CHAPTER 1
INTRODUCTION TO INFORMS & THE CAP® PROGRAM

The Institute for Operations Research and the Management Sciences (INFORMS) is an international scientific society with more than 11,000 members, including Nobel Prize laureates, dedicated to applying scientific methods to help improve decision making, management, and operations. Members of INFORMS work in business, government, and academia.

INFORMS serves the scientific and professional needs of operations research analysts, experts in analytics, consultants, scientists, students, educators, and managers, as well as their institutions, by publishing a variety of journals that describe the latest research in operations research.

INFORMS commissioned a study in 2010 by Capgemini Consulting to evaluate the need for embracing the analytics community as a key membership strategy for the Institute. The Capgemini study concluded that INFORMS should embrace the analytics community and that one of the first initiatives should be a detailed study on the development of a certification and training program to meet the needs of this market.

Further market research corroborated this finding. Mike Hamm of Michael Hamm and Associates wrote of his market research—done in 2011 on behalf of INFORMS—that "I have never seen a candidate audience where [there is such] a high degree of political interest regarding the potential composition and architecture of a future certification program. Everybody wants a piece of this... ."

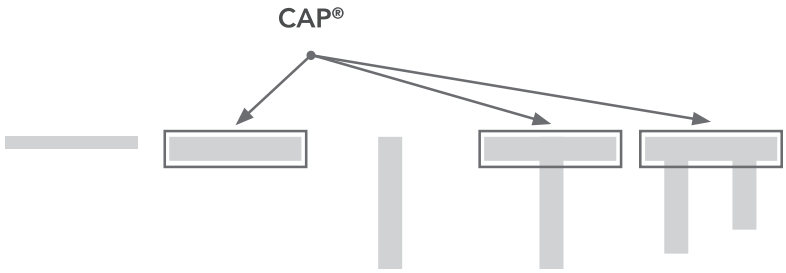
INFORMS defines analytics as the scientific process of transforming data into insight for making better decisions. It is seen as an end-to-end process beginning with identifying the business problem to evaluating and drawing conclusions about the prescribed solution arrived at through the use of analytics. Analytics professionals are skilled at this process.

INFORMS established the analytics certification program to advance the use of analytics by setting agreed upon standards for the profession. The program also advances the analytics profession by providing a means for organizations to identify and develop qualified analytics professionals, by contributing to the career success and continued competence for analytics professionals, and by improving the credibility and visibility of the analytics profession.

INFORMS vision for the Certified Analytics Professional (CAP®) program is to advance the use of analytics to transform the world by setting agreed-upon standards for the profession. The INFORMS mission for the CAP® program is

to advance the analytics profession by providing a high-quality program of certification and by promoting continuing competence for practitioners.

Once INFORMS decided to pursue a certification program, the practicalities of creating the program and its accompanying exam were addressed. According to an article in *Analytics Magazine*, September/October 2012 by Scott Nestler, Jack Levis, and Bill Klimack, the CAP® program is appropriate for the analytical semi-professionals as well as the analytical professionals. However, it will not be a suitable certification for the "analytical amateurs" as depicted in the following graphic (Nestler et al. 2012, Figure 2). The assessment instrument—the exam—contains 100 multiple choice test items and is being administered via paper and pencil for the first year. INFORMS is investigating the possibility of moving to computer-based testing for subsequent years to facilitate serving its international membership.



	(a)	(b)	(c)	(d)	(e)
Analyst Type (Davenport)	Amateur	Semi-professional	Professional	Professional	Professional
Shape	"bar-shaped"	"bar-shaped"	"I-shaped"	"T-shaped"	"Pi-shaped"

Figure 1: Possible shapes of analytics knowledge

For more information on the development of the CAP program, read "Steering Toward Analytics" in *OR/MS Today*, June 2013 (p. 30) by Gary Bennett and Jack Levis.

