is delayed sufficiently to void their product leadership capability, it will be difficult for a firm to justify continued participation in the standards process, as it will be a money losing operation.

Standards Development Organizations The OTA [29] has shown that many SDOs seek to recover the costs of standards development through the sale of standards documents. In fact, this revenue has become a significant fraction of their overall operating budget in some cases (See Table 4). Other revenues for these organizations are typically derived from membership dues and other sources. Thus, the administrative portion of the standards development process is supported by all who purchase standards documents. The other major source of revenues comes from the membership dues of the participating companies. As the OTA pointed out, competition for revenues has led to hostilities within the standards development community [29].

Liaison SDOs also receive benefits from standards developed by other SDOs. They may benefit from not having to develop infrastructure standards, which may simply be referenced. More dramatically the development costs for other types of standards may be all but eliminated, particularly in the case of national standards adopted from the international arena or international standards based upon national standards. Adopting SDOs achieve all of the benefits of the sponsoring SDO with the caveat that their sales of the adopted standard will not be as high.

[10]This has been an area of some controversy. Firms are required to come up with fair and non-discriminatory terms for all intellectual property that they contributed to the committee. The European Telecommunications Standards Institute (ETSI) has developed a policy that *prohibits* firms from collecting any such royalties. This has been a bone of contention between the European Community and the United States

[11]Weiss and Toyofuku [36] found that semiconductor manufacturers, as opposed to developers of end products, were among the most active participants in the development of the IEEE 10BaseT standard.

Users Three categories of users are suggested: producer users, consumer users, and nation states. Producer users provide products or services that are related to the products or services directly based upon the standard. Developers of test suites are a prime example of this category. Another example might be a developer of database systems who uses an SQL compliant front end, produced by a developer, to make their database system more attractive to potential customers. Consumer users make use of products that in some way depend upon the standard. Thus corporations that build client server database systems with SQL front ends derive benefits from the standard nature of the database interface. Similarly, many users derive significant benefits in terms of product cost and system design flexibility from reliance on products that use Postscript as the interchange standard between software and display devices. These consumer users may be small or large groups. They may be vertically integrated corporations or groups of corporations engaged in an enterprise; the largest single group is often the United States government.

The last category of user is the most difficult to define. By referring to it as the nation state we intend to suggest that it is the collection of individuals who benefit from a standard even if they don't make use of it, even indirectly. As a user, the government can play an important role in supporting the emergence of a "bandwagon" around potentially strategic or important technologies [2]. It can be argued that the United States government played this role with internetworking technologies by supporting the ARPAnet (and later the Internet) or by supporting other technologies such as commercial aircraft manufacturing. While the active picking of "winners" and "losers" is often decried as industrial policy, the United States has a tradition of doing this, albeit often for defense reasons[12]. Other countries are more open about their support for emerging standards and technologies.

Assignment of Benefits As with costs, for each kind of standard, the benefits that accrue to different categories vary. Areas of high benefit will require careful examination and elaboration. As shown in Table 5, benefits can be expected to be different for each group depending upon the type of standard. For limited scope standards, the benefits accrue almost exclusively to the developers. For standards that have significant scope in terms of impact, community, or period, significant benefits will accrue to other groups. As with Table 3, the benefits summarized in Table 5 are hypotheses based on informal observation and anecdotal data from the standards development process that must be rigorously tested. The arguments for these hypotheses are stated below:

Reference The benefit of reference standards is indirect at best for developers of all types. There is perhaps a modest benefit for active developers because reference standards can sometimes reduce the cost of developing base and syntax standards in the area, since they provide a consistent framework for standards development. Most of the benefits of reference standards, though, apply to SDOs that make use of them, and to nation states because they simplify and therefore reduce the overall cost of standards development.

