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# A Framework for Developing Prediction Model of Interface Management (IM) for Construction Projects in Alberta

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**Abstract:**

Interface Management (IM) of construction projects has not obtained the suitable level of awareness in the last two to three decades, which has harmfully affected project performance. Poor IM causes projects delay, which negatively impact projects cost. It impacts also projects safety, quality, scope change control, and team work performance. Although many researchers have discussed and reported different methods for performance measurement, insufficient project performance measurement is one of the major problems affecting construction industry. This research study is a framework for measuring IM in construction projects and its impact on project performance. Based on previous research on analysis and extraction of IM factors of independent variables (interface problems) using exploratory factor analysis, four phases are conducted in this research. First phase is enhancing project performance by developing and applying a multiple-regression analysis model between the underlying interface problem factors and the project performance indicators. These indicators are divided into soft issues and hard issues. The hard issues are quality management, schedule management, cost management, scope management, and safety and the soft issue is the team work. Second phase is measuring the severity of each IM problem on project IM performance. Based on those two phases, third step is developing a simulation model for prediction of project performance based on expected IM performance. Finally, fourth step is providing practical guidelines and suggestion for improving and enhancing the interface management (IM) performance that is adequate to all parties engaged in Alberta construction projects.

**Keywords**: Interface management, construction, performance, multiple-regression analysis model, prediction model.

## 1. INTRODUCTION

In terms of both value and employment, the construction industry is the largest industry sector in Canada. Construction industry of Alberta has made an important contribution to Western Canada's economy. In 2009, $26.2 billion (10.6 % of Alberta's gross domestic product) was spent on construction projects (Alberta's Economic Development 2011). Interface Management (IM) of construction projects has not obtained the suitable awareness in the last two to three decades, which has harmfully affected project performance (Al-Hammad 1990, Sozen 1996, Pavitt and Gibb 2003, Nooteboom 2004, Chen et al. 2008). Although many researchers have discussed and reported different methods for performance measurement, insufficient performance measurement is one of the major problems affecting construction industry. Interface management has been reported to account for approximately 20% of the total project cost by many researchers (Nooteboom 2004). In multidiscipline large projects, there are more than 75,000 task-related interfaces (Nooteboom 2004). In Alberta, There is a lack of studies for identification and enhancing of interface problems in construction projects. None of the existing studies developed a prediction model of IM impacts on construction project performance in Alberta. The main objective of this study are enhancing the IM among different project parties involved in the construction projects as well as increasing the effectiveness throughout the project lifecycle. In order to achieve that, four problems will be answered in this study:

1. What are the relationships between the extracted interface management factors (the underlying interface problem factors) and the project performance indicators of construction projects in Alberta?
2. What is the risk associated with each of the interface problems on project performance?
3. Could we predict project performance at the early stages of the project and recommend solutions for management?
4. What are the procedures or areas for improving interface management (IM) performance that is acceptable to all parties engaged in construction projects?

Consequently, this paper introduces a framework to enhance project performance in Alberta construction projects by developing and applying a prediction model of interface management (IM) performance for construction projects. Furthermore, this research will develop IM risk analysis model in construction projects. These models evaluate and predict project performance based on IM performance, and consequently suggest practical guidelines and beneficial management practices.

## 2. LITERATURE REVIEW

The previous studies in the areas of construction interface management (IM) definitions, categorization IM, and IM problems among various construction parties are summarized. As well as, the IM benefits to construction projects, project performance measurement, risk analysis, prediction model. The useful information from the previous studies and the methodologies that used in those studies are reported and discussed. Latest publications on the area of the interface management (IM) among projects parties during the different project phases are presented under this section as follows:

### 2.1 Interface Management Definition

Although there is no agreement among different previous researchers about the definition of the IM, the existing definitions discussed the boundary circumstances among phases, tools, physical elements/components, systems, organization, people and others (Wren 1967, Wideman 2002). Huang et al. (2008) defined the IM in the Mass Rapid Transit System (MRTS) construction projects as "the matters required to be physically and functionally coordinated or cooperated with among two or more subjects", which is considered to be an appropriate for this research study. Reader can be referring to Weshah et al. (2012) for further details about categorization of IM problems issues.

### 2.2 Categorization of Interface Management (IM) Problems Issues

Various categorizations of interface problems have been provided by many researchers as shown in Table1. Reader can be referring to Weshah et al. (2012) for further details about categorization of IM problems issue.