ABOUT THE PROFESSIONAL JOB TASK ANALYSIS

A job task analysis (JTA) is a comprehensive description of the duties and responsibilities of a profession, occupation, or specialty area; our approach consists of four elements: 1) domains of practice, 2) tasks performed, 3) knowledge required for effective performance on the job, and 4) domain weights that account for the importance of and frequency with which the tasks are performed. More specifically, the JTA for the CAP® program can be viewed as an outline of a partial body of knowledge, as it represents a delineation of common or typical tasks performed and knowledge applied by analytics professionals, grouped together in a hierarchical domain structure. In the course of analytics work, these tasks may be performed multiple times with modifications based on data, findings, and results, as part of ongoing feedback loops that are routinely a part of practice. The JTA serves as the test blueprint for exam development and links what is done on the job to what is measured by the certification examination. This linkage is necessary to establish a valid, practice-related examination. It is important to realize that the JTA is a dynamic document that will change in the future to reflect best practices and changes in the analytics profession.

The JTA study defines the current knowledge, skills, and abilities (KSAs) that must be demonstrated by analytics professionals to effectively and successfully provide these services. KSAs are validated according to their frequency of use and importance. The JTA also serves as a "blueprint" for the content (performance domains) of the INFORMS CAP® examination.

INFORMS upholds stringent guidelines for the construction and implementation of the examination development and administration process. An 11-member panel of subject matter experts (SMEs) was selected to develop the first JTA for the CAP® credential. This group was called the Analytics Certification Job Task Analysis Working Group.

The following leaders in the analytics profession were selected to participate in this important project:

- Arnold Greenland (IBM Global Business Services)
- Bill Klimack (Chevron)
- Jack Levis (UPS)
- Daymond Ling (Canadian Imperial Bank of Commerce)
- Freeman Marvin (Innovative Decisions, Inc.)
- Scott Nestler (Naval Postgraduate School)
- Jerry Oglesby (SAS)
- Michael Rappa (North Carolina State/ Institute for Advanced Analytics)
- Tim Rey (Dow Chemical)
- Rita Sallam (Gartner)
- Sam Savage (Stanford/Vector Economics)

The findings of this working group were then validated by a random sample of practicing analytics professionals. Feedback from this survey resulted in slight modifications of the performance domains, tasks, and knowledge that comprise the test blueprint that determines the content of the CAP® examination.

In developing the JTA, members of the working group relied on their knowledge of practice gained from years of experience, academic program content, corporate job descriptions in analytics, and articles from professional and scholarly publications.

The following table includes the final domains and weights derived from the JTA and a review of validation survey recommendations.

Domain	**Approximate Weight**
I. Business Problem (Question) Framing	12%–18%
II. Analytics Problem Framing	14%–20%
III. Data	18%–26%
IV. Methodology (Approach) Selection	12%–18%
V. Model Building	13%–19%
VI. Deployment	7%–11%
VII. Model Life Cycle Management	4%–8%

The INFORMS CAP® examination is based on the following test blueprint derived from the JTA process. The final agreed-upon weights reflect the percentage of questions from each domain that will be included in each test form.

The JTA and the test blueprint resulting from this process will be reviewed periodically and updated as needed to reflect current practices in analytics. The list of domains and key tasks follows:

(12%–18%) Domain I Business Problem (Question) Framing

(The ability to understand a business problem and determine whether the problem is amenable to an analytics solution.)

T-1 Obtain or receive problem statement and usability requirements
T-2 Identify stakeholders
T-3 Determine whether the problem is amenable to an analytics solution
T-4 Refine the problem statement and delineate constraints

T-5 Define an initial set of business benefits
T-6 Obtain stakeholder agreement on the business problem statement

(14%–20%) Domain II Analytics Problem Framing

(The ability to reformulate a business problem into an analytics problem with a potential analytics solution.)

T-1 Reformulate problem statement as an analytics problem
T-2 Develop a proposed set of drivers and relationships to outputs
T-3 State the set of assumptions related to the problem
T-4 Define key metrics of success
T-5 Obtain stakeholder agreement on the approach

(18%–26%) Domain III Data

(The ability to work effectively with data to help identify potential relationships that will lead to refinement of the business and analytics problem.)

T-1 Identify and prioritize data needs and sources
T-2 Acquire data
T-3 Harmonize, rescale, clean, and share data
T-4 Identify relationships in the data
T-5 Document and report findings (e.g., insights, results, business performance)
T-6 Refine the business and analytics problem statements

(12%–18%) Domain IV Methodology (Approach) Selection

(The ability to identify and select potential approaches for solving the business problem.)

T-1 Identify available problem solving approaches (methods)
T-2 Select software tools
T-3 Test approaches (methods)*
T-4 Select approaches (methods)*

(13%–19%) Domain V Model Building

(The ability to identify and build effective model structures to help solve the business problem.)