Anticipatory Syntax The benefits of anticipatory syntax standards are high, with developers in all categories receiving the benefit of shared committee research and development. Type

[12] In the early days of telegraphy and railroads, the government actively supported the efforts of these new companies by granting them special privileges. The Post Roads Act (1866) gave Western Union the permission to use public rights of way and they could fell trees for poles at no charge [16].

	Reference	**Syntax**		**Base**		**Implmnt.**
		Anticip.	Trad.	Anticip.	Trad.	
Developers						
active	Medium	High	Medium	High	Medium or High	Medium
Type 2 free riders	Low	High	Medium	High	Medium or High	Medium
Type 1 free riders	Medium	Medium	Low	Medium	Low or High	High
SDOs						
sponsoring	Medium	High	Medium	High	Medium	High
liaison	High	Low	Low	Low	Low	N/A
adopting	High	N/A	N/A	High	High	Low or Medium
Users						
producer	N/A	Medium	Low	Medium	Low or Medium	N/A
consumer	N/A	Medium	Medium	High	High	High
nation state	High	High	High	Low	Low	Low

Table 5: Benefit Breakdown by Type of Standard

1 free riders may be expected to miss the benefit of the advance intelligence on issues related to product development. Sponsoring SDOs can expect higher circulation of the standards document if it is the sole or main source of information. While there will be some benefits in guiding the development of implementation standards through liaison SDOs, these are accounted for under the implementation/derivative standards. As with reference models, syntax standards guide the development of other standards, thus reducing the overall costs for nation states.

Traditional Syntax For developers, the benefits of traditional syntax standards are less than those of anticipatory. Rather than spawning new products, the standards likely will require changes to existing products, thus reducing benefits. The benefits to SDOs and users are generally the same as for anticipatory syntax standards with the exception of producer users who, like developers, are likely to see fewer benefits since the traditional syntax standard is likely to imply a change to existing products rather than the production of a new product.

Anticipatory Base The net benefit of these standards varies based on the type of participation. Because of the impact of reduced R&D costs for the anticipatory standard, active developers and Type 2 free riders will benefit the most. The need to come up to speed on the technical issues and problems will likely reduce the benefits for Type 1 free riders. Sponsoring and adopting SDOs benefit because they sell many standards documents, hence improving their revenue stream. Users of all kinds benefit because a costly standards rivalry is avoided– costly in the sense that users would have risked being orphaned by adopting a standard that later turned out to be non-dominant or unsuccessful. However, producers will generally

have benefits constrained because competition in the market place will increase based on the standardized products.

Traditional Base The net benefits of traditional base standards depend heavily on whether one's preferred technology was successful. If it was, then the net benefit is very high; if not, the net benefit is low. For free riders, the net benefits are high, because the development cost is relatively low for both Type 1 and Type 2 free riders. SDOs, however, have a lower benefit because the specification may already be relatively well known in the market, so document sales may be off.

Implementation Because implementation or derivative standards are based on other existing standards, the benefits accruing to Type 1 free riders will be high in that they may simply implement the standard, which is less likely to require significant re-engineering to understand. On the other hand, the developer's benefit is less in light of the cost of development. Since the impact of the standard is very limited, it is of negligible benefit to liaison SDOs. Adopting SDOs may see significant benefit if the standard provides sales with no cost. (It is likely that an international SDO adopting a national standard will benefit more than a national SDO adopting an international standard unless there is a compelling reason to buy the version of the standard produced by the national SDO.) Again, because the scope of the standard is limited the social benefits are likely to be negligible. Because implementation standards are generally more focused on user-related issues, the benefits to consumers are higher.

Approaches to Financing the Standards Process

The framework discussed above can be used to assess the funding of the standards development process. By carefully examining the costs incurred by each participant in each phase of the standards development process for different types of standards, and by comparing these to the benefits achieved by groups for each type of standard, we can assess how each group fares for each type of standard. This provides clues as to which phases of which types of standards are suitable for different standards funding methodologies. This analysis also allows for prediction of which standards with significant social benefits might be under-provided under the current funding scheme.

