Interorganizational System Standards Diffusion: The Role of Industry-based Standards Development Organizations

Matthew L. Nelson
Illinois State University
College of Business
Campus Box 5520
426D Stevenson Hall
Normal, IL 61790-5520
Phone: (309) 661-9140
Fax: (309) 661-9140
mlnelso@ilstu.edu

Michael J. Shaw
University of Illinois
Department of Business Admin
2051 Beckman Institute
405 North Mathews Avenue
Urbana, IL 61801
Phone: (217) 244-1266
Fax: (217) 244-8371
mjshaw@uiuc.edu

ABSTRACT

Integrating cross-company business process standards in an interorganizational system (IOS) context is an emerging phenomenon on several business fronts. The practice is viewed as an enabler towards solidifying business to business connections, streamlining cross-company processes and providing a foundation for web-services. Although the practice is not new, most notably electronic data interchange (EDI) with X12 standards, recent technological innovations have enabled the emergence of IOS standards that are web-enabled, modular, scaleable, cost efficient, and structured around cross-company business process standards. Despite their inherent benefits, the adoption and diffusion of web-based IOS standards has been an extraordinary challenge throughout many industrial groups. This paper examines the diffusion of interorganizational system standards among members of industrial groups where an IOS standards development organization (SDO) exists. A conceptual innovation diffusion model is developed as a basis to understand the factors, determinants and consequences concerning the diffusion of IOS standards. The innovation - organizational - environmental (IOE) lens is employed in the research design and extended to include attributes associated with the SDO and cross-company business processes. The diffusion process is examined through three stages: adoption, deployment, and assimilation. An empirical study is conducted based on cross-sectional surveys of 102 firms from 10 industrial groups encompassing 15 SDOs. During the adoption stage, the determinants were found to be; top management support, feasibility, technology conversion, competitive pressure, SDO participation level, and architecture. During the deployment stage the determinants were found to be; feasibility, competitive pressure, SDO participation level, compatibility, shared business process attributes, architecture and governance. We also examine industrial coordination of the IOS standards development process, consequences of diffusion, and SDO governance and management practices.

KEYWORDS: Interorganizational system standards, Standards Development Organizations, IOS diffusion, industrial group interoperability

* An earlier version of this paper was presented at the *MISQ Special Issue Workshop: Standard Making: A Critical Research Frontier for Information Systems* in Seattle, WA in December 2003.

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INTRODUCTION

The integration of interorganizational business process standards with information technology is an emerging phenomenon across several business fronts. The practice solidifies business to business connections (including EDI) and provides a basis for streamlining cross-company business processes as the "next great frontier for reducing costs, enhancing quality, and speeding operations." (Hammer 2001, page 84). Strategically, the practice is an enabler towards outsourcing (Willet 2004), co-opetition, and pie expansion (Jap 1999). Fundamentally, the practice is viewed as laying the foundation for web-services (Hagel and Brown 2001, Koch 2003) and the building blocks toward the semantic web (Berners-Lee 2001).

Recent technological innovations that permit integration of interorganizational business process standards with information technology include eXtensible Markup Language (XML), Simple Object Access Protocols (SOAP), Web Services Description Language (WSDL) and other application programming interfaces (APIs). This grouping of related innovations, with the addition of Universal Description Discovery and Integration (UDDI), are considered key components of web-services (Hagel and Brown 2001, Koch 2003) and when utilized in an interorganizational system (IOS) context, have profound benefits for members of an industrial group. A fuller breadth of members will finally share in the interoperability capabilities with the rest of the industrial group (including industry action groups, smaller down-stream suppliers, research centers, and many others). Rather than piecemeals of interoperability in certain business segments (e.g. purchase orders or inventories), a broader scope of interoperability capabilities will be possible (engineering, R&D, manufacturing, and beyond). Rather than small portions of information exchanges within a business segment (e.g. goods manufactured), a richer depth of task-level interoperability capabilities will be enabled (production actual versus forecasts, work in progress, spoilage, etc.).

Despite the benefits of industry-wide interoperability, the diffusion of IOS standards among members of an industrial group is proving to be an extraordinary challenge. Although the W3C officially approved XML in 1998, the actual deployments of IOS solutions (utilizing the technology innovations identified above) are a mere fraction of the total end-to-end connections

possible. The reasons are vast and growing in complexity. Intuitively, if a firm's trading partners fail to mutually co-adopt IOS standards few benefits will be gained. Some firms with a large electronic data interchange (EDI) installed base are reluctant to quickly embrace modern-day IOS solutions. They understand the benefits, but the cascading effect of updating back-end legacy systems (and the underlying business processes) for IOS standards that *may* or *may not* reach critical mass is a high-risk proposition. Other industrial groups, such as the marine industry, are intentionally timing the launch of IOS standards development efforts to reap lessons learned and best-practices from early adopter industries. Small to medium sized firms that serve customers from a variety of industrial groups are quick to adopt, but slow to deploy new IOS standards. Due to their size, they have the versatility to participate in a variety of IOS standards development initiatives, but are often forced to *hedge their bets* on which standards will take hold on a cross-industry (horizontal) basis. Many firms are in a wait-n-see mode, to see how others will move. Meanwhile, competitive pressures are mounting. Industry leading firms are beginning to include sunset clauses associated with EDI-based solutions into supplier contracts. Firms must demonstrate their web-services architecture is in place and avoid a *missing link* label towards enabling industry-wide interoperability.

What practices are used to develop and deploy IOS standards throughout an industrial group? What are the antecedent conditions leading towards greater adoption and deployment of IOS standards? What are the consequences of deploying IOS standards? By segmenting diffusion into a multi-stage process (adoption, deployment and assimilation), this study seeks to address these research questions and identify the significant antecedent conditions towards IOS standards diffusion among members of an industrial group where an IOS standards development organization (SDO) exists. Fundamentally, this paper is intended to introduce the need for bridging the research gap between prior studies in IOS diffusion (based predominantly on EDI) versus web-based IOS standards.

The paper is organized as follows. First a brief background is provided regarding the hierarchy of information technology standards organizations, including identification of the IOS standards development process based on a synthesized review of fifteen SDOs. Then a conceptual model of IOS standards adoption and diffusion is proposed. Theoretical support and definitions are provided for the measurement variables, diffusion measures and hypotheses comprehended in this study. The next section describes the research setting, methodology and design of the firm-level cross-sectional surveys. After presenting the results of the empirical

study, the main research findings are discussed. Implications concerning industrial group coordination of IOS standards and recommendations for future lines of inquiry are provided throughout.

DEVELOPMENTS IN INTERORGANIZATIONAL SYSTEM (IOS) STANDARDS

The diffusion of interorganizational systems has been examined from several perspectives. From a technological perspective, researchers have examined the diffusion of proprietary IOS solutions (Grover 1993; Zaheer and Venkatraman 1994), customer-orientated IOS (COIS) (Cavaye 1996), web and e-commerce technologies (Chatterjee, Grewal, Sambamurthy 2002; Gosain 2001; Zhu, Kraemer and Xu 2002), EDI and EDI-like technologies (Saunders and Clark 1992; Reekers and Smithson 1994; Iacovou, Benbasat, and Dexter 1995; Massetti and Zmud 1996; Premkumar, Ramamurthy, and Nilakanta 1994; Premkumar and Ramamurthy 1995, 1997; Crook and Kumar 1998; Teo, Wei, and Benbasat 2003), telecommunication technologies (Grover and Goslar 1993; Sabherwal and Vijayasarathy 1994; Kettinger and Grover 1997) and open systems (Chau and Tam 1997). Researchers have utilized a variety of theoretical frameworks to examine the diffusion of IOS innovations, including grounded theory (Crook and Kumar 1998), mimetic, coercive and normative pressures (Teo, Wei, and Benbasat 2003), power and trust (Hart and Saunders 1997), resource dependency (Reekers and Smithson 1994), the structuration theory of assimilation (Chatterjee, Grewal, Sambamurthy 2002), and the innovation-organizational-environmental framework (Saunders and Clark 1992; Grover and Goslar 1993; Chau and Tam 1997; Iacovou, Benbasat, and Dexter 1995; Premkumar and Ramamurthy 1995; Zhu, Kraemer and Xu 2002).

For purposes of this study, the *innovation-organizational-environmental* (IOE) framework was determined to be the most appropriate starting point. With its origins based on Roger's *Diffusions of Innovations* (1995) the framework has the benefit of generalizeable in its use across a diverse set of disciplines (agriculture, natural sciences, education, and many others). The framework is particularly beneficial in exploratory research with *pre-hoc* studies (prior to widespread adoption of an innovation). The framework provides a theoretical basis of potential determinants of diffusion, regardless of the type of innovation. Thus setting the stage for context specific and longitudinal considerations with a more 'finely tuned' set of apriori antecedent conditions as the innovation reaches greater levels of diffusion.

Furthermore, the IOE framework has proven to be effective in prior technology diffusion studies. The *innovation-organizational-environmental* framework is one of the most widely used frameworks in prior IOS diffusion studies [1]. As with other disciplines in the study of innovation diffusion, IOS diffusion research seeks to examine the diffusion of newer IOS technologies, understand assimilation gaps, predict the adoption of other technologies, and equip practitioners with potential tools and skills to better manage the diffusion process. IOS diffusion research has provided insights for researchers and managers a like. Premkumar and Ramamurthy found that *competitive pressure, exercised power, top management support* and *internal need* were key factors differentiating between proactive adopters of EDI versus reactive adopters of EDI (1995). Grover and Goslar studied a grouping of telecommunication technologies and found that *environmental uncertainty* and decentralized decision making showed significant relationships with usage (1993). In Iacovou, Benbasat, and Dexter's study of EDI adoption in small organizations, the authors differentiated between organizational readiness attributes associated with EDI adoption and suggested techniques to EDI initiators to reduce resistance (1995).

Although the *innovation-organizational-environmental* framework provides a foundation to begin a study, key components are lacking in light of emerging trends in the IOS standards context. First, no known diffusion studies have comprehended the grouping of related technologies used in web-based IOS standards (XML, SOAP, WSDL and other APIs). Researchers have conducted diffusion studies related to web and e-commerce technologies (Chatterjee, Grewal, Sambamurthy 2002; Gosain 2001; Zhu, Kraemer and Xu 2002). The fuller breadth, broader scope, and richer depths enabled by web-based IOS standards bring new industry wide interoperability challenges. Chau and Tam (1997) studied the adoption of open-systems, which the authors defined to be a Type 1b internal IS innovation that result in only 'weak order' effects on end-users and / or the underlying business process (Swanson 1994). The group of technologies in our study can be considered Type III (combined) innovations that are centered around core work processes, tightly integrated with the shared business processes throughout the supply chain and able to be extended to the firm's basic business products and services (Swanson 1994). Which raises the second component, little research has examined attributes associated with cross-company business processes (also referred to as shared business processes) as possible antecedent conditions of IOS diffusion. Although several researchers have examined IOS diffusion across business processes (Premkumar, Ramamurthy, and Nilakanta 1994; Iacovou, Benbasat, and Dexter 1995; Premkumar and Ramamurthy 1995; Kettinger and Grover 1997; Crook and Kumar 1998; Chatterjee, Grewal, Sambamurthy 2002).

Industrial group members maintain an industry-wide data dictionary, collaboratively develop semantic XML standards and structure IOS standards around discretely defined cross-company business processes. Modularity, scalability, and interorganizational business process reengineering have become embedded in modern-day IOS development. Finally, the third component is the role of an industry-based standards development organization (SDO) in the study of IOS diffusion. As described by Swanson (1994), found by Teo, Wei, and Benbasat (2003) and anticipated by others (Grover 1993; Premkumar and Ramamurthy 1995), industry-based SDO's have emerged to play an increasingly important role in the development and diffusion of IOS standards.

Industry-based Standards Development Organizations (SDO)

To briefly distinguish between the tiers of organizations influencing IOS standards (and to pinpoint the type of SDO in consideration for this study), the Internet Engineering Task Force (IETF) develops bit-orientated standards for the Internet. The World Wide Web Consortium (W3C) develops syntactic standards (that ride atop of the IETF's standards) for the World Wide Web (HTML, XML, etc.). The International Organization for Standardization (ISO) is described to have a top-down or structuralist approach with standards development (Libicki 2000). Structuralist-based SDOs develop comprehensive sets of standards in hopes of encompassing current and future endeavors in relation to their constructs. Industry-based SDO's, on the other hand, are depicted as minimalist towards their standards development activities. Minimalist-based SDO's develop standards in small sub-sets (*develop a little, test a little*) and only after there's a sufficient and demonstrated need for the standard by the targeted user group(s). Development of specific semantic standards is the scope of consortia organizations that either have a horizontal (cross-industry) or vertical (industry group) focus. ANSI X12 and OASIS are two of the most publicized horizontally focused (cross-industry) SDOs. ANSI developed X12 standards for formatting EDI business messages and OASIS is developing ebXML and UBL for the formatting of XML-based business messages. Industry focused SDO organizations include RosettaNet, papiNet, CIDX, PIDX, and many others and are the type of SDO under examination in this paper.