T-1 Identify model structures*
T-2 Run and evaluate the models
T-3 Calibrate models and data*
T-4 Integrate the models*
T-5 Document and communicate findings (including assumptions, limitations, and constraints)

**Tasks that are beyond the scope of the CAP® certification exam and will not be tested.*

(7%–11%) Domain VI Deployment

(The ability to deploy the selected model to help solve the business problem.)

T-1 Perform business validation of the model
T-2 Deliver report with findings; or
T-3 Create model, usability, and system requirements for production
T-4 Deliver production model/system*
T-5 Support deployment

(4%–8%) Domain VII Model Life Cycle Management

(The ability to manage the model life cycle to evaluate business benefit of the model over time.)

T-1 Document initial structure
T-2 Track model quality
T-3 Recalibrate and maintain the model*
T-4 Support training activities
T-5 Evaluate the business benefit of the model over time

The knowledge statements for the CAP® program have been identified but not individually assigned to each task. The knowledge statements appropriate to a given task have been used. Not all statements are appropriate for all tasks, although there may appear to be some blanks in coverage this is not the case.

K-1 Characteristics of a business problem statement (i.e., a clear and concise statement of the problem describing the situation and stating the desired end state or goal)

K-2 Interviewing (questioning) techniques (i.e., the process by which a practitioner elicits information and understanding from business experts, including strategies for the success of the project)

K-3 Client business processes (i.e., the processes used by the client or project sponsor that are related to the problem)

K-4 Client and client-related organizational structures

K-5 Modeling options (i.e., the analytic approaches available for seeking a solution to the problem or answer to the question including optimization, simulation, forecasting, statistical analysis, data mining, machine learning, etc.)

K-6 Resources necessary for analytics solutions (e.g., human, data, computing, software)

**Tasks that are beyond the scope of the CAP® certification exam and will not be tested.*

K-7 Performance measurement (i.e., the technical and business metrics by which the client and the analyst measure the success of the project)

K-8 Risk/return (i.e., trade-offs between prioritizing the primary objective and minimizing the likelihood of significant penalty taking into account therisk attitude of the decision maker)

K-9 Presentation techniques (i.e., strategies for communicating analytics problems and solutions to a broad audience of business clients)

K-10 Structure of decisions (e.g., influence diagrams, decision trees, system structures)

K-11 Negotiation techniques (i.e., strategies and methods that allow the analytics professional to reach a shared understanding with the client)

K-12 Data rules (e.g., privacy, intellectual property, security, governance, copyright, sharing)

K-13 Data architecture (i.e., a description of how data are processed, stored, and used in organizational systems including conceptual, logical, and physical aspects)

K-14 Data extraction technologies (e.g., scripting, spreadsheets/ databases,connection tools, standards-based connectivity options, unstructured data extraction tools)

K-15 Visualization techniques (i.e., any technique for creating images, diagrams or animations to communicate a message including data visualization, information visualization, statistical graphics, presentation graphics, etc.)

K-16 Statistics (descriptive, correlation, regression, etc.)

K-17 Software tools

THE FIVE E'S

The five E's are ethics, education, experience, examination, and effectiveness. These are the five pillars of the Certified Analytics Professional.

The CAP® credentialed person will have read, agreed to, and signed the code of ethics that governs behavior of a professional analyst. This code was created by the Task Force who are among the originators of the program (see Figure 1). The code is intended to describe the accepted behavior of an analytics professional. All candidates for the CAP® must agree to the code of ethics as part of the application process. Actions that are opposed to the code of ethics may be reason to rescind the CAP® credential.

Education is considered essential for the analytics professional. Candidates must have at least a bachelor's degree from a regionally accredited college or university. Experience goes hand in hand with education as part of the prerequisites for application. The higher and more appropriate the education earned, the less experience is required.

Examination is the fourth leg or pillar of the CAP® program. Through examination we seek confirmation that the applicant has knowledge of those areas of the job/task analysis that are considered essential for practice. Because the examination is based on a broad spectrum of practice rather than the content of a course or series of courses, it must be constructed with due care. Each test item or question has been created carefully so as to ensure a fair, valid, and reliable examination that discriminates against no one except for those who do not have the knowledge to earn the CAP® credential. Each item is reviewed and refined numerous times by a committee of subject matter experts in the field of analytics. The sole reason to use a test item is as a tool to determine who is knowledgeable. Because there may be a lot riding on the successful completion of the exam, the test items must be carefully crafted.