Table 6 is an initial attempt at constructing such a matrix. This table was constructed using information from the previous tables; note that the cost data is a result of mapping the costs of the phases defined in Table 3 onto the user communities of Table 5, using Table 2 as a guideline. As outlined in Table 2, active developers incur relatively high costs for all of their activities, Type 2 free riders incur "medium" costs, and Type 1 free riders incur low costs. Similarly, it seems reasonable to assume that sponsoring SDOs incur high cost in general (except with implementation standards), with liaison SDOs incurring medium costs (because they attend the sponsoring SDO's meetings), and adopting SDOs low costs, since they simply adopt the work of another SDO. Generally speaking, users incur low costs because they generally do not attend the standards meetings. Producer users are more likely to incur higher costs than consumer users, because the economic consequences of the standard are higher, so they are more likely to

	Reference		**Syntax**				**Base**				**Implmnt.**	
			Anticip.		Trad.		Anticip.		Trad.			
Participant	Cost	Ben.	Cost	Ben.	Cost	Ben.	Cost	Ben.	Cost	Ben.	Cost	Ben.
Developers												
active	H	M	H	H	H	M	H	H	H	M/H	H	M
T2 free riders	M	L	M	H	M	M	M	H	M	M/H	M	M
T1 free riders	N/A	M	L	M	L	L	N/A	M	L	L/H	L	H
SDOs												
sponsoring	H	M	H	H	L	M	H	H	L/H	M	L	H
liaison	L	H	L	L	L	L	L	L	L	L	L	N/A
adopting	L	H	N/A	N/A	N/A	N/A	L	H	L	H	L	L/M
Users												
producer	N/A	N/A	L	M	L	L	L	M	L	L/M		N/A
consumer	N/A	N/A	L	M	L	M	L	H	L	H	L	H
nation state	H	H	H	H	H	H	H	L	H	L	H	L

Table 6: Cost and Benefit Analysis by Type of Standard

attend the committee meetings. Assigning costs for the nation state is quite difficult. To do this properly requires some concept of national investment in a standard, efficiency losses for *not* having a standard, and the actual direct expenditures of government. This is quite difficult to assess accurately, but is most likely to be high across the board.

It is also important to briefly discuss what is labelled as "benefits" in Table 6. The benefits presented in Table 5 were *net* benefits, that is, benefits beyond costs. Thus, in a sense, costs are considered twice. The other factor that must be considered is the "specificity" of the benefits. That is, are the benefits of the standard easily identifiable to developers (specific) or are they less realizable in particular products (diffuse)? An example of a diffuse benefit would be the benefits attributable to a reference model. Firms that contributed to the development of the OSI reference model could not ship products containing the reference model. Benefits would exist, however, because the *structure* of different vendors' data communications systems would be similar, allowing for easier interoperation. Furthermore, if a developer of the reference model intended to develop subsequent base or syntax standards consistent with the reference model, presumably this development would be expedited because a framework for the base standards would exist. Hence, diffuse benefits do not imply absence of benefits; diffuse benefits merely imply difficulty in *measuring* benefits, which can reduce the *apparent* benefit.

To identify areas that might be fruitful for alternative funding approaches, it is appropriate to examine those where the development costs are high but the net benefits are low to medium. Examining Table 6, it is clear that reference standards fit that category, as do traditional syntax standards, traditional base standards, and implementation standards. It is also clear that sponsoring SDOs must be provided some form of compensation for the development of high-benefit standards. These standards are likely candidates for adoption by other SDOs; while this is a good thing from the standpoint of public policy, it is something that must be addressed on the compensation side to ensure the continual development of high benefit standards.