Appendix A provides a comparison of fifteen industry-based SDOs. Despite variations in membership size, year incepted, completed messages, and message types many similarities remain. Participation in the SDO is voluntary, the IOS standards are made freely available to the public, they have a non-profit orientation, and decision making is consensus driven (typically

based on voting rights associated with membership type). In addition, SDO members include stakeholders from the extended industrial group (producers, distributors, small and medium sized firms, non-profit industry interests groups, university research centers, governmental units and others). With levels of cooperation rarely witnessed, industrial group members are jointly decomposing cross company business processes into task-level interoperability needs between organizations. They are agreeing on common sets of parameters that enable choreographing cross company processes that are in compliance with contractual agreements, industry practices, governmental regulations and technical requirements. If inconsistencies or inefficiencies are detected, consensus is reached and the processes are reengineered. Utilizing an industry-wide data dictionary, they are developing common sets of business terms, definitions and forms. By integrating these process standards with recent technological innovations (XML, WSDL, SOAP and other APIs) industrial groups are developing a comprehensive set of interorganizational system standards structured around discrete cross company business processes (referred to as IOS standards).

IOS Standards Development Process

Based on a synthesized understanding from several SDOs, the IOS standards development process works as follows: (1) Develop and maintain an overarching data model for the industrial group. (2) Choreograph business data flows and modularize these flows into shared business processes that need to occur between partners. (3) Reach consensus and prioritize which shared business processes will be documented, standardized and the associated timing. (4) Standardize and document the common business fields, terms and definitions, including the development of document type definitions (DTD), XML messages and ISO compliance checks. A discrete (modularized) shared business process that has completed step four is commonly referred to as a completed *message* in industry. Upon completion of the initial version of a message, they proceed through development with (5) Testing & Reviews, (6) Deployments and (7) Certifications and Compliance.

An illustration of this can be briefly explained in the chemical industry. CIDX is a non-profit SDO for the chemical industry. In late 2000, CIDX members voted to ratify new by-laws thereby broadening and transforming the association into a neutral standards body focused on improving the ease, speed and cost of transacting business electronically between chemical companies and their trading partners. CIDX membership is voluntary, the standards development process is consensus-driven, the technology standards are platform independent,

vendor neutral and are based on open standards (made freely available to the public). As of August 2003, CIDX had 75 member firms and had developed IOS standards for 52 messages ranging from *Order Create, Qualification Requests,* and *Quality Testing Report*. The 52 messages are grouped into 8 broader functional categories (*Customer, Catalog and RFQ, Purchase Order, Logistics, Financials, Forecasting, Exchange Interactions,* and *Product Information*). The SDO provides a strict hierarchy of guidelines to following when formalizing their IOS standards. Each message has a DTD (document type definition) with a hierarchy of messaging guidelines, structure guidelines, and data element guidelines that must be adhered to. Each DTD provides compliance with ISO related guidelines (e.g. ISO 8601 is a format for structuring date and time elements, ISO 639-1 is the two-character language code and ISO 639-2/T is the three-character code). In addition, developers provide a corresponding set of sample XML messages for each of the 52 DTDs. Although the messages are modularized around discrete shared business processes, a single data dictionary is used throughout CIDX to insure consistent use and interpretation of business terms, data types, data lengths, definitions, synonyms and so on throughout their current (and forthcoming) messages.

This scenario is not unique to the chemical industry. RosettaNet develops IOS standards for the semiconductor and IT industries. Their focus on standardized shared business processes (i.e. messages) in RosettaNet are referred to as PIPs® (Partner Interface Processes) and examples include *Request PO, Ship from stock and Debit, Request Quote*, and 50 others (Nelson, et. al. 2002). HR-XML develops IOS standards for the human resources industry (e.g. *Background Checking, Benefits Enrollment* and 26 others). Open GIS develops IOS standards for the geo-spatial industry (e.g. *Image Coordinate Transformation Specification, Geography Markup Language* and 31 others). In fact, *XML.org* (a portal that acts as a registry for XML-based IOS standards) had registered submissions from 42 different industrial groups as of August 2003.

Collectively, the existence of this phenomenon represents a significant change in the development and diffusion of IOS standards. Modern-day IOS solutions are open standards-based, collaboratively developed, structured around narrowly defined cross-company business processes and able to be distributed via the web. Compared with EDI solutions from the past, the notions of modularity, scalability, open-source code and interorganizational business process reengineering are embedded in modern-day IOS development. What are the

antecedent conditions leading towards greater adoption and deployment of IOS standards? What are the consequences of deploying IOS standards?

RESEARCH MODEL

The intent of this study is to address these research questions by examining the diffusion of IOS standards throughout an industrial group. This scope is defined to include the diffusion of information technology standards innovations used strictly in an *interorganizational system* context. The innovations are a grouping of related technologies that include XML, SOAP, WSDL and other APIs (referred to as the IOS technology standards grouping). Although this grouping is considered to provide the key components underlying web-services, the *commonly accepted* notion of web-services entails a greater breadth of services than comprehended in this study (e.g. data storage services, application service providers) (Hagel and Brown 2001; Koch 2003). Thus, this study's focus is on the diffusion of the IOS technology standards grouping in a business to business, *interorganizational system* context, among members of an industrial group where an SDO exists.

This study will introduce a conceptual IOS standards diffusion model, empirically compare the model in a real work environment and report the findings. The unit of analysis is the firm. Based on the framework described above, Figure 1 contains the proposed conceptual IOS Standards Diffusion model. The measurement variables are grouped into four constructs and are defined below (*organizational readiness, innovation attributes, external environmental* and the *SDO*). The dependent variables correspond to the three stages of IOS standards diffusion (adoption, deployment and assimilation). The same conceptual model (including all measurement variables) is used for all three stages. The only variation is alternating the dependent variable (adoption, deployment versus assimilation). Although statistical results are provided for all three IOS diffusion stages, formal hypotheses are constructed and empirically tested for the first two stages only (adoption and deployment). As this study is exploratory in nature with respect to the assimilation stage, the results will provide insights into antecedent conditions of IOS standards assimilation and set the stage for future longitudinal considerations (e.g. from three perspectives volume, diversity and breadth as recommended by Massetti and Zmud (1996)).

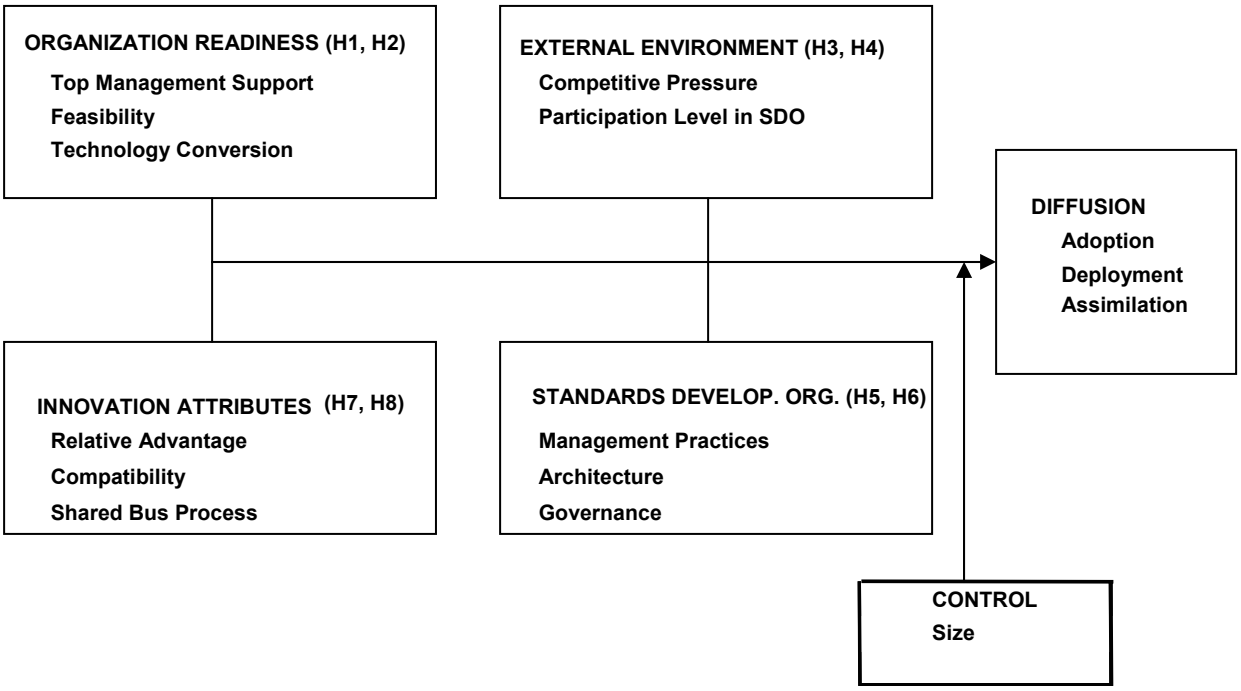


Figure 1. IOS Standards Diffusion Conceptual Model

The IOS diffusion stages are treated as the dependent variables in the model and include *adoption, deployment* and *assimilation*. *Adoption* is a dichotomous variable and indicates whether the firm has reached a decision ('yes' or 'no') to begin utilizing the IOS standards technology grouping in an interorganizational system context. *Deployment* is a dichotomous variable and indicates whether a firm has actually implemented the IOS standards technology grouping in an interorganizational system context. *Assimilation* is based on a modified version of the Guttman scale with seven levels of IOS standards technology assimilation levels is used (0-unaware to 7-general deployment). Structuring the conceptual model in this multi-stage fashion provides the ability to isolate the effects of measurement variables on the three dependent variables. Distinguishing between adoption versus deployment is advocated in situations where significant assimilation gaps are likely to exist (Fichman and Kemerer 1999). Assimilation gaps (large time differences between adopting a new technology versus deployment of the new technology) have been found to exist when a technology is susceptible to network externalities and knowledge barriers (Fichman and Kemerer 1999). The nature of IOS standards is such that, if a firm's trading partners fail to mutually co-adopt the standards, few benefits will be gained. Structuring the conceptual model in this fashion also enables enhanced understanding of industrial group level coordination of IOS standards (Johnston and Gregor 2000).

Organizational Readiness

The organizational readiness construct captures firm level attributes of the organization that assess the overall readiness of the firm towards diffusing the innovations. Assessing an organization's readiness is a fundamental and necessary step prior to launching a new information systems development project (Hoffer, George and Valacich 2002). This step is particularly relevant when an organization is considering the use of IOS standards with external trading partners. Compared with other technologies, the effective diffusion of IOS standards are an outward manifestation of an organization's ability to plan, commit and execute according to requirements established with external trading partners. This requires evaluating top management's support, financial and technical feasibility (Iacovou, Benbasat, and Dexter 1995) and the type technology that the organization is converting from. Top management's leadership and support will be essential for successful involvement in IOS standards diffusion. The risk of failure could have far reaching impact into supplier contracts, customer contracts and the organization's reputation in the industry. Examples of top management support include the commitment of resources (human and capital) and the existence of a project champion who is enthusiastic, willing and capable to act as the organization's focal point (Premkumar and Ramamurthy 1995; Grover 1993; Chatterjee, Grewal, Sambamurthy 2002). Financial feasibility may include conducting cost-benefit analysis, forecasting total cash expenditures, and estimating the indirect impact of the new technology (product costs, process re-engineering efforts, etc.). Likewise, technical feasibility may include assessing skill sets of the IS staff, identifying infrastructure enhancements necessary to accommodate the new technology, and evaluating and prioritizing which shared business processes should be automated.

