3.5 **USE OF A BUSINESS PROCESS MODEL AS A TEACHING TOOL IN AN UNDERGRADUATE WEATHER FORECASTING COURSE**

John M. Lanicci *
Embry-Riddle Aeronautical University, Daytona Beach, Florida

1. INTRODUCTION

A new approach is presented to teaching a senior-level undergraduate course, entitled *Forecasting Techniques*. The approach departs from more traditional practices of looking at forecasting as a purely scientific process by introducing a business process model as an organizing concept for the course.

The applied meteorology degree program at Embry-Riddle Aeronautical University's (ERAU) Daytona Beach campus has been in existence since 2000. At the end of the fall 2007 semester, there were 106 undergraduate majors and 35 minors in the program. *Forecasting Techniques* is a three-credit course. It is the second in a three-course sequence that begins with a five-credit *Weather Analysis* course (essentially a combination of basic and advanced synoptic meteorology and computer applications), and ends with a capstone course called *Weather Operations Seminar*, which prepares the students for the different types of career paths that may be chosen upon graduation.

The motivation for taking a different approach to teaching the forecasting techniques course results from the realization that modern weather forecasting has become a process that is too complex to study from the scientific perspective alone. The author researched several U.S. undergraduate programs and noted that forecasting topics are no longer covered in a single course from a technical perspective, but now appear in a variety of courses with various formats; these include:

1) Current weather discussions (some held in collaboration with National Weather Service (NWS) forecasters in places where the local NWS office is collocated with or is nearby a university meteorology department);

2) Forecasting labs and practicums:

3) Traditional lecture courses with exercises.

It is also well known that weather and climate information are being used by an increasing number of small and large businesses to mitigate risk and gain competitive advantages (see, for example, the Weather Risk Management Association's web site, http://www.wrma.org/default.asp). Several large university meteorology programs have adapted to these new practices by offering concentrations at undergraduate and graduate levels. See, for example, Penn State University's Weather Risk Management option (see the web site http://www.met.psu.edu/risk/course_info.html for more information), and the University of Oklahoma's Master of Science in Professional Meteorology program (http://weather.ou.edu/pdf/MSPM%20Brochure.pdf).

Additionally, the author's experiences with a similar process model used to describe U.S. Air Force weather operations provided a useful analytical tool for determining which portions of the weather forecasting process needed to be updated due to changes in user requirements, world events, and information technology.

In the classroom, the model was employed with the following educational purposes in mind:

1) To present weather forecasting as an orderly, organized process in order to help students focus the application of their knowledge obtained in previous meteorology courses;

2) To allow the subject of weather forecasting to be examined from the points of view of both a science problem as well as a business problem;

3) To introduce the students to the use of business process models, which they would not have seen in their other meteorology courses, but will be helpful to them in their professional careers;

4) To present the students with a useful organizing concept within which to integrate the lectures, assignments, and practicums that are used throughout the course.

In this paper, a brief history of the model is presented, along with details of the model and its use within the course.

* Corresponding author address: John M. Lanicci, Embry-Riddle Aeronautical University, Applied Meteorology Program, Daytona Beach, FL 32114-3900; e-mail: john.lanicci@erau.edu.

2. DESCRIPTION OF THE BUSINESS MODEL

2.1 History of the Business Model Used in the Course

The business model used in the course was originally developed by the U.S. Air Force to describe its weather operations in the 1990s. The first version of the model attempted to show how the collection of weather data, the analysis and forecast process, and the subsequent creation of tailored weather applications products allow military forces to “exploit” the weather against an adversary (Massie, et al., 1995; Lanicci, 1998). An early version of the model is shown in Figure 1. This version does not provide a lot of detail about how military operations actually use the weather in the decision-making process.

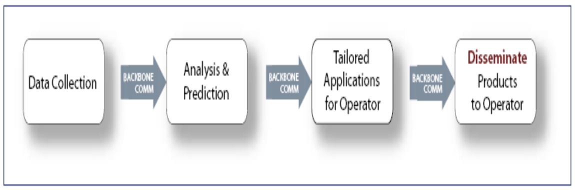

Figure 1. Air Force Weather Analysis and Forecasting Cycle as described by Massie et al. (1995) and Lanicci (1998).

A subsequent version of the model was introduced in a concept paper by Lanicci (2003), in which the linear process described in Figure 1 is transformed into a continuous cycle (Figure 2). In this construct, a four-dimensional environmental database is continuously updated with data from both conventional and non-conventional sources, and the information is integrated into various command and control operations at echelons throughout the military. It will be shown in the next section how the business model being used in the forecasting techniques course can be applied to the Next-Generation Air Transportation System, which intends to create a similar database and integrate weather into aviation decision-making throughout the community—not unlike what is shown in Figure 2 for the military side.