### 2.3 Interface Management Benefits to Construction Projects

Chen et al. (2007) reported the benefits of including IM into the whole construction process as follows:

- Deal with project difficulty by classifying and reporting the best practices Interface management that can be used and applied in the future projects.
- Meet the customer desires by improving the design in terms of the risk, cost, quality, etc.
- Facilitate a well-organized construction project delivery system, when take-actions regarding the project changes.
- Decrease the uncertainties within the construction projects and regulate the work flows for different types of interfaces.
- Build good relationships among different parties involved with the construction projects to get effective communication, coordination, and cooperation among them.
- Minimize project complexity by improving subcontracting and work packaging.
- Identify the interfaces at early stage of the project which minimize the interfaces issues within the project phases.
- Assist project participants to have a deep-understanding of project difficulty.

Table 1: List of the Interfaces Categorization

| Interfaces categorization | References |
|---|---|
| Physical Interfaces, Contractual Interface, Organizational Interfaces. | Gibb and Pavitt 2003 |
| Information Interfaces | Experts from industry |
| Inadequate Contract And Specification, Financial Problems, Environmental Problems, And Other Problems. | Al-Hammed 2000 |
| Management, Experience, Coordination, Contract, Acts Of God, And Regulation. | Huang 2008 |
| Management, Experience, Negotiation, Contract, Unavoidable, And Law. | Ku et al. 2010 |
| Physical, functional, contractual/organizational, and resource interfaces | Chen et al. 2010 |

### 2.4 Project Performance Measurement

A summary of project performance measurement indicators is provided under this section as shown in Table 2. In terms of quality of the built facilities and project performance, the interface problems and issues have been recognized to considerably harm the construction industry (Chen et al. 2010). Despite the project performance measurements are significant topic in construction industry, the data on the project performance measurements are very limited. There are no specific standards to measure the project performance (Costa et al. 2004 a). Generally, insufficient project performance measurement is one of the major problems affects construction industry (Costa et al. 2004). Many researchers have discussed and reported a numerous methods and indicators to measure the project performance. In 1992, principles have been developed to measure the project success among owners, designers, and contractors (Sanvido et al. 1992). All of them are in agreement that, the successful projects have to meet the budget and the schedule, have no legal claims, as well as meet the profit goals. Weston and Gibson

(1993) have measured many project performance indicators in terms of; value engineering savings, change-order cost, cost growth, schedule growth and claims cost. Pocock, J.B. et al. (1996) presented an approach for measuring the relationship between the project participants communication and project performance indicators in terms of cost growth, schedule growth, number of contract modifications, claims cost, value-engineering savings, and safety information. Bassioni et al. (2004) reviewed the major performance measurement frames and their implantation in U.K construction companies as well as the relationships between the performance measurement and strategic management. Barraza and Bueno (2007) set up a new probabilistic project control idea to guarantee a suitable forecast of project performance related to not go beyond schedule risk level and planned budget. This idea includes in the implementation of performance control limit curves for both actual cost and beyond time. Also, there are some performance measurements that have been established for benchmarking in different countries; Australia, Brazil (Costa et al. 2004 b), Chile (CDT 2002), the UK (KPI 2001) and the U.S.A (CII 2000).

Table 2: The Common Used Project Performance Indicators

| **Indicator** | **Reference** |
|---|---|
| Field Rework Factor | CII 2000 |
| Schedule Deviation | Sanvido et al. 1992, Weston and Gibson 1993, Pocock J.B. et al. 1996, Griffith et al. 1999, KPI 2003, CDT 2002, CII 2000 |
| Change Cost Factor | CII 2000 |
| Urgent Orders | CDT 2002 |
| Subcontracting | CDT 2002 |
| Quality (Defects) | KPI 2003 |
| Safety (Incident rate) | KPI 2003, CII 2000 |
| Safety (Lost workday incident rate) | CII 2000 |
| Number of Contract Modifications<br>Percent Amount of Contract Modification | Pocock, J.B. et al. 1996, CDT 2002 |
| Number of Claims Percent Amount Of Claims | Weston and Gibson 1993 |
| Value Engineering Savings | Weston and Gibson 1993 |
| Client Satisfaction | KPI 2003, Ilhan et al. 2005 |
| Productivity | KPI 2003, CDT 2002 |
| Cost Deviation (total cost, phase cost, etc.) | Sanvido et al. 1992, Weston and Gibson 1993, Pocock, J.B. et al. 1996, Alarcon and Ashley 1996, Griffith et al. 1999, KPI 2003, CDT 2002, CII 2000 |

## 2.5 Risk Analysis

This section is aimed to provide a comprehensive literature review on the concept of risk and risk analysis. The existing body of knowledge in the area of risk and uncertainty, risk management process, and risk analysis process were summarized. The beneficial information from the previous studies is reviewed and reported.