> **Hypothesis (H1):** *Organizational Readiness attributes will have a positive (and significant) relationship with IOS standards adoption.*
>
> **Hypothesis (H2):** *Organizational Readiness attributes will have a positive (and significant) relationship with IOS standards deployment.*

External Environment

Intuitively, the external environment should be considered a potential significant factor in the diffusion of IOS standards. External environment variables such as *competitive pressure*, *partner power*, and *market uncertainty* have evolved as common determinants towards IOS adoption (Iacovou, Benbasat, and Dexter 1995; Premkumar, Ramamurthy and Crum 1997; Zhu, Kraemer and Xu 2002). Since, the majority of prior IOS diffusion studies were conducted using

EDI or EDI-like technology the overall 'pressure' to adopt IOS technology was primarily from one or two dominant firms[1]. In the current business climate (where co-opetition is evolving towards the industrial-group level) perceived pressure on a firm to adopt IOS standards may be felt from the entire industry (as opposed to a single firm). Thus when comparing the present study to prior IOS diffusion models, the notion of *partner power* has been dropped and competitive pressure is anticipated to be greater. In addition, expectations of market trends is considered and its' definition is consistent with Cho's, "Expectation for market trend is the degree of expectation that the target technology will be pervasively adopted in the industry in the future" (Cho and Kim 2002, page 130). Furthermore, participation levels in an industry-based SDO are anticipated to be a significant influence (Teo, Wei, and Benbasat 2003). Participation levels in an SDO can manifest through several means (e.g. participating in development activities, becoming a member, or implementing their IOS standards).

> **Hypothesis (H3)**. *The external environment attributes will have a positive (and significant) relationship with the IOS standards adoption.*
>
> **Hypothesis (H4)**. *The external environment attributes will have a positive relationship with the deployment of IOS standards. Participation levels in an SDO will have significant relationship towards IOS standards deployment.*

Standards Development Organization (SDO)

The SDO construct examines attributes of the SDO and its' potential influence towards diffusion of the innovations. The role of an SDO has emerged as pivotal in the development of IOS standards. Industrial groups are viewing an SDO as a moderator in the collaboration process, an enabler towards generating cost savings through leveraged development efforts, and as a means towards integrating 'best-in-class' IOS standards. Since this construct has rarely been used in prior IOS diffusion studies, a survey of critical success factors in alliance organizations was conducted to develop an SDO role continuum. This continuum provides criteria to evaluate the SDO with respect to its' organizational attributes and impact on the target technology's diffusion. Components of this role continuum include SDO management practices such as collaboration mechanisms, ability to meet performance expectations, problem resolution techniques, and clarity of goals and objectives (Monczka, Petersen, and Handfield 1998; Whipple and Frankel 2000). IOS architecture attributes include modularity levels and compatibility with business processes. IOS governance includes attributes related to the structure of the SDO, non-profit status, and objectives of the SDO. IOS diffusion researchers

have recommended examining the role of an IOS standards alliance organization (Premkumar and Ramamurthy 1995; Grover 1993).

Hypothesis (H5). *SDO attributes will have a positive relationship with IOS standards adoption. Governance and Architecture will also have a significant relationship towards IOS standards adoption*.

Hypothesis (H6). *SDO attributes will have a positive (and significant) relationship with IOS standards deployment.*

Innovation Attributes

Attributes associated with the innovation itself are some of the most frequently tested and significant variables in diffusion models (Rogers 1995; Tornatzky and Klein1982). IOS diffusion is no exception with attributes such as *relative advantage, cost* and *compatibility* of the technology as some of the most frequent determinants towards IOS diffusion. This study has three components of IOS technology attributes that include compatibility, relative advantage and shared business process attributes. Compatibility assesses the compatibility of the IOS solution with the organization's IS infrastructure and work procedure needs of the firm. Relative advantage is defined as the extent to which a potential adopting organization views the innovation as offering direct financial and operational benefits over previous ways of performing the same tasks. Since the relative cost to benefits of the innovation is comprehended in this definition, the direct 'cost' of the technology is not isolated as a separate measurement variable. Attributes associated with the underlying shared business process are also examined. Characteristics of the shared business process such as required response times, required exchange volumes, exchange frequency, consistent field terminology and business definitions are all attributes that may influence an organizations decision to implement IOS standards.

Hypothesis (H7). *Innovation attributes will have a positive relationship with IOS standards adoption. Relative Advantage and / or Shared Business Process attributes will also have a significant relationship towards IOS standards adoption.*

Hypothesis (H8). *Innovation attributes will have a positive (and significant) relationship with IOS standards deployment.*

RESEARCH SETTING AND METHOD

The final research design selected for this study was the culmination of a two-year development effort. The preliminary work began with a detailed examination of a single implementation instance of IOS standards between a distributor and manufacturer in the electronic components industry. This provided insight into the technology under study, the use of interoperability standards and the mutual operational and economic benefits to firms on each side of the IOS. The number one challenge identified by participants in the study was adoption. That is, how to encourage other partner firms to co-adopt IOS standards developed by their industry's SDO. These findings fueled the development of an initial conceptual IOS standards adoption model and survey instrument. This first pre-test of the instrument was administered to eight firms (encompassing four different IOS solutions) from a single industrial group. The results shed light on the pivotal role of an SDO, performance measures for assessing consequences of diffusion and qualitative insights into constructs that influence the diffusion process and how the mixture of these constructs may vary with diffusion levels. The first pre-test resulted in several changes (improvements) to the survey instrument and all responses were dropped. The second pre-test was conducted with ten firms from three industrial groups and resulted in only minor changes to the survey instrument (item sequence and minor phrase changes to better enable cross-sectional understanding). Responses from the second pre-test were retained. Add to these insights the results of literature survey work in alliance organizations and IOS diffusion, and the following research design was crafted [2].

A cross-sectional firm level survey was conducted to empirically compare the conceptual model to a real work environment and test the hypotheses. Appendix B outlines the survey structure, item counts and hypothesized impact. The sampling frame includes firms that are members of an SDO or a user of IOS standards, or who are considering the possibility of either. The organizational title associated with the targeted individual respondent from the firm is Director of IT Standards, Assistant Director of IT Standards, CIO or one of their direct reports (respectively). The identification of specific candidate firms to send surveys was a two-staged approach. First, a candidate list of all firms and SDO organizations that submitted IOS standards to the XML.org registry were identified. The XML.org registry, launched in 1999 by OASIS, was utilized since its' mission is to "provide an environment and community where technologists and businesspeople alike are encouraged to unite in the adoption of interoperability standards". XML.org acts as a portal for industries to submit IOS standards in

order to minimize overlap and duplication of efforts. As of August 2003, this portal had registered IOS standards from 46 industries and received 16,700 page views from over 4,400 visitors per day. The second stage was to identify firms that are members (or affiliated) with an SDO. In total, 979 firms were identified that fit the sampling profile. The candidate list was then reduced to exclude organizations that were developing standards for intra-organizational purposes only, duplicates, no longer in existence, or was individuals (as opposed to a firm). A total of 579 firm level surveys were distributed.

Operationalization of Variables

The survey instrument design is shown in Appendix B, which includes the constructs, survey items and item descriptions (summarized in Table 1). The survey instrument is structured in four sections (organizational, SDO, industry consequences and demographics). The organizational section includes items referring to the firm's use of the IOS technology standards grouping (strictly in an interorganizational context) and comprehends all items associated with the Organizational Readiness, External Environment, and Innovation constructs. For the SDO section of the survey, respondents were asked to consider their firms predominant SDO (one in which they were participants in, or aware of for their industrial group). The IOS standards diffusion stages are treated as the dependent variables in the model and include *adoption, deployment* and *assimilation* (as previously defined).

The Organizational Readiness construct consists of three variables: *top management support, feasibility* and *technology conversion*. Consistent with Chatterjee, et. al.'s top management participation dimension, three activity-based items are used to assess this variable; the assignment of a champion, communication of support, and active participation in developing the vision and strategy for the new technology (Chatterjee, Grewal, and Sambamurthy 2002). *Feasibility* considers financial and technical readiness. Iacovou et al, defines financial readiness as the 'financial resources available to pay for installation costs, implementation of any subsequent enhancements, and ongoing expenses during usage' (Iacovou, Benbasat, and Dexter 1995, page 469). Technical readiness is referred to as 'the level of sophistication of IT usage and IT management in an organization' (Iacovou, Benbasat, and Dexter 1995, page 469). Two survey items are used for each of these variables that request respondents to assess the firms financial and technical readiness of developing, implementing and maintaining the technology, as well as the resources to make work-flow changes to accommodate the new technology. *Technology conversion* refers to the extent of older IOS solutions (e.g. EDI or EDI-

like) installed in the firm, relative to the extent of modern-day IOS solution implementations. Based on five categories of IOS solutions (manual-based, semi-automated, EDI or EDI-like, proprietary and IOS standards) respondents were asked to indicate the extent of their firms' use of these solutions on a 5-point scale ranging from 0-for no use to 4- extensive use.

Construct	Measurement Variable	Item Measure Description
ORGANIZATIONAL READINESS	Top Management Support	- Actively participate - Assigned project champion - Effectively communicates support
	Feasibility (Financial & Technical)	- Technical sophistication to implement & maintain - Technical sophistication to make work flow changes - Financial resources to implement & maintain - Financial resources to make work flow changes
	Technology Conversion Type	- Extent of IOS solutions use (EDI, manual proprietary) - Extent of IOS solutions use (Internet-based)
INNOVATION ATTRIBUTES	Relative Advantage	- Direct operational benefits - Direct financial benefits
	Compatibility	- Required work procedure changes are consistent - Consistent w/ future vision of IS infrastructure - Compatible with existing IS infrastructure
	Shared Business Process Needs	- Enhances timeliness - Provide reliable data communications - Improve data integrity - Improve collaboration levels
EXTERNAL ENVIRONMENT	Competitive Pressure	- Meet trading partner requirements - Industrial group pressure - Firm will loose competitive edge
	Participation Level in an SDO	- SDO member status, user status, development status - Committed to implement IOS SPI next 12 months
STANDARDS DEVELOPMENT ORGANIZATION	Management Practices	- Open & honest communications - SDO meets performance expectations - Responsibilities are appropriately delegated - SDO's goals are well communicated - SDO is neutral w.r.t. to all member firms
	Architecture	- Modularity levels are appropriate - Technical standards are conducive to interoperability - Vendor neutral technical standards - Require minimal changes to business processes - Accurate and useful standards documentation
	Governance	- SDO's mission and objectives - An SDO should be a non-profit entity - SDO benefits are well understood

Table 1. Independent (Measurement) Variables used in the Study Grouped by Four Research Constructs

Two Environmental factors under consideration include *competitive pressure* and *participation level in an SDO*. *Competitive pressure* is the perceived external influence from trading partners, the industry, and the firm's potential for loosing competitive advantage (Premkumar, Ramamurthy and Crum 1997). *Participation level in an SDO* is a combination of four types of interactions that may occur between an SDO and a respondent firm. These interactions include the firm's membership status in an SDO (dichotomous with 'member' or 'non-member'), participation status in SDO developmental efforts (dichotomous with 'yes' or 'no'), user status of the SDO's IOS solutions (dichotomous with 'user' or 'non-user') and the firm's projection of whether they will implement an IOS standards in the next 12 months (on a 7-point Likert scale).

Three variables evaluate attributes of the specific Innovation under study: *relative advantage, compatibility* and characteristics of the underlying cross-company *shared business process*. The definition of *relative advantage* is the extent to which a potential adopting organization views the innovation as offering direct financial and operational benefits over previous ways of performing the same tasks (Rogers 1995). Examples of direct financial benefits include increased inventory turnover, ROI, and enhanced payback as a direct result of implementing the standards. Examples of direct operational benefits include reduced cycle times, increased throughput capability, and improved response times. *Compatibility* is measured from three perspectives: compatibility of the innovation with the firm's values and beliefs, compatibility of the innovation with the IS infrastructure and work procedure needs of the firm (Rogers 1995; Tornatzky and Klein 1982; Premkumar, Ramamurthy, and Nilakanta 1994). *Shared business process* attributes are characteristics associated with the underlying cross-company business process (e.g. transaction volume, timeliness, effectiveness, accuracy, integrity and other collaboration level needs). Due to the similarity in potential effects of *relative advantage* and *shared business process* attributes, the possibility of replacing and / or combining the two variables will be examined. Although *relative advantage* has routinely been proven to be a significant factor in technology adoption across numerous studies, the chief complaint about *relative advantage* is its lack of specificity (Tornatzky and Klein 1982). An attempt will be made to develop a set of *shared business process* attributes that are 'generic' enough to span across multiple types of business processes, yet comprehensive enough to include the theoretical support for both *relative advantage* and *shared business process* attributes.