All test items are written with reference to the specific domain, task, and knowledge statements outlined earlier. Test items are also sourced to ensure that all items are readily available and should be known to everyone who is an analytics professional. No items are written based on proprietary data or sources that are known only to a select few. For examples, see the Candidate Handbook that contains 24 questions or items that are indicative of the style of test item but that do not themselves appear on the exam. In the future, there may be additional items that we will release from the item bank and use as practice test questions. The CAP® program is so new that INFORMS does not yet have items that have outlasted their usefulness as a discriminatory tool to distinguish between the knowledgeable and those who do not yet possess the knowledge.

The rules for item writing are specific and few:

- Avoid negative stems or questions as much as possible
- Do not use 'All of the above' or 'None of the above' as answer options
- Avoid excess verbiage
- Avoid disadvantaging any part of the test population but the unknowing
- Ask only one question at a time
- Ensure that the incorrect answers are incorrect for a specific reason

Effectiveness is the art of applying your knowledge and skill in a way that enables achievement of your organization's goals. The soft skills required are dealt with more fully in Appendix A: Soft Skills. Nevertheless, the skilled analyst must be diplomatic and aware enough to understand the context of the business problem and the stakeholder agendas involved while not allowing that understanding to bias the process or the truth thereby developed.

The Certified Analytics Professional (CAP®) program is not the work of one person or one department: it would not have been possible without the support of professionals in the field. You can see a long list of those professionals on the INFORMS website under Contributors (www.informs.org/Certification-Continuing-Ed/Analytics-Certification/Contributors).

This study guide is the culmination of a massive collaborative effort among concerned professionals to develop a guide that will assist future CAPs. The guide is not intended to give the answer to each and every test question. Rather, it is intended to guide the individual toward the knowledge of an analytics professional and to let the individual use his or her discretion as to areas that warrant further study. The guide includes reference materials for this further study. The guide is also intended to be a comprehensive outline for those who are working in, intend to work in, or are preparing to work in an analytics area. Because being an effective analytics professional is as much of an art as a science, the study guide relies heavily on case studies, examples, and stories.

If you have comments on the guide, the certification program, or wish to assist with the further development and dissemination of the CAP® program, please feel free to e-mail certification@informs.org.

CHAPTER 2
DOMAIN I – BUSINESS PROBLEM FRAMING

WHAT WILL YOU LEARN IN THIS CHAPTER?

In this chapter, you will learn about the first step of an analytics project: framing the business problem. You will learn, as a part of these processes, how to determine the business problem, identify and enlist stakeholders, determine if the problem has an analytics solution, refine the problem statement as necessary, and define the set of business benefits.

Learning Objectives

1. Obtain or receive the problem statement and usability requirements
2. Identify stakeholders
3. Determine whether the problem is amenable to an analytics solution
4. Refine the problem statement and delineate constraints
5. Define an initial set of business benefits
6. Obtain stakeholder agreement on the business problem statement

Key Concepts/Fundamentals

OBJECTIVE 1. RECEIVE & REFINE THE BUSINESS PROBLEM

A business problem statement generally starts by describing a business opportunity or threat, or an issue in broad terms. For example, it could simply start by saying 'our growth has been stagnant for the last two years' or a bit less broad 'our Seattle plant is experiencing production problems and is missing deadlines.' Most client firms in their early meetings with you (the analytics professional) will tend to report what they are experiencing as problems. As they do that, they will use their own language and key terms. Do get definitions of all terms, as meanings change between organizations.

Another factor to consider is that the client firm representatives in these meetings also play an important role in what is reported and how it is reported. It is natural that each representative (of the firm) uses their own lenses and contexts to report (and thus frame) the way they see the problem. These views are all very important on their own merits because they inform the analyst in some useful way. However,

because of the individual lenses used to report these observations, sometimes these views can have a good degree of variance regarding causes and effects, and thus may obscure the real issues.

One popular way to frame a business opportunity or problem is to obtain reliable information on the five W's: who, what, where, when, and why.