### 2.5.1 Risk Definition

Although many researchers have discussed and reported definitions of the term “Risk, there is no specific meaning for this term. There is a variety of viewpoint of what risk means. It is varies from one context to another one and from one industry sector to another one (Moskowitz and Bunn 1987). For instance, the Project Management Body of Knowledge (PMBOK) defined the risk as “an uncertain event or condition that, if it occurs, has a positive or a negative effect on at least one project objective, such as time, cost, scope or quality” (PMI 2004, 238). The Association for the Advancement of Cost Engineering (AACE) (2007) offer definition of the term risk as follows (1) “The degree of dispersion or variability around the expected or "best" value”. (2) “An ambiguous term that can mean any of the following: a) All uncertainty (threats + opportunities); or

b) Downside uncertainty (threats); or (c) The net impact or effect of uncertainty (threats - opportunities)". (3) "Probability of an undesirable outcome" (Abdelgawad 2011, 18). Al-Bahar and Crandall defined risk as "the exposure to the chance of occurrences of events adversely or favorably affecting project objectives as a consequence of uncertainty" (1990, 535). Baloi and Price defined risk in the construction industry as" the likelihood of a detrimental event occurring to the project" (2003, 262). Jannadi and Almishar defined risk as "a measure of the probability, severity, and exposure of all the hazards of an activity" (2003, 492). Cooper et al. defined risk in a project context as "the chance of something happening that will have an impact upon objectives" (Abdelgawad 2011, 17). AbouRizk is defined the risk as: "The possibility of suffering loss or harm and the impact (safety, health, environment, investment etc.) that loss brings onto the involved party. Risk can be characterized in terms of its severity" (2008, 2).

### 2.5.2 Risk Analysis Process

AbouRizk (2008) identified the Risk Analysis as "The process of identifying risk factors and quantifying those factors to estimate the likelihood and magnitude of their impact" (AbouRizk 2008, 2). Abdelgawad (2011) has discussed various techniques to quantify the risk event of the construction projects (qualitative and quantitative) and summarized the advantage and disadvantage for each technique.

## 2.6 Prediction Model

Generally, there are many tools being used for project management performance prediction modeling. They are quantitative (analytical techniques), qualitative (administrative tools), or computer tools (software and hardware) (ENCI 619.61 2006). In the last two to three decades, Information technologies applications in construction (ITC) tools turn out to be an important topic in construction projects to support the decision makers. The information technology (IT) application is must for more effective and efficient IM, due to the complexity of the interface management (IM) (Chen et. al. 2010). Despite the awareness of the interface management issues is widely recognized, the IT oriented IM tools and approaches are delayed (Chen et. al. 2010). El-Ghandour and Al-Hussein (2003 and 2004) discussed the use and integration of nine ITC tools within 43 construction areas (for example, scheduling, risk management, quality management, etc) between 1992 and 2001. Tools are Simulation (AbouRizk and Hajjar 1998), 3D rendering, fuzzy set theory (FS), expert system (ES), database system (DB), data modeling (M), geographic information systems (GIS), neural networks (NN), and virtual reality (VR). In addition to these tools, others can be used to predict the outcomes of IM such as, Regression models, Fuzzy techniques, Neural Networks, and Hybrid techniques (Fuzzy Neural Networks, Fuzzy Clustering, Fuzzy Expert System, and Bayesian belief networks (BBNs).

## 2.7 Areas for Improving Interface Management Performance

Many researchers have reported the procedures or areas for improving the interface management performance among different parties involved in different construction projects, as shown in Table 3.