Before policy decisions are made, it is necessary to validate the authors' assessment of the

relative magnitudes of costs and benefits for various types of standards. This framework may be used to collect data on a large enough sample of standards that predictions of actual costs and benefits can be made with a degree of confidence. Because of the distributed private nature of the funding, it is difficult to quantify the costs–no one wishes to be the first to acknowledge the cost[13]. A thorough analysis of the costs and benefits will, we believe, lead to a less charged and more productive discussion of alternative structures and funding for standards setting in the United States in a era of rapid change in a global economy. We can then begin to consider experiments that will allow us to compare actual standards provision behavior with hypothesized under-provision of standards. If we are able to show that some standards are under-provided, then we can consider alternatives for financing these socially desirable standards. Below, we examine the current approach to funding standardization and suggest two possible modifications, one based on a "standards fee" and the other based on government funding.

An Analysis of the Present Approach to Standardization

Under the current system (in the United States), the costs are borne privately, but not necessarily in proportion to the benefits. It is possible for firms to free ride and still have access to the public good[14]. Nonetheless the current system attempts to recover administrative costs through profits on the sale of standards documents. Anyone who purchases the document subsidizes the system, even though those who incur the bulk of the cost–the developers–are not reimbursed directly for their investment except through the sale of products, licensing fees, and consulting fees, as described above.

The major advantage of this approach to financing standards is that those who stand to gain the most from a standard have the strongest incentive to contribute at the highest level. Thus, the system naturally allocates the development costs among the potential beneficiaries. In terms of the model proposed above, the weaknesses of the current system include:

1. If no firm anticipates a significant benefit, then the standard will not be developed, despite the social benefit of having the standard. This is particularly problematic for standards or standards-related activities where the benefit is less tangible, such as reference standards, long range planning, and executive functions.

2. The firms act on *expected* benefits. If their expectations are wrong because of delays in implementation of the standard (as with ISDN), because of free riders, or for other reasons, then the firm may be less willing to invest in standards development in the future.

3. Due to network and public good effects, the benefits of the standard may be distributed disproportionately to the costs incurred to develop it. This results in a net welfare loss to society if the standard is not developed.

4. Recovering the cost of standards development via document sales leads to competition among SDOs instead of coordination [29]. As the cost of the standards documents increase,

[13]One way to view consortia is as an effort to exclude from the benefits of standardization those who are not willing to pay the costs. Thus, the high cost of consortia membership may be viewed as a cheaper alternative than the cost of participating in the traditional SDO process.

[14]For example, a firm could refuse to pay membership fees to the SDOs and still participate in the process. SDOs are afraid of limiting participation because of the antitrust liabilities raised in the Hydrolevel vs. ASME case.

the dissemination of the standard decreases. Thus, it is not clear that the benefits of standards are completely realized[15].

5. There is no central authority for coordinating the efforts of the various SDOs. While the Information Systems Standards Board of ANSI makes an effort to avoid and resolve disputes between various SDOs, this does not coordinate strategic planning for the various SDOs, nor does it serve to coordinate submissions to the various SDOs. Thus, planning and requirements analysis are carried out in a vacuum.

6. The conformance test development, certification, and registry functions are not directly accounted for in the model. While an SDO produces the standard, other organizations are responsible for developing test suites. For example, in the case of POSIX, while the base standard is developed by the IEEE, conformance tests have been developed by National Institute for Standards and Technology and X/OPEN. The situation is complicated further by the fact that certification of conformance in accord with the suites may be by the developer under self certification, or by yet another party–an accredited certification agency such as Corporation for Open Systems. In a simple world, such an arrangement might be workable. In the real world, the development of conformance test suites may uncover errors in the standard, and the certification process may mandate changes to both the standard and the conformance tests. All of this requires cross-organizational communication under the current model and greatly increases the total cost (see Cashin [7]).

7. Perhaps more disturbing from a national point of view, dissemination of standards is driven by market demand. There is no coordinated effort to "sell" a given approach. This is particularly important for anticipatory standards, which are at heart marketing devices. This attitude is changing, and one sees encouraging developments in the telecommunications field (see Matute [21]). At the same time, important standards in the IT arena continue to languish in part for lack of marketing effort. SGML serves as one example in this area (for a discussion of SGML's development and adoption, see Adler [1]).