Three measurement variables are introduced in this study in an IOS standards context regarding an industry-based SDO and include *governance, management practices,* and *architecture*. *Governance* refers to the standard development organization's intended function, structure, and manner as an IOS standards setting organization for the industrial group(s) it is intended to serve. *Governance* includes three items regarding the SDO's mission and objectives, non-for-profit status, and understanding of the industry-wide benefits. *Management practices* refers to the standard development organization's specific techniques and norms to manage, coordinate and interact as an independent alliance organization for the industrial group(s) it is intended to serve. *Management practices* includes items regarding communications effectiveness, trustworthiness, ability to meet performance expectations, neutrality to all partner organizations (no favoritism), and delegation of responsibilities (Rai, Borah and Ramaprasad 1996; Whipple and Frankel 2000). *Architecture* refers to the

information and communication technology (ICT) interoperability standards framework as managed by the SDO. *SDO architecture* includes items associated with modularity levels (message scope), conduciveness to high collaboration levels, vendor neutrality and accuracy and thoroughness of technical standards documentation.

Due to the proprietary nature of items in the consequences section (e.g. revenue trends, entry barrier assessments, anticipated ROI levels to justify IOS standards expenditures, IOS standards longevity expectations) respondents were asked to assess consequence measures with respect to their industrial group (as opposed to a specific firm). A total of 18 consequence measures were assessed by respondents for three time periods (current, mid-term and longer-term) based on time since deployment of IOS standards through out their industrial group. Each time period utilized a perception-based measure on a 5-point scale (ranging from 1 - significant decrease, 3 - no change, to 5 - significant increase).

TABLE 2 - RESPONDENT DEMOGRAPHICS

COUNTRY OF ORIGIN		INDUSTRY		ORGANIZATION TYPE	
UNITED STATES	59	GEO-SPATIAL	17	MANUFACTURER	33
UK	12	ELECTRONIC COMP	17	GEO-SPATIAL SERVICES	11
TAWAIN (ROC)	10	PETROLEUM	16	TECHNOLOGY PROVIDER	10
GERMANY	5	HUMAN RESOURCES	11	NP INDUSTRY INTEREST GROUP	9
CANADA	3	SEMI-CONDUCTOR	11	STAFFING SERVICES	8
SWITZERLAND	2	EDUCATION	8	EDUCATION	7
JAPAN	2	AUTOMOTIVE	8	ENERGY EXPLORATION	5
BELGIUM	2	PAPER	6	GOVERNMENTAL	4
NETHERLANDS	1	CHEMICAL	5	ENERGY PRODUCTION	4
AUSTRALIA	1	MARINE	3	DISTRIBUTOR	4
FRANCE	1			PRINTING / PUBLISHING	4
IRELAND	1			AUTOMOTIVE RETAIL	3
SINGAPORE	1				
FINLAND	1				
DENMARK	1				
TOTAL	102	TOTAL	102	TOTAL	102

EMPLOYEE COUNT		TRADING PARTNERS		ANNUAL BUDGET (REVENUES)	
LESS THAN 25	14	LESS THAN 25	19	LESS THAN $1 million	12
25 ~ 99	11	25 ~ 49	5	$1M ~ $9 MILLION	10
100 ~ 499	13	50 ~ 74	4	$10M ~ $49 MILLION	10
500 ~ 999	9	75 ~ 99	2	$50M ~ $99 MILLION	4
1,000 ~ 4,999	13	100 ~ 149	4	$100m ~ $499 million	12
5,000 ~ 9,999	8	150 ~ 199	4	$500M ~ $999 MILLION	7
10,000 AND GREATER	34	200 ~ 250	21	$1 BILLION OR GREATER	44
		GREATER THAN 250	43	GOVERNMENT OR N/A	3
TOTAL	102	TOTAL	102	TOTAL	102

Respondents

590 firm-level surveys were distributed with a total of 102 responses and 18 rejections received. An additional 34 firms indicated their willingness to respond but only provided partially

completed surveys (which are excluded). Multiple responses from a single firm were averaged and considered as a single response. The overall effective response rate is 17.3%.

Candidate firms were provided the option to have the survey administered via (a) paper copy through postal mail, (b) digital copy through electronic mail, or (c) conference call interview. Of the 102 respondents, three chose the paper option, 67 chose the digital option and 32 chose the interview option. Survey questions are the same regardless of the option selected by the respondent and the same individual conducted all interviews. Collectively, the firms originate from 14 countries, represent ten industrial groups, and participate in 15 SDOs. The firms can be classified into 12 organizational types, ranging from manufacturers, distributors, energy exploration / production, printers / publishers, and a host of service orientated firms (staffing, governmental, geo-spatial, and automotive retail). See Table 2 for a summary of respondent firm demographics. Contrary to some other studies, responses from technology providers and non-profit industry interest groups were retained for analysis purposes (Chatterjee, Grewal, and Sambamurthy 2002). These types of organizations fit the sampling profile for this study. In addition, most of these firms are users, implementers, or (at a minimum) stakeholders with respect to the diffusion of IOS standards throughout the industrial group.

Potential response bias was examined from three perspectives: completed surveys as percent of SDO members, non-responses as percent of surveys distributed and rejections as percent of SDO members. For larger SDO organizations (those with 75 members or more) results were consistent at the industrial group level and demonstrated no potential response, non-response or rejection bias. For smaller SDO organizations, ratios did significantly vary (up to a maximum of 51% of variation) with respect to three industrial groups. These variations were attributed to a low absolute count of participating members and the short time horizon since the inception of the industrial group's SDO. Overall, these results provided no reasons to justify further investigation into potential response, non-response or rejection bias.

Test of Factors

Content validity was qualitatively assessed through three preliminary studies, two pre-tests, and multiple reviews of the survey instrument. Content and construct validity were further qualitatively substantiated through a literature survey conducted of IOS diffusion publications including a comprehensive coding of measurement variables and significance findings[1]. This resulted in the use of the IOE framework and provided a basis for deriving seven of the 12

measurement variables and 21 of the 42 survey items. See Appendix B for descriptions of constructs, measurement variables, survey items and item descriptions (Straub 1989). Reliability of the survey instrument's items was also quantitatively validated through calculating Cronbach alphas for each measurement variable. The alphas range from .70 to .77 and are itemized in Table 3 - Reliability of Factors. Although the Chronbach alphas are lower than Straub's (1989) .8 rule-of-thumb, they are greater than Nunnally's .6 threshold. Due to the rich mix of survey items based on prior research and the introduction of new survey items pertaining to the role of the SDO, these levels are deemed appropriate for this context.

TABLE 3 - RELIABILITY OF FACTORS

		Cronbach Alpha
TopMan	3 items	0.710
Feasibility	4 items	0.734
CompPre	3 items	0.713
RelAdv	2 items	0.714
Compab	3 items	0.700
ShareBus	4 items	0.746
ManaPra	5 items	0.724
Archit	5 items	0.722
Govern	3 items	0.713

Convergent validity and discriminant validity were also quantitatively assessed through factor analysis. Principle Components Analysis was conducted for all nine multi-item factors. Out of the 32 item loadings, all but three of the survey items loaded high (>.50 threshold) in their factors. Thus, demonstrating a good degree of convergent validity. The three exceptions are discussed below. Discriminant validity was further quantitatively assessed using an item correlation matrix 'counting' technique (Chau and Tam 1997). Generally speaking, validity is established by counting the number of higher correlations outside of an item's factor and then comparing the result with the total possible number of correlations. The general rule of thumb is discriminant validity is established if the above ratio is less than 50%. Out of the 560 total possible correlations, 220 (or 39%) experienced higher correlations outside of their own variable. Thus, these results outperform the general rule of 50% and provide support of discriminant validity.

Further examination of this issue, as well as the Principle Component Analysis (PCA) reveals the following. First, one-third of the instances of higher item correlations is associated with the *compatibility* variable. Researchers have generally separated the *compatibility* variable between

values of the firm versus the innovation. This study started under that premise until preliminary PCA results indicated that one of the *compatibility* items should be either be combined or act as a stand-alone measure. It was decided to combine the measures and avoid a single-item measure. The other two-thirds of instances of higher item correlations are associated with two of the new variables introduced in this study (*management practices* and a*rchitecture*). Since this study is one of the first to provide framing of an SDO's role throughout an industrial group, it was decided to error on the side of too many items (as opposed to too few), to better enable research succession and progression. Table 4 includes the descriptive statistics

TABLE 4 - DESCRIPTIVE STATISTICS

Variable	N	Mean	Std Dev	Min	Max
TopMan	102	5.16	1.53	1	7
Feasibility	102	5.64	0.97	2	7
CompPre	102	5.26	1.27	1	7
SDOPart	102	4.29	1.20	0	5
RelAdv	102	5.15	1.17	2	7
Compab	102	3.90	0.93	0	5
ShareBus	102	5.83	0.83	2	7
ManaPra	102	5.22	0.91	3	7
Archit	102	5.38	0.80	2	7
Govern	102	5.94	0.72	3	7
TechConv	102	1.42	0.67	-1	3
AnnSales	102	4.99	2.27	1	7

RESULTS

The IOS diffusion stages are treated as the dependent variables in the model and include *adoption, deployment* and *assimilation.* Multiple logistics regression technique was chosen to test the hypotheses. The dichotomous nature of the dependent variables (adoption versus non-adoption) and (deployment versus non-deployment) would have necessarily broken assumptions of multiple regression analysis. The benefit of logistic regression is its' flexibility and ability to accommodate dichotomous and scaled (intervals) responses. The logistic function predictor variables may be quantitative, qualitative, and may represent curvature or interaction effects (Neter 1996). Maximum likelihood estimates (MLE) was used to estimate parameters of the multiple logistic response function. The consequence results are provided in Appendix C.

From the IOS Standards Adoption Stage

The distinction between adopters and non-adopters of IOS standards technology is based on responses to the 7-point technology assimilation scale (see Table 5). Responses of five, six or seven on the assimilation scale indicated that the firm adopted the innovations. Non-adopters were based on responses of four, three or two. No firms indicated their unawareness, rejection or discontinuance. Overall, there are 80 adopters and 22 non-adopters of the innovations in an IOS context.

The first three columns in Table 6 summarize the significant variables in the model's adoption stage, including the coefficients, Wald statistics and significance levels based on the multiple logistics function. In distinguishing between adopters versus non-adopters the following measurement variables were found to be significant: *top management support, feasibility, technology conversion, competitive pressure, participation level in an SDO,* and *architecture*. Thus supporting hypotheses H1 (Organizational Readiness attributes) and hypothesis H3 (External Environment attributes), and providing partial support of hypothesis H5 (with respect to the positive direction and significance of *architecture*). Hypothesis H5 is partially not supported with respect to the negative direction and lack of significance of *governance*, and the negative direction of *SDO management practices*. Hypothesis H7 is not supported due to the lack of significance of all Innovation related attributes and the negative direction of *relative advantage* and *shared business process* attributes. See Figure 2 for a summary of hypothesis test results.

TABLE 5 - RESPONDENT DIFFUSION LEVELS OF IOS STANDARDS TECHNOLOGY

		STAGE 1 - ADOPTION		STAGE 2 - DEPLOYMENT		STAGE 3 - ASSIMILATION				TOTAL
	ASSIMILATION LEVEL	Adopters	Non-Adopters	Deployers	Non-Deployers	Non-Adopter	Adopter & Non-Deploy	Ltd Deploy	Gen Deploy	
1	Unaware		0		0	0				0
2	Awareness		8		8	8				8
3	Interest		8		8	8				8
4	Evaluation / Trial		6		6	6				6
5	Commitment	22			22		22			22
6	Limited Deployment	30		30				30		30
7	General Deployment	28		28					28	28
TOTALS		80	22	58	44	22	22	30	28	102

Goodness of fit for the final model (which includes significant effects only, including main effects and interactions) is significant at the 0.1212 level on a χ^2 distribution. Utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .596. Based on the literature survey, the averaged explained variation in prior IOS diffusion studies is .31[1]. Thus this model's explained variation is significantly greater than the average for this context. The reason may be two-fold. First, the IOS diffusion literature survey resulted in the use of the IOE framework (excluding specific contextual factors) and provided a basis for deriving seven of the 12 measurement variables and 21 of the 42 survey items. Second, preliminary studies (including two pre-tests) and multiple reviews of the survey instrument were conducted prior to launching the present study.