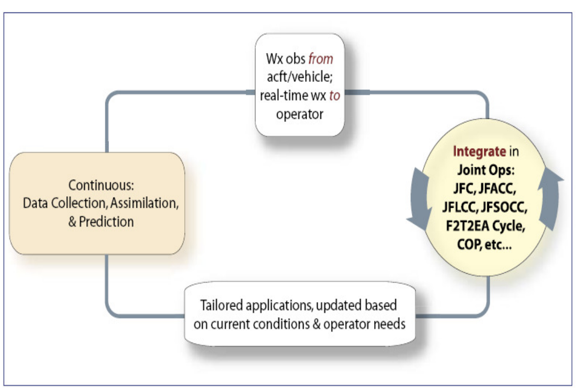

Figure 2. Revised Air Force Weather Analysis and Forecasting Cycle as described by Lanicci (2003).

It should also be pointed out that the military weather community is not the only entity that has employed a process model to describe the analysis and forecast process. Dutton (2002) used a similar construct to illustrate the opportunities available for weather and climate services at the start of this decade (see Figure 3).

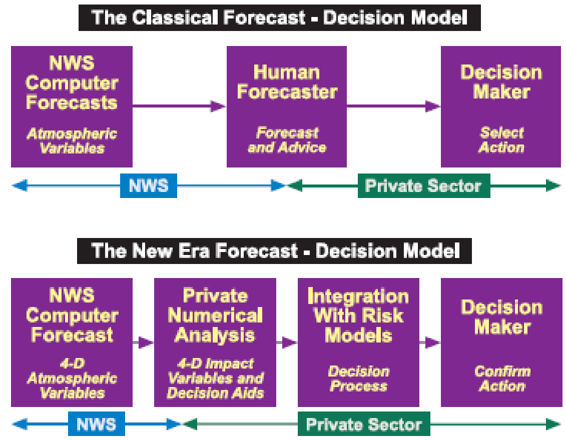

Figure 3. Weather Analysis and Forecast Cycle transformation in the public and private sectors as described by Dutton (2002).

2.2 The Business Model As Used in the Course

The version of the weather analysis and forecast cycle process model employed in the Forecasting Techniques course is adapted from the Air Force model of the mid 1990s from Figure 1, but is much more complicated (see Figure 4). This version of the model contains two primary “tiers”: 1) The weather analysis and forecast process; and 2) The provider-user relationship. These two tiers are introduced to the students in two parts.

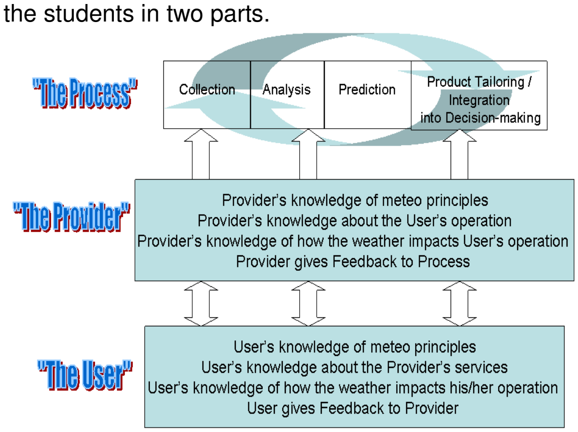

Figure 4. Business model employed in ERAU’s *Forecasting Techniques* course. The top portion of the model pertains to weather analysis and forecasting as a scientific process. The bottom portions of the model introduce the idea of weather forecasting from a business process perspective. The connecting arrows illustrate the interactions/feedback among the provider, user, and the technical portion of the analysis and forecasting process.

First, we studied the forecast process from the traditional scientific point of view, using the "Process" (top tier) portion of the diagram in Figure 4. This part of the course employed traditional lectures covering each phase of the analysis and forecast process, such as meteorological collection platforms and how they are evolving (*Collection*), the importance of data assimilation in operational numerical analysis and forecast systems (*Analysis*), and characteristics of numerical models run at the National Centers for Environmental Prediction (*Prediction*). The *Product Tailoring/ Integration into Decision-making* phase actually began with a discussion of numerical model post-processing (including an introduction to model output statistics), before moving into product tailoring for different user communities. A set of city-pair forecast exercises allows the students to apply the knowledge gained during this segment before moving on to the more complicated portion of the course.

At this point, we introduced the second tier of the business model, which examines the relationship between the *provider* of meteorological information and the *user* of that information. Within the *Provider-User* relationship, we briefly examine concepts pertaining to this relationship from both the points of view of the provider and the user. For example, in the segment of the model entitled *Provider's Knowledge of Meteo Principles*, we discuss concepts beyond basic course work that a forecaster needs to know, such as use of climatology in forecasting, knowledge of local effects (e.g., terrain, water bodies) and phenomenology (e.g., vulnerability to severe storms). Several homework and in-class exercises reinforce these ideas. Concurrent with this material, we examine the *User's Knowledge of Meteo Principles*. In this segment, we discuss "classes" of users, such as the general public, specialized users such as aircrews, and groups who could be *both* providers and users of weather forecasts (e.g., other forecasters, air traffic controllers). As we examine the different classes of users, we introduce the students to the concept of user requirements determination, a very complex process for which many scientific professionals are unprepared when they move into management positions later in their careers. Another concept that is examined during this phase is forecast verification and value-added. The *User's Guide to ECMWF Products* (Persson and Grazzini, 2005) has a very useful section on forecast verification and basic value-added concepts such as Cost/Loss ratio, and is utilized in this portion of the course.