Table 3: List of the Areas for Improving the Interface Management Performance

| Procedures or Areas | Reference |
|---|---|
| Identify, as early as Possible, The Interface Responsibilities. | Pavitt and Gibb 2003 |
| Applying of Management and Communication Techniques Among Different Parties Involved In The Projects. | Center for Chemical Process Safety 2004 |
| Implement Engineering, Procurement, and Construction Standards. | Alarcon and Mardones 1998 |
| Coordinate among Multi-Disciplines and Specialties. | Alarcon and Mardones 1998 |
| Control of the Circulation of Data Within the Project Teams. | Pavitt and Gibb 2003 |
| Through the Construction and Commissioning of New Facilities, Define a Clear Simultaneous Operation (Simops) Procedure of Existing Facilities. | Collins and Durham 2008 |

## 3. RESEARCH METHODOLOGY

### 3.1 Research Design and Approach

The basis for research design and approach presents under this section. Usually, the most appropriate tools for collecting data in construction projects are; complete literature review, direct (continuous) observations of individual worker, interviews that consist of qualitative (open-ended) and quantitative questions, and questionnaire surveys that including qualitative and quantitative questions. This section presents different phases of proposal model. Previous study was accomplished to categorize the IM factors contributing in interface conflicts among different parties engaged in different projects in two stages as shown on Figure 1. The First stage, a complete literature review and pilot studies in industry were performed. It concluded the recognition of major 47 interface problems. Second stage, a web-based online survey was performed with participants from industry. Reader can be referring to Weshah et al. (2012) for further details about this previous study. The research survey questions were designed based on the interface problems and issues, and project performance indicators; quality management, schedule management, cost management, scope management, safety, and team work. Based on the results of a previous research study regarding the analysis and extraction factors of independent variables (interface problems) using exploratory factor analysis, four phases will be conducted in this research as shown in Figure 2, as follows:

**First Phase: Developing and Applying a Multiple-Regression Analysis Model**

As the first step to examine the collected data, this phase develops and applies a multiple regression analysis model between the underlying interface problem factors and the project performance indicators; quality, cost, schedule, scope, team work, and safety. This will measure interrelationship of each IM factor and each construction project performance indicator. The followings is the hypothesis that has been established for that: There would be significant regression coefficient between the extracted IM factors and each performance indicator; quality management, schedule management, cost management, scope management, safety, team work.

**Second Phase: Identification of the Severity of Each IM Problem**

This phase measures the severity of each IM problem on project performance by using risk analysis method. The participants were being asked to assess the interface problems' impact and probability of occurrence on interface management IM.

**Third Phase: Development of the Model and the Validation**

Based on results of previous two phases, this phase develops a model for prediction of project performance based on expected IM.

**Fourth Phase; Defining Areas for Improving IM**

Based on the previous three phases, last phase collects data regarding existing and proposed interface management procedures and/or areas for improving interface management performance by conducting in-depth interviews. Accordingly, provides practical guidelines of suggestions and recommendations for improving and enhancing the IM that is adequate to all parties engaged in Alberta construction projects.

### 3.2 Research Methods

The research methodology has been discussed based on the combination of qualitative and quantitative methods in the previous section.

Three integrated steps were used to apply these methods; Literature survey, data collection, and data analysis.

### 3.2.1 Literature Survey

Recent publications on the area of interface management (IM) for construction projects are evaluated and reported under this section by reviewing conference proceeding, journals paper and previous related studies.

### 3.2.2 Data Collection

Data were collected from different types of construction projects including: oil and gas, commercial and buildings infrastructure transportation, and manufacturing. As well as, different types of companies were included in data collection such as Engineering Procurement and Construction (EPC), owner, Engineering Procurement and Construction Management (EPCM), construction management companies, construction contractor/sub-contractor, engineering consultant, architecture, and architecture and engineering. Furthermore, all the parties that engaged in the construction process, consisting: engineers construction managers, procurement staff, quality engineers, safety leader, architects, planners, project engineers, and project controllers were included in the data collection. Two techniques were used to collect the data; questionnaire, and in-depth interviews after the survey. The next two sections will discuss these two techniques in details. The questionnaire has been circulated through the members of the following associations and groups: The Association of Professional Engineers and Geoscientists of Alberta (APEGGA), Project Management Focus Group (PMFG), Consulting Engineering for Alberta (CEA), Consulting Architects of Alberta, and Alberta Construction Association (ACA).