TABLE 6 - RESULTS

CONSTRUCT	STAGE 1 - ADOPTION			STAGE 2 - DEPLOYMENT			STAGE 3 - ASSIMILATION		
Measurement Variable	Coefficient	Wald Statistic	Significance	Coefficient	Wald Statistic	Significance	Coefficient	Wald Statistic	Significance
ORGANIZATIONAL READINESS									
Top Management Support	0.849	4.959	0.026	n.s.	n.s.	n.s.	0.401	5.373	0.021
Feasibility (Fin & Tech)	1.450	6.193	0.013	0.859	5.943	0.015	0.673	5.689	0.017
Technology Conversion	2.037	5.885	0.015	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
EXTERNAL ENVIRONMENT									
Competitive Pressure	6.004	5.648	0.018	2.168	3.445	0.064	2.698	5.759	0.016
Participation Level in an SDO	7.670	6.313	0.012	3.298	5.273	0.022	3.812	7.960	0.005
INNOVATION ATTRIBUTES									
Relative Advantage	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Compatibility	n.s.	n.s.	n.s.	7.496	6.242	0.013	3.974	5.448	0.020
Shared Business Process	n.s.	n.s.	n.s.	3.764	3.934	0.047	2.141	3.138	0.077
STANDARDS DEVELOP ORG (SDO)									
Management Practices	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Architecture	1.674	5.652	0.017	0.957	5.096	0.024	0.657	4.235	0.040
Governance	n.s.	n.s.	n.s.	-1.137	5.496	0.019	-1.049	7.473	0.006
CONTROL									
Size (Annual Budget)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
MODEL FIT									
	AIC	Goodness of Fit		AIC	Goodness of Fit		AIC	Goodness of Fit	
		Dev / DF	Chi Squr / DF		Dev / DF	Chi Squr / DF		Dev / DF	Chi Squr / DF
INITIAL MODEL	71.64	0.38*	0.91	131.76	1.15	1.24	250.28	not reported	
FINAL MODEL	57.34	0.45	1.18	117.82	1.06	1.10	240.50	not reported	
FINAL MODEL SIGNIFIGANCE			0.1212		0.3195	0.2476			
		df=91	df=91		df=92	df=92			
R^2 L "% OF EXPLAINED VARIATION"			0.5960			0.2987			0.2361

From the IOS Standards Deployment Stage

The distinction between deployment versus and non-deployment is based on responses to the 7-point technology assimilation scale (see Table 5). Responses of six or seven on the assimilation scale indicated the firm had implemented the innovations in an IOS context. Responses of five, four, three or two on the assimilation scale indicated the firm had not

implemented the innovations. Overall, there are 58 deployers and 44 non-deployers of the innovations in an IOS context.

The middle three columns in Table 6 summarize the significant variables in the model's deployment stage, including the coefficients, Wald statistics and significance levels. In distinguishing between deployers versus non-deployers the following measurement variables were found to be significant: *feasibility, competitive pressure, participation level in an SDO, compatibility, shared business process, architecture* and *governance.* The findings provide limited support of hypothesis H2 (Organizational Readiness attributes) with respect to the positive direction and significance of *feasibility*, and support of hypothesis H4 (External Environment attributes). In addition, hypothesis H6 (SDO attributes) has limited support. The *architecture* attribute is positive and significant, however *governance* was significant (but in a negative direction) and *management practices* was not significant. There is support of hypothesis H8 with two attributes of the Innovation (*compatibility* and *shared business process*) that are significant and positive towards IOS standards deployment.

Goodness of fit for the final model (which includes significant effects only, including main effects and interactions) is significant at the 0.2476 level on a χ^2 distribution. Utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .2987. Based on the literature survey, the averaged explained variation in prior IOS diffusion studies is .31[1]. Thus the deployment versus non-deployment results are consistent with prior diffusion studies in this context. The decline in explained variation, however, from stage 1 to stage 2 is significant. This may be indicative of several industrial groups that are on the brink of deploying the innovations under study, and thus a richer empirical understanding of adoption determinants exists.

FIGURE 2 - RESULTS OF TEST OF HYPOTHESES		
H1	Organizational Readiness attributes will have a positive (and significant) relationship with IOS standards adoption.	Supported
H2	Organizational Readiness attributes will have a positive (and significant) relationship with IOS standards deployment.	Partial Support (w.r.t. Feasibility)
H3	The external environment attributes will have a positive (and significant) relationship with the IOS standards adoption.	Supported
H4	The external environment attributes will have a positive relationship with the deployment of IOS standards. Participation levels in an SDO will have significant relationship towards IOS standards deployment.	Supported (and Competitive Pressure is significant)
H5	SDO attributes will have a positive relationship with IOS standards adoption. Governance and Architecture will also have a significant relationship towards IOS standards adoption.	Partial Support (w.r.t. Architecture)
H6	SDO attributes will have a positive (and significant) relationship with IOS standards deployment.	Partial Support (w.r.t. Architecture). Governance was significant, but negative
H7	Innovation attributes will have a positive relationship with IOS standards adoption. Relative Advantage and / or Shared Business Process attributes will also have a significant relationship towards IOS standards adoption.	Not Supported
H8	Innovation attributes will have a positive (and significant) relationship with IOS standards deployment.	Partial Support (w.r.t. Compatability and SBP).

From the IOS Standards Assimilation Stage

The distinction between assimilation levels of IOS standards is based on responses to the 7-point technology assimilation scale. As depicted on Table 5, responses are grouped into four categories; (a) *Non-adopters* were respondents who answered two, three, or four, (b) *Adopters & Non-Deployers* were respondents who answered five, (c) *Limited Deployers* were respondents who answered six and (d) *General Deployers* were respondents who answered seven. Overall, there are 22 non-adopters, 22 adopters but non-deployers, 30 limited deployers and 28 general deployers of the innovations in an IOS context.

The final three columns in Table 6 summarize the significant variables in the model's assimilation stage, including the coefficients, Wald statistics and significance levels based on the polytomous logistics function (Neter 1996). In distinguishing between assimilation categories the following measurement variables were found to be significant: *top management support*, *feasibility, competitive pressure, participation level in an SDO, compatibility, shared business process, architecture* and *governance.* Although no formal tests of hypotheses were established for the assimilation stage, these findings provide insights for future longitudinal studies as greater levels of IOS standards diffusion are reached throughout industrial groups (e.g. examining diffusion from three perspectives volume, diversity and breadth as recommended by Massetti and Zmud (1996)). Overall, the model fit was improved between the initial and final model from an Akaike Information Criterion (AIC) of 250.28 to a final AIC of

240.5. The final model significance was not assessed due to the polytomous logistics regression. However, since this model is based on the same data as the two prior stages (where confirmatory fit results were conducted) we can assume a satisfactory fit. Utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .2361.

Control Variable

The control variable firm *size* was tested in all three stages from three potential perspectives (sales or annual budget, trading partner count and employee count). From all three perspectives and in all three stages, the size control variable was a non-significant factor towards IOS standards diffusion.

DISCUSSION

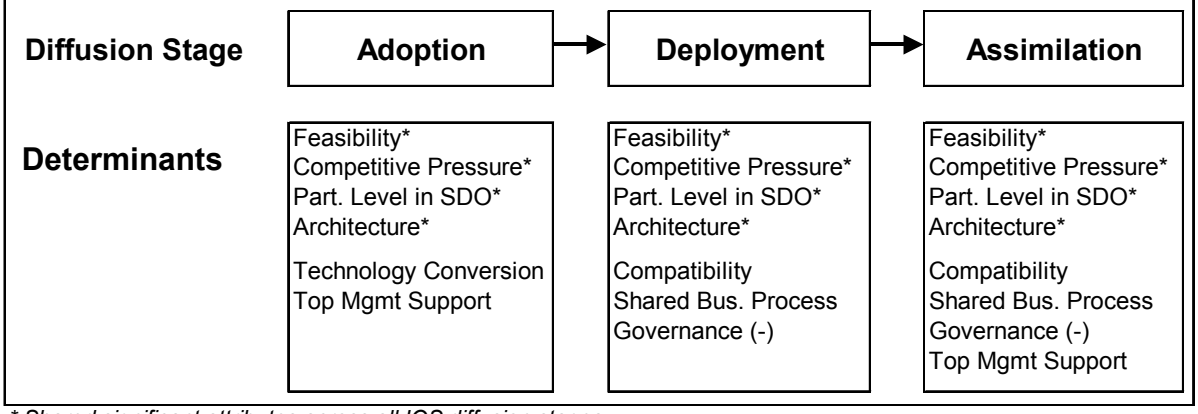
An industrial group's ultimate intentions with developing IOS standards may be cost cutting, process efficiency, outsourcing, co-opetition, building a foundation for web-services or simply enhancing industry-wide interoperability. The emergence of this phenomenon is clear and the diffusion process is proving to be an extraordinary challenge. This study sought to examine the development and diffusion process of IOS standards throughout an industrial group. A conceptual IOS standards diffusion model was defined and segmented into three stages (adoption, deployment and assimilation) and empirically compared to a real work environment. The significant antecedent conditions for each stage were identified and are summarized in Table 6 and Figure 3. The analysis and empirical results suggest the findings can be grouped into the following emerging patterns (major findings) associated with IOS standards diffusion.

- Shifted Focus / Strategies between Adoption and Deployment Stages
- Common IOS Diffusion Determinants
- Contrasts between EDI versus web-based IOS standards Diffusion Determinants
- The Emerging Role of an Industry-based SDO
- IOS Standards Diffusion across Industrial Groups

Shifted Focus / Strategies between Adoption and Deployment Stages: *The multi-stage analysis revealed that a different mix of determinants is associated with IOS standards adoption versus deployment.* In the adoption stage, broader enterprise-wide considerations are paramount (refer to Table 6). These Organizational Readiness attributes include demonstrated *top management support*, technical and financial *feasibility* and the relative installed base of

older IOS solutions (e.g. EDI, proprietary or semi-automated solutions). In contrast, the deployment stage is based more on operational considerations specific to the shared business process and the technology's compatibility. Thus, as firms progress from adoption to implementation, the types of decisions shift from "Whether the firm should adopt IOS standards", towards "When and how do we implement the standards with trading partner X, for business process Y". The decisions become more finite and organizational attributes become less important and attributes associated with the technology become more important. In fact, an examination of Table 6 indicates the lack of any attributes associated with the innovation itself (e.g. *relative advantage, compatibility, shared business process attributes*) to be significant during adoption. An interpretation of this finding is that the direct operational and financial benefits (e.g. cost reductions, enhanced response times) enabled by IOS standards are not significant factors in distinguishing between adopters versus non-adopters. This finding is in contrast to the prevalence of the *relative advantage* construct in prior innovation research (Rogers 1995; Tornatzky and Klein 1982), but is not without precedence in the study of IOS diffusion (Premkumar, Ramamurthy and Nilakanta 1994; Chau and Tam 1997; Grover 1993).

Figure 3 - Determinants Towards IOS Standards Diffusion



** Shared significant attributes across all IOS diffusion stages.*

Common IOS Diffusion Determinants: *The four common determinants across all diffusion stages are feasibility, architecture, competitive pressure and participation levels in an SDO.* Despite the noted differences in determinants between adoption and deployment, a common set of determinants shared across all three stages of IOS standards diffusion have emerged and are highlighted in Figure 3. *Feasibility*, similar to the notion of readiness (Chwelos, Benbasat, and Dexter 2001; Iacovou, Benbasat, and Dexter 1995), refers to the firms' technical sophistication to develop and make workflow changes to use IOS standards technology, and their financial resources to purchase and maintain the technology. The start-up cost associated

with implementing a firm's first series of IOS standards was approximately $100,000 in 2001 (Behrman 2002). The incremental cost thereafter was considered minimal and could be incurred on a piece-meal basis (e.g. an additional server or software license purchase as volumes necessitated). By the end of 2003 firms had estimated this initial start-up cost to be cut in half (and dropping). Based on survey responses an emerging group of firms no longer associate these start-up costs with IOS standards (*per se*), but rather view them as part of the firm's ongoing IT infrastructure maintenance. Although no known use of the *architecture* variable was found in our literature survey, it was a significant antecedent condition across all diffusion stages. *Architecture* of an SDO's IOS standards includes their defined scope (modularity level), conduciveness towards interoperability, vendor neutrality and quality of technical standards documentation. Collectively, these provide rich attributes that an industry-based SDO may seek to achieve. C*ompetitive pressure* was also found to be a significant antecedent condition across all diffusion stages. This is consistent with the literature survey findings where *competitive pressure* was the most frequent determinant of IOS diffusion[1]. With IOS standards development rooted in industry-wide consortia, however, this pressure can be expected to be broader-based from an entire industrial group. The second External Environment variable is *participation levels in an SDO*, which can manifest in several ways. Some firms participate in the industrial groups' standards development process, but then fail to internally deploy IOS standards. Some firms implement IOS standards, but then fail to become a formal member of the SDO. Some firms choose to adopt IOS standards, but then fail to participate in the SDO's standards development process. Overall these findings suggest the greater the number of participation touch-points with an SDO, the greater the levels of IOS standards diffusion (across all three stages). The result is a clear recommendation to SDOs, to improve diffusion levels, actively engage firms with a rich diversity of participation alternatives (standards development efforts, membership, testing / evaluation, etc.). This finding is consistent with findings from recent researchers (Teo, Wei, and Benbasat 2003) and recommendations from others (Reekers and Smithson 1994; Grover 1993; Cavaye 1996).