These shortcomings may be overcome in part by establishing additional mechanisms for funding standards. By imposing a "standards fee" or tax, those using products that rely on the standard would finance its development. In some ways, this approach attempts to recoup the cost of intellectual property embodied in the standards. While this may be conceptually sensible, significant distributional problems exist. A more extreme approach recognizes that standards are a public good, and would use public funds collected through general taxation to pay for the process, as is done in some countries. This approach relies on the taxation system for fairness and appropriate cost allocation.

In the standards fee approach, each product conforming to a standard would be subject to a surcharge to assist in the recovery of the cost of developing the standard(s) on which it is based. The fee would be collected and distributed to all developers of the standard until the costs that they incurred in developing the standard were covered. Thus, standards development is funded directly by users, as it is today, except that free riders' products would not be exempt from

[15] A common argument in the Internet community today is that the success of IETF standards is at least in part attributable to the low cost of obtaining these standards.

the cost of developing the standard. Thus, the cost differential of developers' and free riders' products would be based solely on the underlying production costs and not on the existence or absence of standards development costs. While this addresses the issue of the free ridership, it would require the development of guidelines to insure that fees are distributed in an equitable fashion. Further, policy would be required to balance and distribute the fees from widely adopted, profitable standards among those that are less profitable.

One can also make a case for direct government financing. Garcia [13, 14] has studied the role of government in standards at some length. In [13], she argued that the current standards process had its roots in the early 1900s, and reflects the market realities of that time, as well as the pluralistic tradition of the United States In [14], she argued for the rationality of a stronger government role in U.S. standards setting given the present market realities. In particular, she pointed out that:

- It is well known that all economic transactions have *transaction costs* associated with them [37]. Standards can reduce transaction costs, so government involvement to ensure an adequate supply of standards (that is, to ensure that they are not under-provided by our current market-based approach) results in increased economic efficiency, which generally meets economic and social goals.

- The lack of an active, coordinated standards development strategy could be a disadvantage vis-a-vis our competitors who have such a strategy. By failing to set the standards-setting agenda, we can be at a disadvantage in global markets, which reduces our overall competitiveness as a nation.

- The failure to support standards development processes in emerging economies, such as Mexico, India, and China, even as our most significant trading partners are doing so, leaves the United States at a significant future disadvantage in potentially important markets.

None of this addresses the role of government as a *financier* of the standards process. Garcia tends to argue that government should take a more active role in coordinating the activities of various organizations, and perhaps in setting the agenda for them, but stops short of proposing and analyzing a government-funded standards development process. What effect would government financing of the standards process have? How would it be carried out? These are but a few of the questions that emerge as such a proposal is considered.

In this approach, standards are viewed as a public good, and broadly based government revenues are used to reimburse the developers of standards. This can be done either through direct payments or through tax credits. While this is the standard approach to financing public goods, it is potentially distortive because it is not sector specific. That is, everyone's taxes contribute to finance standards even if someone never makes use of a standard, either directly or indirectly. The difficulties that were raised in the previous section apply as well.

This is the approach, indirectly, taken by ETSI. In ETSI, *paid* standards developers are used to accelerate the development of a standard (as was noted above). The money for this expense comes from member countries, hence from a general tax levied on the citizens for the standards development process. Thus, this approach is not without precedent.

Summary

We have presented a preliminary framework for considering standards financing. Clearly much work must still be done in this area, particularly to establish an empirical basis for the conclusions. Nonetheless, it seems that some alternative financing mechanism must be found for some types of standards, lest they be under-provided. We have proposed two alternative financing mechanisms as a basis for the continuing discussion in this area. While the details must still be worked out for both of the alternatives, we believe that they would solve the under-provision problem, even though they might raise other problems.

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