#### 3.2.2.1 Empirical Questionnaire and Data Collection

Based on interface problems that were collected through the literatures, the pilot studies, face-to-face interviews, and the format recommended by professionals in industry in previous study, the survey questionnaire was designed. The survey includes quantitative and qualitative questions in two sections; demographic information, and interface problems. The research survey questions were designed based on the interface problems, and project performance indicators; quality schedule, cost, scope, safety, and team work as shown in Table 4. Two techniques were used to design appropriate questionnaire; the checklist and rating scale. The participants were being invited to assess the impact of 47 interface problems on interface management performance and overall project performance. Six and seven Likert scales were built to get the survey questionnaire responses with the end points being; extremely unlikely to very likely, negligible to disastrous, and unimportant to very important. Many researchers have recognized that Likert scale is appropriate for perception-oriented questions.

#### 3.2.2.2 In-depth interviews

After conducted the survey, in-depth interviews will be conducted to collect data concerning existing and proposed interface management procedures or areas to improve IM performance.

### 3.2.3 Data Organizing, Analyzing, Interpreting, and Modelling Stage

Both quantitative and Qualitative will be analyzed to deal with the research questions.

#### 3.2.3.1 Qualitative Data Analysis

The following steps will be used to analyze the qualitative data collection of in-depth interviews of areas and procedures to improve IM (Creswell, 1998) as follows: Organizing, Scrutinizing, Categorizing, Synthesizing.

3.2.3.2 Quantitative Data Analysis

A multi-regression analysis tool will be used to analyze the data collected from the survey. The multiple regression models will be used to investigate the relationship between the extracted interface management problems factors and the project performance indicators (quality, schedule, cost, scope, safety, and team work). Risk matrix will be used for risk analysis of IM problems and their impact on project IM performance. Third, a prediction tool will be used for prediction of existing or expected IM on overall project performance for example, simulation using Simphony (AbouRizk and Hajjar 1998).

Table 4: Survey Question Sample

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Extremely Unlikely … Very Likely | Negligible … Disastrous | Unimportant … Very Important | | | | | |
| | 1 2 3 4 5 6 | 1 2 3 4 5 6 | 1 2 3 4 5 6 7 | | | | | |
| IM problems | Probability of occurrence | Impact | Project performance | | | | | |
| | | | Quality | Schedule | Cost | Scope | Safety | Team Work |
| Lack of project management | | | | | | | | |

IM problems | IM risk analysis model | IM problems Impact on Project Performance

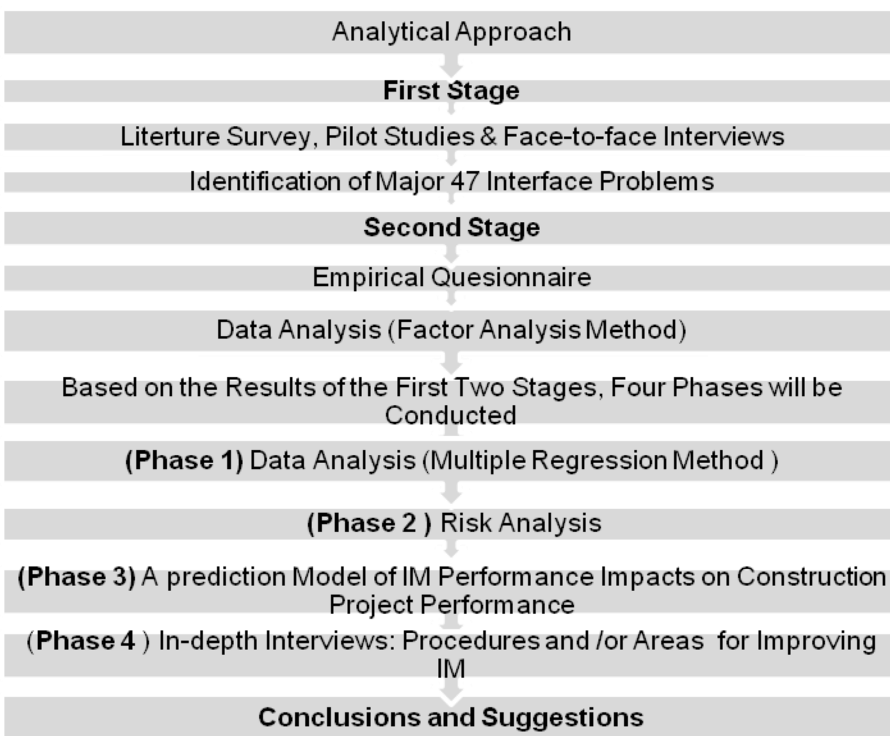


Figure 1: Analytical Block Diagram for Integrated Construction IM Model Development