Contrasts between EDI versus web-based IOS standards Diffusion Determinants: *The diffusion of web-based IOS standards entails a different mix of antecedent conditions than EDI diffusion. Compared with EDI diffusion from the past, size and relative advantage are no longer significant antecedent conditions*. The majority of prior innovation studies that examined IT standards diffusion in an interorganizational system context pertained to ANSI X12 standards for use in EDI (e.g. purchasing and inventory interorganizational systems). A literature survey of

prior IOS diffusion studies was conducted as part of our preliminary work [1]. Based on synthesizing the findings across all studies, the most frequent determinants of EDI (and EDI-Like) diffusion are *competitive pressure, relative advantage, compatibility, size* and *top management support* [1]. As discussed, *top management support* is significant towards adoption and assimilation, *compatibility* is significant towards deployment and assimilation, and *competitive pressure* is significant across all three IOS diffusion stages. Two of the five items however (*size* of the firm and *relative advantage* of the technology) were found non-significant antecedent conditions in IOS standards diffusion and should be briefly discussed. First, the control variable firm *size* was tested in all three stages from three perspectives (sales, trading partner count and employee count) and was found non-significant in all cases. Traditionally, a firm's *size* has been considered a potential significant factor in IOS diffusion due to EDI's relative large up-front expenses and coercive adoption practices along the supply chain. This no longer appears to the case with the IOS standards technology grouping. Thus it is not surprising to learn that small to medium sized firms reported some of the greatest IOS standards assimilation levels (based on a categorization of respondents in Appendix C).

Second, one of the original intentions of this study was to examine the possibility of combining the *relative advantage* with *shared business process* attributes (with hopes of providing specificity towards the meaning of the direct operational and financial benefits enabled by the technology). Based on principal components analysis (PCA) results these variables are distinct. *Relative advantage* is non-significant across all three diffusion stages and *shared business process* attributes are significant in the deployment and assimilation stages. Modern-day IOS solutions are structured around shared business processes. SDOs coordinate work groups whose sole focus is to document consistent definitions, develop parameters and choreograph information flows, all of which are designed around cross company business processes. Some of these attributes include timeliness, data accuracy, communications effectiveness, data integrity, and collaboration levels. From a researcher's perspective, *shared business process* attributes have become pivotal in modern day IOS solutions and their role should be comprehended in future diffusion studies.

The Emerging Role of an Industry-based SDO: *IOS standards diffusion determinants are closely linked to the emerging role of an industry-based SDO. While maintaining a base line of services throughout all stages, SDO focus areas should advance as diffusion levels progress.* As this study has examined, the members of an SDO management team are in a precarious

position. They are bound to upset some members most of the time, and rarely have the opportunity to exceed expectations any of the time. They are independent moderators in managing a shift from competition to co-opetition and enablers towards true pie-expansion among members of an industry group. Despite these challenges, this study provides needed insights into the emerging role of industry-based SDOs. A common set of determinants has evolved that are shared across all diffusion stages (*architecture, feasibility, participation levels in SDO and competitive pressure*). SDO's can extend these findings to a base line of services that begin with establishing an IOS standards *architecture* that is vendor neutral, open-standards based, structured around discretely defined shared business processes, well documented and enables industry-wide interoperability. Technical *feasibility* can be enhanced throughout the industrial group via collaborative research and development sessions, lessons learned, best practices and other knowledge sharing techniques. *SDO participation levels* can be sustained by offering a rich mix of participation alternatives (touch-points) through all diffusion stages.

During the adoption stage, SDOs should focus on higher-order strategic benefits provided to the potential adopting firm (*top management support* and *technology conversion*). With organization-level attributes important during adoption, SDOs should actively engage a firm's *top management support* and assist them to clearly enumerate the interoperability benefits and with the assignment of a project champion. Although firms with a larger installed base of older IOS solutions are not necessarily more likely to deploy, they are more likely to adopt IOS standards. SDOs can leverage this *technology conversion* finding to ease 'fence-sitter' firms into the diffusion process.

During the deployment stage, determinants shift from organization-level attributes towards SDO and innovation related attributes (*compatibility, shared business process attributes, governance*). As diffusion levels progress, so should the role of an SDO. Firms are more focused on "When and how to implement IOS standards with trading partner X, for business process Y". Further, the newly deployed firm is likely confronting internal resistance to change and their recently spent capital expenditures have yet to provide returns. Pressures rise during deployment, making SDO outreach and support crucial. By demonstrating the *compatibility* of these innovations with the firm's future and correlating the investments with web-services readiness, an SDO can assist a newly deployed firm manage the pressures. *Shared business process attributes* provide additional avenues to demonstrating compatibility (compliance with governmental regulations, improved enforcement of contractual arrangements), operational

benefits (enhanced response times, increased throughput) and *financial feasibility* (reduced standards negotiation efforts, shared R&D expenses).

During the assimilation stage, high-end user firms are emerging as the industry seeks to achieve sustained diffusion. The same determinants exist as the deployment stage, with the addition of *top management support*. Again, as diffusion levels progress, so should the role of an SDO. Re-engage *top management support* of high-end user firms and enlist assistance with industry-wide initiatives and with outreach activities to firms in lower diffusion stages. When necessary, demonstrate the standards are compliant and / or compatible with similar IOS standards on a cross-industry (horizontal) basis.

The significance of the *governance* variable (but with a negative relationship) is indicative of this emerging role of an SDO. Recall, *governance* includes items related to the SDO's scope and mission, its' non-profit status, and the perceived benefits provided to firms. Thus, firms with the greatest assimilation levels are the same firms seeking the greatest number of services from an SDO. They often disagree with the SDO's governance since they seek additional value-added services. For example, respondents from the electronics industry are seeking case studies (or white papers) regarding the business process reengineering associated with IOS standards implementations (rather than just the technical-based case studies). Respondents in the geo-spatial industry are seeking permanent walk-in hosting labs to allow potential IOS standards users to 'kick the tires' at any time. Respondent firms from several industries are seeking improved compliance and conformances testing procedures. One of the highest points of feedback regarding additional SDO services sought is IOS standards adoption assistance among members from the *entire* industrial group. Many respondent firms indicated their willingness to change the SDO's status to *for-profit* in order to fund additional services. The point of these illustrations is not to further burden an SDO. Rather, it is to illustrate the emerging role of an SDO and how their focus areas should advance as IOS standards diffusion levels progress throughout the industrial group. The SDO management team should acknowledge these untapped needs, enlist assistance, delegate accordingly and manage expectations. Recall, the greater the number of participation touch-points, the greater the likelihood of IOS standards diffusion.

IOS Standards Diffusion across Industrial Groups: *Industrial groups have varying levels of IOS standards diffusion that can be explained by the determinants from this study. By*

examining the circumstances surrounding each, the industrial group's relative position on the IOS standards diffusion curve can be explained in relation to the significant antecedent conditions identified in the study. Figure 4 depicts an IOS standards deployment curve assessment for several industrial groups. The vertical axis approximates diffusion levels based on equal weighting of the number of members and completed messages from the industrial group's primary SDO (in rank order from the greatest to the least). The horizontal axis tiers the industrial groups based on IOS standards adoption timeliness (qualitatively assessed from the consolidated survey responses). Conceptually, this graph provides the ability to compare the relative progression of each industrial group along an innovation diffusion curve. Findings from this study can explain this relative progression and further illustrates the emerging patterns in IOS standards diffusion. For example, the semi-conductor industry is an Early Adopter of IOS standards (located in the far right of Figure 4). RosettaNet, an SDO for semi-conductor industry, has assembled over 500 member firms, completed 53 messages (with another 52 pending review) and developed the RosettaNet Interoperability Framework (RNIF v2.0) that is accepted throughout their industrial group (and beginning to be adopted by other industrial groups). Their recent alliances with UCC and OASIS squarely positions them to confront the horizontal convergence issue. RosettaNet's ability to develop an effective architectural framework, nurture an industry-wide collaborative working environment, and confront diffusion inhibitors has contributed to the industrial group's ability towards managing extraordinary competitive pressures.

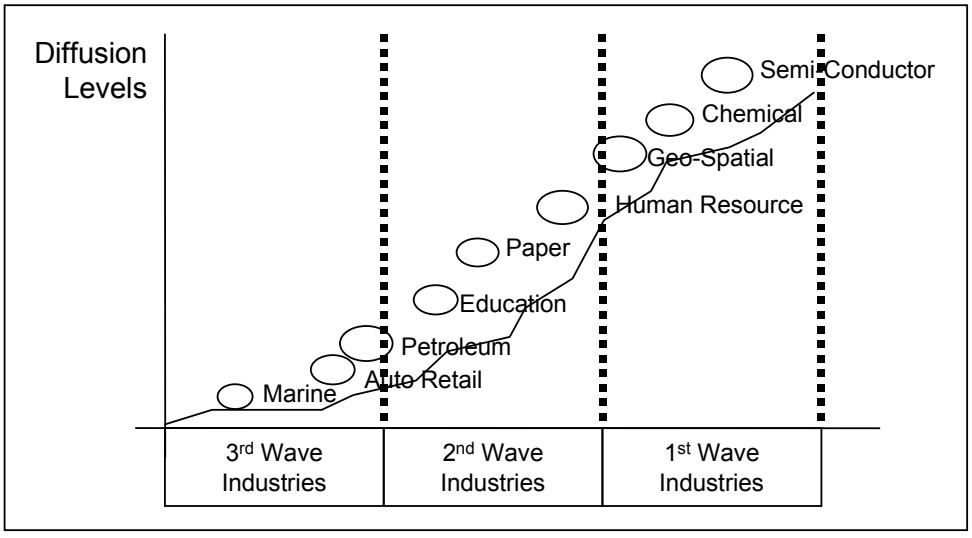


Figure 4 – Industrial Group IOS Standards Diffusion Levels

A second example is the human resources industry (towards the middle of Figure 4). HR-XML, an SDO for the human resources industry, has assembled over 150 member firms, completed 27 messages (with many more under review) and serves both a vertical focus (with HR staffing firms) and horizontal focus (HR departments). HR-XML's recent launch of compliance and certification programs in 2003 will further build the awareness and support for HR specific interoperability needs and possibly encourage vendors to integrate IOS standards into off-the-shelf (less costly) solutions. This SDO's ability to tightly integrate complex shared business processes into IOS standards, promote the need for interoperability, and mediate interests from an extraordinary diverse set of stakeholders has assisted their industrial group members to manage through substantial regulatory pressures. A third example is the petroleum industry (towards the left of Figure 4). IOS standards development is split between three SDOs (POSC, PPDM and PIDX). Collectively, the primary inhibitors of further diffusion are the lack of a consistent IOS standards *architecture* and a large EDI installed based. The industry may consider taking advantage of their strong management support and collaborative working relationships and better align the mission, scope and efforts of the three SDOs into a unified IOS standards architecture. Mature industries should avoid the trap of clinging to out-dated shared business processes associated with their sunk EDI investments and consider developing comprehensive set of IOS standards in light of modern day IOS solutions.

CONCLUSIONS

Despite the profound industry-wide interoperability benefits, the diffusion of web-based IOS standards has proven to be a challenge. By extending the IOE framework to include attributes of the SDO and the cross-company business process, this study developed a conceptual innovation diffusion model and segmented the IOS standards diffusion process into three stages (adoption, deployment and assimilation). The conceptual model was empirically compared to a real work environment based on a cross-sectional survey of 102 firms from 10 industrial groups representing15 SDOs. The significant antecedent conditions towards each diffusion stage were identified and the hypothesis tests results reported. Contributions, implications and recommendations were provided to researchers and practitioners throughout the discussion and are briefly highlighted below.