- Who: are the stakeholders who satisfy one or more of the following with respect to the project: funding, using, creating, or affected by the project's outcome.
- What: problem/function is the project meant to solve/perform?
- Where: does the problem occur? Or where does the function need to be performed? Are the physical and spatial characteristics articulated?
- When: does the problem occur, or function need to be performed? When does the project need to be completed?
- Why: does the problem occur, or function need to occur?

OBJECTIVE 2. IDENTIFY STAKEHOLDERS

Of the five W's, who (the stakeholders are) is probably the most critical to the long term success of the project. Stakeholders are anyone affected by the project, not just those in the initial meetings, and they may have different levels of input or involvement during the project. A stakeholder analysis helps identify the following:

- The interests of all stakeholders, who may affect or be affected by the project, along with their constraints.
- Potential issues that could disrupt the project.
- Key people for information distribution during execution phase.
- Groups that should be encouraged to participate in different stages of the project.
- Communication planning and stakeholder management strategies during the project planning phase.
- Ways to reduce potential negative impacts and manage negative stakeholders.

OBJECTIVE 3. DETERMINE WHETHER THE PROBLEM IS AMENABLE TO AN ANALYTICS SOLUTION

Before more time and money is spent on solving the problem, it is time to figure out if this problem is likely to have an analytics solution. First of all, does the answer and the change process to get there lie within the organization's control? Second, does the requisite data exist or can it be obtained? Third, can the likely problem be solved and/or modeled? Last, but perhaps most importantly, can the organization accept and deploy the answer? The problem may not be amenable to an analytics solution because of the characteristics of the problem or the limitations of the analytic tools/methods available. The problem statement could be reassessed to make it amenable to the available analytic tools/methods, or if this is not possible, the project deemed not feasible. If there isn't a feasible way forward, the ethical analyst will say so to the key stakeholders.

For the Seattle plant example, it may be decided to use mathematical optimization software to improve the plant's process. This will work as long as data exist on inputs and outputs for each step in the plant process, and as long as the stakeholders are willing to accept new ways of operating that won't necessarily match current work policies and procedures.

OBJECTIVE 4. REFINE PROBLEM STATEMENT & DELINEATE CONSTRAINTS

After the initial analysis, it may be necessary to refine the problem statement to make it more accurate, more appropriate to the stakeholders, or more amenable to available analytic tools/methods. As part of this process, it will become necessary to define what constraints the project will operate under. These constraints could be analytical, financial, or political in nature.

For the Seattle plant example, an optimization problem with a large number of constraints or a complex objective function may not be solvable within the capability of the available software/hardware combination. In this case the problem may need to be restated with fewer constraints and/or a less complex objective function. This may cause the problem statement to be updated to make sure that the approach will satisfy—just to name a few of the potential constraints—desired accuracy and repeatability, program cost, timeframe, and number of stakeholders impacted, either positively or negatively.

OBJECTIVE 5. DEFINE AN INITIAL SET OF BUSINESS BENEFITS

With the problem statement set, it is now possible to define the initial set of business benefits. These benefits may be determined quantitatively or qualitatively. If quantitative, it may be financial (e.g., net present value) or contractual (e.g., service level agreements). This is also known as the business case.

For the Seattle plant example, an initial determination of the financial benefit due to optimal use of resources should be determined along with an initial view of the required project goals determined, e.g., plant is currently losing money at the rate of 3% of gross sales with current performance and needs to come to 5% margin on gross sales. The key profit driver is on-time performance, which is currently 68% and needs to get to 98%. How will it get there? At this stage we think it is because there is plant capacity being wasted, so we're going to look at optimizing our scheduling and manufacturing processes to reduce overall time by reducing queue and wait time. You'll note that we haven't said, yet, that we're going to simulate incoming orders with one distribution and performance of each machine on the floor with their own distributions, even though we may be thinking about doing just that. At this stage, the problem is a business problem and the objectives are business objectives.

OBJECTIVE 6. OBTAIN STAKEHOLDER AGREEMENT ON THE PROBLEM STATEMENT

With the problem statement refined and the initial business benefits determined, it is necessary to obtain stakeholder agreement before proceeding further with the project. It may be necessary to repeat this cycle several times until stakeholder concurrence with the particulars of the project are achieved and permission to proceed is granted. At the end of this process, you will have agreement on the project's objectives, initial approach, and resources to get there.

SUMMARY

Although business problem framing is not the analytical heart of an analytics project, it is probably the most important because it sets the expectations and limitations of the project.

FURTHER READING

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