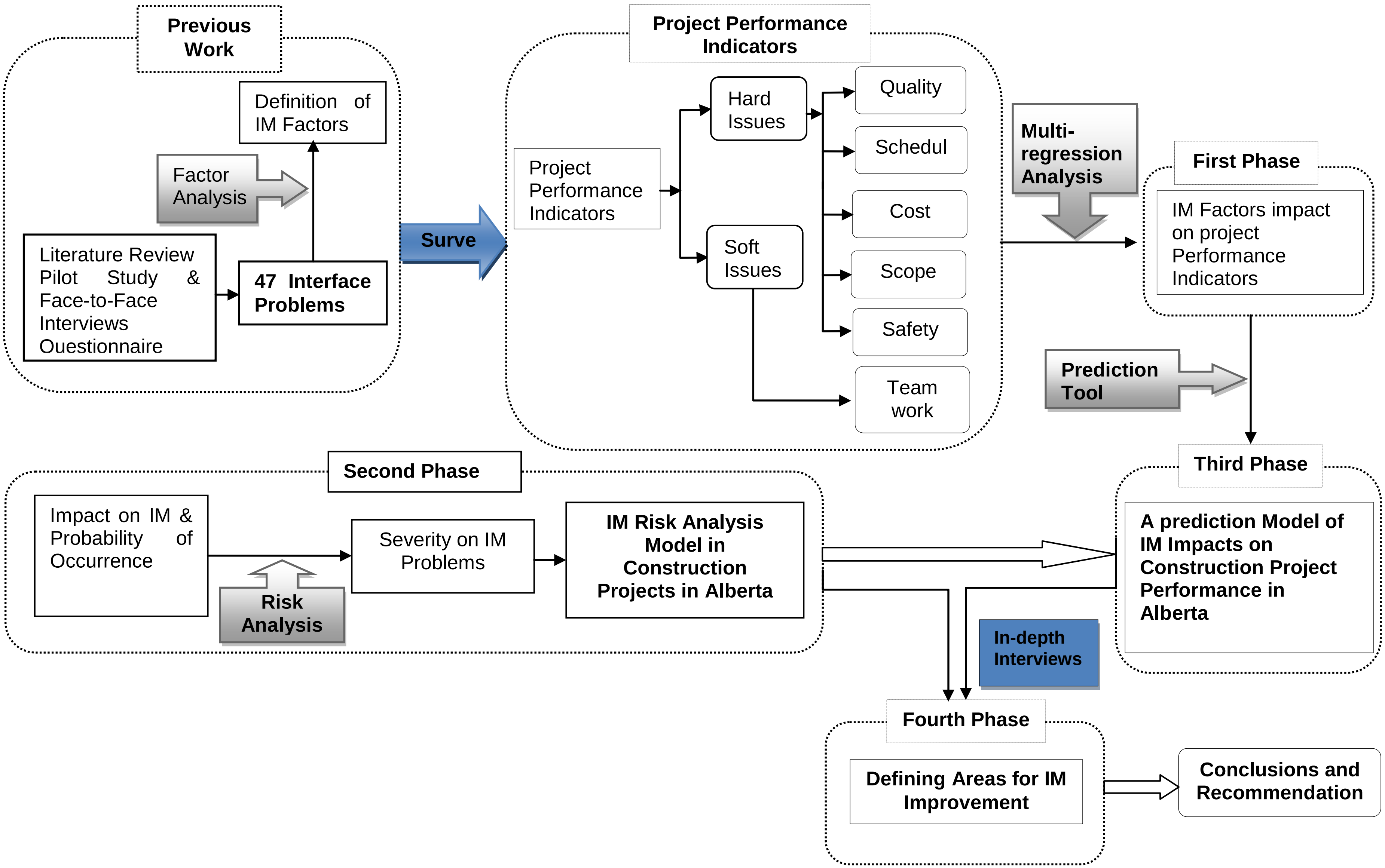


Figure 2: Diagram for Construction Projects integrated Interface Management (IM) Model Framework

## 4. CONCLUSIONS AND POTENTIAL FUTURE RESEARCH

Based on the previous identified major interface management factors impacting construction project performance, a new integrated IM model framework is introduced in this paper. The contribution by this work will help construction industry in Alberta to predict project performance and overall project performance at early stage of the project initiation. This could assist project managers to focus on certain tools, areas, and procedures and improve them at the early stage of the project life cycle to optimize overall project performance.

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