This paper is intended to bridge the research gap between prior studies in IOS diffusion (based predominantly on EDI) versus web-based IOS standards. This is the first known study to examine diffusion of the technology grouping (XML, SOAP, WSDL, and other APIs) in an IOS standard, industrial group context. The overwhelming result was the emergence of an industry-based SDO as pivotal from development through assimilation in the IOS standards process. The multi-stage conceptual model and empirical analysis revealed insights into a common set of determinants that influence all stages of diffusion, as well as distinct determinants to each stage. The findings were discussed for each diffusion stage and in the context of the emerging role of an SDO. Just as determinants vary between IOS diffusion stages, so should the role of an SDO. The assimilation stage of IOS standards diffusion was positioned as exploratory for purposes of this study. Since IOS standards are merely on the brink of widespread assimilation, the determinant findings provide a basis for researchers to begin development of more advanced assimilation models. Additional research recommendations include examining the impact of an SDO's standards versioning policy and assessing the likelihood of industry-based IOS standards to be adopted on a cross-industry (horizontal) basis. Both items may significantly influence an SDO's success and the assimilation of IOS standards in the future. The paper concluded with the development of an industrial group IOS standards deployment curve. By correlating the unique contextual factors of each industrial group to the determinants found in our conceptual model, the relative position of each industrial group along the IOS standards deployment curve was better understood.

[1] A literature survey of IOS diffusion studies was conducted as part of the preliminary work leading to this study. The survey coded findings from 21 publications (encompassing 6,092 samples and 187 measurement variables) towards IOS adoption and diffusion. The studies are identified with footnote 1 in References. Based on vote-counting techniques for synthesizing research, a common framework and the most frequent determinants towards IOS diffusion were assessed. An extended discussion regarding the results will be provided in a forthcoming paper.

[2] A RosettaNet white paper entitled "Measuring Business Benefits of RosettaNet Standards: A Co-Adoption Model " examines similar issues in detail and can be found at http://www.rosettanet.org/roistudies.

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- XML in 10 Points http://www.www.w3.org/XML/1999/XML~in-10-points
- Flynn, Peter (2002) editor for The XML FAQ Special Interest Group, v.2.1, 2002 http://www.ucc.ie/xml/#index is the web-site for

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(Note to Reviewer(s): The paper has a relative large set of appendices in order to supplement a reader's understanding and provide more detailed information (if necessary). The appendices are *modules,* in that they can be removed from the paper with minor impact on the main body of the text.)

APPENDIX A

Industry-based SDO Illustrations

Industry-Based Standards Development Organization (SDO) Examples

Example SDO	HR-XML http://www.hr-xml.org	papiNet http://www.PAPINet.org	Open GIS http://www.opengis.org	PIDX http://www.pidx.org	STARS http://www.starstandard.org/	IMS http://www.imsglobal.org	eMSA http://www.emsa.org	RosettaNet http://www.rosettanet.org
Industrial Group	Human Resources	Paper	Geo Spatial	Petroleum & Oil	Automotive	Education	Marine	Semi-Conductor Mfr
Profit Orientation / Partnerships	Non-Profit	Partnered with Idealliance. Non-profit orientation.	Non-Profit	American Petroleum Institute's (API) committee on Electronic Business. Non-profit orientation.	Non-Profit	A project within the National Learning Infrastructure Initiative of EDUCAUSE	European Marine STEP Association (EMSA). Non-Profit orientation.	Merged with UCC in 2002. Non-profit orientation.
Membership Fee Structure	Fixed annual fees based on Charter, General, Associate or Academic membership types. Fees also vary by end-user versus technology vendors.	Annual fees based on firm revenues. Fees also vary by technology vendors and industry champions.	Fixed annual fees based on Strategic, Principle, Technical Committees, Associate or Academic and Governmental membership types.	Annual fees based on firm revenues (distinctions made for governmental and academic institutions).	Fixed annual fees based on organization type (Dealerships, Mfrs, SIG) and membership status (active versus associate).	Annual fees based on firm revenues.	Annual fees based on firm employee count. Distinctions made for academics.	Fixed annual fees based on geography and voting privelages.
Industry Participation	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary
Development Process	Consensus based on membership voting rights.	Consensus based on membership voting rights.	Consensus based on membership voting rights.	Consensus based on membership voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.
Standards Availability	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public
Members	150	47	258	27	39	64	15	500
Year	1999	1999	1994	2002*	2001	1997	1994	1998
Messages Completed Pending (In Review)	27 not known	28 5	7 12	11 5	15 not known	9 3	6 2	53 52
IOS Standards Examples	Background Checking Benefits Enrollment Competencies Contact Method Education History	Credit Debit Note Goods Receipt Availability Order Confirmation Business Acknowledgment	Imagery Mark Up Language Spec Image Coordinate Transform Web Map Service Interfaces Grid Coverages Gazetteer Service Interface	FieldTicket FieldTicketResponse Invoice InvoiceResponse OrderCreate	Parts Inventory Delivery Reporting Financial Statement General Acknowledgements Labor Operations	Learner Information Package Question & Test Interoperability IMS Vocabulary Definition Learning Design IMS Digital Repositories	Hull Structural Design Data Society type approval & product Quote machinery product data Integration & catalogue procureme Machinery design data	Notification of Failure Distribute Design Engineering Info Distribute Product Master Request Quote Request Purchase Order

Example SDO	CIDX http://www.cidx.org	EIDX http://www.eidx.org	PPDM http://www.ppdm.org	POSC http://www.posc.org	OAG http://www.openapplications.org	SIF http://www.sifinfo.org	IdeaAlliance http://www.idealliance.org
Industrial Group	Chemical	Electronic Components	Petroleum & Oil	E&P Industry	Multiple, but primarily Automotive	K-12 Education	Publishing and other info-driven enterprises
Profit Orientation / Partnerships	Non-Profit orientation.	Merger with CompTIA in 2001.	Non-Profit	Non-Profit	Non-Profit, but founding members include the major ERP vendors.	Non-Profit	Non-profit orientation.
Membership Fee Structure	Annual fees based on firm revenues. Distinctions made for Founding members.	Reciprocal memberships through Edifice (one-time membership & fixed annual fee), AIAG and OAG	Annual fees based on firm revenues.	Annual fees based on firm revenues.	Annual fees based on firm revenues.	Annual fees based on firm revenues.	Annual dues based on firm revenues and firm types.
Industry Participation	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary
Development Process	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category and / or voting rights.
Standards Availability	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public
Members	75	55	98	100	37	120	202
Year	2000*	1987	1989	1990	1995	1997	1966
Messages Completed Pending (In Review)	52 not known	16 broad curriculums not known	16 not known	23 8	61 Scenarios not known	11 not known	Not known (atleast 50) Not known
IOS Standards Examples	Qualification Request Qualification Response Customer Specific Catalog Update Product Catalog Update Request for Quote	Business Process EC Technologies Guidelines & Standards	Business Associates Work Orders Seismic Line Summaries Velocities Product and Information	Loggraphics Epicentre WellHeaderML WellPlotML V0.4	Production Synchronization Purchase Order Integration Purchase Order Process Purchasing to A/P Project Accounting Synchronizatio	Acknowledge Receipt Register Subscribe Unregister	Content Creation and Management Supply Chain Management Digital Advertising Workflow Color Mgmt & Production Workflow Postal & Newsstand Distribution Shipment 'n Logistics Specification

APPENDIX B

Research Construct, Measurement Variables, and Survey Instrument

Construct	Measurement Variable	MV Code	Variable Source	Hypoth. Impact: Adoption	Hypoth. Impact: Deployment	Survey Items	Item Measure Description	Scale
ORGANIZATION READINESS	Top Management Support	TopMan	Prior	+ / Sig	+ / Sig	4(a)	- Actively participate	7-point Likert (SD~SA)
						4(b)	- Assigned project champion	7-point Likert (SD~SA)
						4(c)	- Effectively communicates support	7-point Likert (SD~SA)
	Feasibility (Financial & Technical)	Feasibility	Prior	+ / Sig	+ / Sig	5(a)	- Technical sophistication to implement & maintain	7-point Likert (SD~SA)
						5(b)	- Technical sophistication to make work flow change	7-point Likert (SD~SA)
						6(a)	- Financial resources to implement & maintain	7-point Likert (SD~SA)
						6(b)	- Financial resources to make work flow changes	7-point Likert (SD~SA)
	Technology Conversion	TechConv	New	+ / Sig	+ / Sig	Sum of D14(a~d)	- Installed base of former IOS (EDI, manul, proprietar	5-point (None to Extens)
						minus D14(e)	comared to IOS SPI solutions	5-point (None to Extens)
INNOVATION ATTRIBUTES	Relative Advantage	RelAdv	Prior	+ / Sig	+ / Sig	11	- Direct operational benefits	7-point Likert (SD~SA)
						12	- Direct financial benefits	7-point Likert (SD~SA)
	Compatibility	Compab	Prior	+	+ / Sig	3	- Required work procedure changes are consistent	7-point Likert (SD~SA)
						13	- Consistent w/ future vision of IS infrastructure	7-point Likert (SD~SA)
						14	- Compatible with existing IS infrastructure	7-point Likert (SD~SA)
	Shared Business Process Needs	ShareBus	Derived	+ / Sig	+ / Sig	15(b)	- Enhances timeliness	7-point Likert (SD~SA)
						15(c)	- Provide reliable data communications	7-point Likert (SD~SA)
						15(e)	- Improve data integrity	7-point Likert (SD~SA)
						15(f)	- Improve collaboration levels	7-point Likert (SD~SA)
EXTERNAL ENVIRONMENT	Competitive Pressure	CompPre	Prior	+ / Sig	+	7	- Meet trading partner requirements	7-point Likert (SD~SA)
						8	- Industrial group pressure	7-point Likert (SD~SA)
						9	- Firm will loose competitive edge	7-point Likert (SD~SA)
	Participation Level in an SDO	SDOPart	Derived	+ / Sig	+ / Sig	17 + 18 + 19	- User status, Development status, Member Status	Dichotomous 'yes' / 'no'
						+ (2 * #24)	- Committment to implement IOS SPI next 12 mths	7-point Likert (SD~SA)
STANDARDS DEVELOPMENT ORGANIZATION	Management Practices	ManaPra	New	+ / Sig	+ / Sig	28	- Open & honest communications	7-point Likert (SD~SA)
						29	- SDO meets performance expectations	7-point Likert (SD~SA)
						30	- Responsibilities are appropriately delegated	7-point Likert (SD~SA)
						31	- SDO's goals are well communicated	7-point Likert (SD~SA)
						32	- SDO is neutral w.r.t. to all member firms	7-point Likert (SD~SA)
	Architecture	Archit	New	+	+ / Sig	34	- Modularity levels are appropriate	7-point Likert (SD~SA)
						35	- Standards are conducive to interoperability	7-point Likert (SD~SA)
						36	- Vendor neutral technical standards	7-point Likert (SD~SA)
						37	- Require minimal changes to business processes	7-point Likert (SD~SA)
						38	- Accurate and useful standards documentation	7-point Likert (SD~SA)
	Governance	Govern	New	+ / Sig	+ / Sig	21	- SDO's mission and objectives	7-point Likert (SD~SA)
						23	- An SDO should be a non-profit entity	7-point Likert (SD~SA)
						25	- SDO benefits are well understood	7-point Likert (SD~SA)
CONSEQUENCE MEASURES	Direct Financial Measures	DFB	Prior	n/a	n/a	47	- Direct financial benefits	5-point Decrease to
		CapExp	Prior	n/a	n/a	54	- Capital expenditures	for three time periods
		DFBa, b, c	New	n/a	n/a	51, 52, 53	- DFB of increase trading partners versus standards	Same as above
		EmpTr	Prior	n/a	n/a	41	- Employee training	Same as above
	Direct Operational Measures	DOB	Prior	n/a	n/a	46	- Direct operational benefits	Same as above
		IOSD	Prior	n/a	n/a	49	- IOS development	Same as above
		IOSI	Prior	n/a	n/a	50	- IOS implementation	Same as above
		NegTime	New	n/a	n/a	48	- Negotiation time of IT standards	Same as above
		TPComp	Prior	n/a	n/a	44	- Compliance with trading partner mandates.	Same as above
	Indirect Measures	TPLoy	Prior	n/a	n/a	43	- Trading partner loyalty.	Same as above
		EntBar	Prior	n/a	n/a	45	- Entry barriers	Same as above
		NRO	Prior	n/a	n/a	42	- New revenue opportunities	Same as above
		MLT	Prior	n/a	n/a	55	- Manufacturing lead times	Same as above
		PSC	Prior	n/a	n/a	56	- Product / service costs	Same as above
TOTALS	12 Measurement Variables		Conceptual Model has 43 items + Descriptive Analysis 39 items = Total of 82 items					

APPENDIX C

Results Concerning Industry Consequences

This study also examines the direct and indirect impact of IOS standards. The results provide insights into the consequences on an industrial group as a result of diffusing IOS standards. The effects are cumulative and tiered into 1st, 2nd, and 3rd ordered effects based on time since deployment. Respondents provided insights into 18 consequences measures for the short-term (immediate), medium-term (next 1 to 2 years) and longer-term (next 3 to 4 years). Due to the proprietary nature of survey items in this survey section, respondents were asked to assess consequences with respect to their industrial group (as opposed to a specific firm). 16 of the measures utilized a perception-based measure on a 5-point scale (ranging from 1 - significant decrease, 2 - decrease, 3 - no change, 4 - increase and 5 - significant increase) for each time period. Two additional consequence measures (a) anticipated longevity of IOS standards and (b) annual return on investment (ROI) required to justify IOS standards, utilized 7-point scaled responses including the option of an other category for specific responses. Table C-1 provides the consolidated results of consequence measures. The response values have been normalized (to a 0 scale), averaged and are cumulative over the three time periods. Thus, anything above 0 reflects a *mean cumulative anticipated consequence increase*, anything below 0 reflects a *mean cumulative consequence decrease*.

Overall the consequence trends on an industrial group are extremely favorable with respect to the adoption and diffusion of these innovations. As a starting base line, respondents indicated that a 14.2% annual ROI would be necessary to justify expenditures on the IOS standards technology grouping and anticipate the longevity of IOS standards to be at least 35.7 months (or greater). The direct financial benefits (ROI, firm profitability, payback) and direct operational benefits (improved response times, greater throughput capability, timeliness) of diffusing IOS standards are both positive and anticipated to grow during the three time periods (with operational benefits increasing at a greater rate).

Two unexpected findings from this analysis are briefly discussed below. First, at the outset of this study, it was anticipated that three areas would provide the greatest financial and operational benefits of IOS standards diffusion (reductions in standards negotiation efforts, and reduced IOS development and implementation time). Although modest reductions in these areas are anticipated in outer periods, they pale in comparison to anticipated benefits in new

revenue opportunities and cost savings in the firm's product or services. From a sheer volume and dollar size perspective, new revenue and product cost savings opportunities have significant and far-reaching implications throughout an organization. Second, no significant difference exist in the financial benefits of implementing IOS standards across new trading partners, versus implementing new IOS standards across existing trading partners**.** Thus it is anticipated that the learning curve associated with bringing on new trading partners, is similar to that of diffusing new standards across the same trading partners. This was typically not the case with older IOS solutions such as EDI and EDI-like technologies.

Also indicated in Table C-1 are numerous indirect benefits enabled from diffusing IOS standards. For example, key intangible benefits include improved trading partner loyalty, improved compliance with trading partner mandates and manufacturing lead-time reductions. Overall, entry barriers in an industrial group are expected to remain relatively unchanged with the diffusion of IOS standards, and capital expenditures associated with the IT infrastructure are expected to increase during all three time periods.

TABLE C-1 INDUSTRIAL GROUP CONSEQUENCES OF IOS STANDARDS

EXPECTED LONGEVITY OF IOS STANDARDS *	35.7 months
REQUIRED ROI TO JUSTIFY IOS STANDARDS EXPENSES *	14.2% per annum

	All Respondents (n=102)		
	Short Term	Mid Term	Long Term
	Immediate	1 ~ 2 Yrs	3 ~ 4 Yrs
Cumulative Maximum Absolute Value-->	+/-2	+/-4	+/-6
CONSEQUENCE MEASURES			
DIRECT MEASURES			
Direct Operational Benefits	+ 0.5	+ 1.4	+ 2.5
Direct Financial Benefits	+ 0.1	+ 0.8	+ 1.9
With new trading partners (same standards)	+ 0.5	+ 1.4	+ 2.5
With new standards (same trading partners)	+ 0.4	+ 1.3	+ 2.3
With new trading partners and new standards	+ 0.5	+ 1.3	+ 2.3
Employee training expenditures	+ 0.7	+ 0.9	+ 0.5
Standards negotiation time & expenditures	+ 0.0	- 0.3	- 0.7
IOS Development time & expenditures	+ 0.5	+ 0.4	+ 0.1
IOS Implementation time & expenditures	+ 0.3	+ 0.1	- 0.5
INDIRECT MEASURES			
Trading Partner Loyalty	+ 0.5	+ 1.2	+ 1.9
Compliance w/ trading partner mandates	+ 0.6	+ 1.3	+ 2.0
Entry Barriers in Industry	+ 0.2	+ 0.2	+ 0.1
Revenue (or the attraction of new customers)	+ 0.4	+ 1.3	+ 2.2
Infrastructure Capital Expenditures	+ 0.7	+ 1.0	+ 1.0
Manufacturing Lead Times	+ 0.0	- 0.2	- 0.6
Cost of providing the firm's services / products	+ 0.1	- 0.2	- 0.8

NOTES:
* Weighted average based on scale responses (incl. specific responses in "Other" category)
** Starting from a baseline of 0, the sign (+ or -) indicates the direction of the consequence (increases or decreases). The values indicates the cumulative mean magnitude of the consequence measure based on the survey results.
** Consequences measures are cumulative effects over three time periods based on time since deployment.

APPENDIX D

Profiles of Firm Level IOS Standards Assimilation

Consistent with techniques used in prior diffusion studies (Grover 1993; Grover and Goslar 1993; Sabherwal and Vijayasarathy 1994 and others), a categorization of all survey respondents is provided in this appendix. For purposes of this analysis non-adopters are combined into a single group referred to as Fence-Sitters. Indicating these firms have IOS standards available to them (through their industry's SDO) and have demonstrated awareness, interest or are conducting evaluations / trials regarding the technology, but have currently elected not to adopt (nor deploy) in an IOS context. The result is a categorization of respondents into four categories based on their IOS standards assimilation level: (1) Fence-Sitters (Non-Adopters), (2) Commitment (Adopter, Non-Deployer), (3) Light Users (Limited Deployment) and (4) Heavy Users (General Deployment). See Table 5 for assimilation levels of survey respondents. Table D-1 includes key demographics, installed base, consequence measures, and potential influential measures towards progressing the category from one assimilation phase to the next (based on study's findings from the conceptual model, hypothesis testing and other empirical results).

The Fence-Sitters (non-adopters) are equally composed of small, medium and large sized organizations. The have the lowest expectation of ROI levels to justify IOS standards expenditures, but also expect the greatest longevity of the standards. They have a relatively balanced installed based of older IOS solutions and web-based IOS solutions. An analysis of the anticipated consequence results sheds light on the obstacles preventing fence-sitters from achieving greater assimilation levels. Fence-sitters have the lowest expectations regarding the financial, operational and indirect benefits from diffusing IOS standards (lead times, product cost savings, and trading partner loyalty).

The Commitment Group (Adopters but Non-Users) are equally composed of small, medium and large sized organizations. They also have a balanced installed based of older IOS solutions versus web-based IOS solutions. Ironically, the commitment group has the highest ROI expectations to justify IOS standards related expenditures, but also have the lowest longevity expectations of the standards (just the opposite result was reported of Fence-sitters). This is challenging to explain since they also have the lowest expectations regarding increased revenue opportunities and the greatest anticipated expenditure increases associated with new

IOS systems development, implementation and infrastructure expenditures. Based on the qualitative survey feedback, firms in the Commitment Group have experienced substantial pressure from industry and trading partners to adopt. They have made the adoption decision, but just beginning to ramp-up their internal capabilities to accommodate the upcoming implementations. Firms in the commitment group expect cost savings through reductions in IOS standards negotiation efforts and product cost. They have responded to industry pressures to 'play in their industry's standards game', but now must deliver the financial and operational benefits internally to their management.

The Light Users (Limited Deployment) represent the largest sized firms with the largest existing installed based of semi-automated and EDI-based IOS solutions. They have the greatest expectations regarding increases in trading partner loyalty and compliance with trading partner mandates. Although these firms may not be the leaders in "pushing" IOS standards through out an industrial group, their size and bargaining power always makes them forces to contend with. They have sunk-cost investments in EDI and will be reluctant to sustain diffusion of IOS standards unless the benefits can be demonstrated directly to them. More importantly however, is the ripple effect of adopting new IOS standards throughout their backend applications and internal business processes. Based on survey feedback, these larger firms are willing to make the necessary work flow changes to accommodate IOS standards, but they will only do it once. Their chief concern is the ability for the vertically orientated IOS standards to gain momentum and uptake on a cross-industry (horizontal) basis. Clearly, large up-take reduces the likelihood of massive rework in the future. Although these larger organizations could hold the key towards wide-spread diffusion among an industrial group, most have currently avoided making widespread mandates. They have chosen rather, the "*develop a little, implement a little*" approach.

The General Deployment (Heavy Users) is the most experienced group of firms with IOS standards technology. These are small to medium-sized organizations with minimal EDI installations and already operate the majority of their IOS solutions over the web. Heavy Users have the greatest expectations of the direct operational and financial benefits enabled by IOS standards. Sustaining diffusion from this group of firms will most likely not be a substantial problem. They are enjoying the benefits of being the most experienced and knowledgeable with respect to this technology

TABLE D-1 CATEGORIZATION OF RESPONDENTS

	Fence-Sitters	Commitment	Light Users	Heavy Users
n=	22	22	30	28
DESCRIPTION	Demonstrated Interest in IOS standards, but are non-adopters	Adopters, but Non-Users	Deployed IOS standards technology in three or less IOS	Deploy IOS standards in all major new systems development (where applicable)
FIRM SIZE	Balanced between Small, Med, Large Firms	Balanced between Small, Med, Large Firms	Large to Medium Sized Firms	Small to Medium Sized Firms
EXPECTED LONGEVITY OF IOS STANDARDS *	45 or greater	27 or greater	36 or greater	33 or greater
REQUIRED ROI TO JUSTIFY EXPENDITURES *	8.9%	17.8%	14.2%	17.4%
EXISTING IOS SOLUTIONS INSTALLED BASE **				
Manual Solutions	Low	High	Moderate	Moderate
Semi-Automated	Low	Moderate	High	Moderate
EDI orEDI-Like	Moderate	High	High	Low
Other / Proprietary	Low	Moderate	Low	Low
Internet-Based	Moderate	Moderate	Low	High
OBSTACLES TOWARDS ADOPTION / DIFFUSION	Unaware of the industry-wide nature and benefits of the SDO Lowest expectations of Direct Operational Benefits Lowest expectations of Direct Financial Benefits	Lowest expected longevity of IOS standards Lowest expectations of indirect revenue growth / opportunities Greatest expected increases in IOS development & expenditures. Greatest expected increases in new infrastructure expenditures	Overcoming large EDI installed base The largest sized firms, Internal ripple effect of IOS standards cascades thru the organizaton. Avoidance of re-work. Reluctant to deploy new IOS standards, if uptake is not likely on a cross-industry (horizontal basis). Lack of resolutions to overcome horizontal convergence.	Very few obstacles. These small to medium sized firms are the market leaders of this technology.
INFLUENTIAL MEASURES TOWARDS DIFFUSION	Promote the SDO first, and the technology second. Maximize the number of 'touch points' with the SDO. Promote the technical and financial 'feasibility' of utilzing IOS standards Engage support from the fence-sitter's top management Adjust ROI and longevity expectations.	Promote the technology first, and the SDO second. Demonstrate the indirect benefits of deploying IOS standards SDO outreach is crucial. Demonstrate infrastructure investments associated w/ establishing a transactional presence via the web. Demonstrate the compatibility of the technology.	Demonstrate the benefits of IOS standards on business process by business process basis. Emphasis the industry-wide benefits and network externalities. Engage the horizontal convergence issue. Manage the SDO governance issues (manage and meet expectations, stay focused, satisfy unmet demands).	Manage the SDO governance issues (manage and meet expectations, stay focused, satisfy unmet demands). Engage the Heavy users with outreach activities. Engage the horizontal convergence issue.

* Weighted average based on scale responses (incl. specific responses in "Other" category)
** EXISTING IOS SOLUTIONS (High-Indicates Largest Installed Base, Low-Indicates the Smallest Installed Base)