The study of the Provider-User relationship is linked back to the process flow diagram when we examine how different types of users (e.g., general public, business, and the military) employ tailored weather forecast products and integrate them into their decision-making processes. The exercises introduced here give the students, now working in teams, experience in preparing different types of forecasts, varying from synoptic-scale products similar to those of the Hydrometeorological Prediction Center, to local forecasts for a hypothetical weather-sensitive customer.

The capstone for this portion of the course is a visit to the 45th Weather Squadron at Cape Canaveral Air Force Station to get a first-hand look at weather operations there, and how their tailored weather decision guidance is integrated into the decision-making process for space launches.

3. AN APPLICATION OF THE BUSINESS MODEL

The business process model also allows us to examine future changes in weather forecasting, driven by new user requirements and technology. During the academic year just completed, the author came across a number of examples of emerging weather dissemination technologies. One technology in particular, real-time information to the cockpit (RTIC), is a fascinating candidate for using the process model to study adaptations that will need to be made by both providers and users as the technology matures and becomes more ubiquitous in the aviation community.

In order to use the business process model to study RTIC, one must understand the larger context of RTIC within the Next Generation Air Transportation System (NextGen, or NGATS), an intergovernmental effort to transform the national air transportation system by the year 2020 (see the NGATS web site, http://www.jpdo.gov/, for details). The NGATS program is essentially under the purview of the Joint Program Development Office (JPDO), the central organization that coordinates the specialized efforts of the Departments of Transportation, Defense, Homeland Security, Commerce, FAA, NASA, and the White House Office of Science and Technology Policy. The *National Plan for Aeronautics Research and Development and Related Infrastructure* provides the nation's first integrated plan that the Federal aeronautics research and development (R&D) community should pursue for both R&D and related infrastructure (National Science and Technology Council, 2007). The creation of a real-time, authoritative, single-source weather database is mentioned in the plan several times as a means to improve aviation decision-making, reduce delays, and create a safer system that can handle the increased capacity that is predicted over the next 15-20 years (not unlike the process described in Figure 2).

It is within this context that RTIC must be examined, and the business model must first be evaluated to determine if it is suitable for application to this new and interesting problem. The first area to examine is the top tier weather processing cycle in Figure 4. It turns out that many of the RTIC technologies that employ weather are essentially very sophisticated dissemination tools more than anything else. The result is that the tailored products created from model and conventional data sources such as radar and meteorological satellites are now going directly to the cockpit, where aircrews can use them to make faster in-flight decisions than ever before. However, there is no uniformity or standardization regarding which types of products are displayed, their format, or how they should be used in the cockpit. It is obvious that the *Integration into Decision-making* block of the process flow diagram can be significantly affected by these new technologies, begging the question of whether the model in its current state is adequate for studying the problem. It is the author's opinion that dissemination technology is starting to play such an important role in changing the way that weather information is being integrated into user decisions, that a *Dissemination* step must be added to the process model in order to study these changes properly. This change to the top portion of the process model is illustrated in Fig. 5.

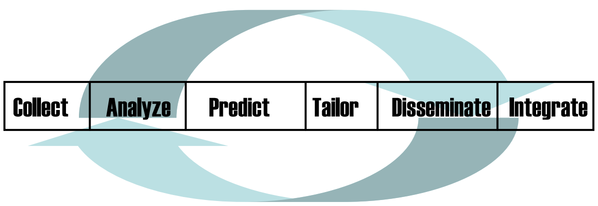

Figure 5. Revised process model with Dissemination added.

Once we have made this change to the model, we can properly evaluate how new dissemination technologies can lead to changes in the decision-making process by the user community. One of the aspects of this change has to do with how well equipped the user community is to use these new weather-to-the-cockpit technologies in the first place. This issue naturally leads to the Provider-User tier of the business model, specifically the *User's Knowledge of Meteo Principles* and the *Provider's Capabilities*, where several pertinent questions can be posed for further investigation using the business model. One question that could be posed has to do with whether there is an education and training issue associated with these new dissemination technologies. For example, if the RTIC capability includes real-time NEXRAD data, how many pilots are familiar enough with the various NEXRAD products to be able to make an informed decision in-flight based on that data displayed in the cockpit? Should they make these decisions on their own, or should they still contact en-route flight services to get their questions answered? (Albeit with much more situational awareness than prior to the advent of the RTIC technology.)

4. CONCLUSIONS

This paper discussed the use of a business process model of the weather analysis and forecasting process in a senior-level undergraduate forecasting techniques course currently offered at ERAU. The use of such a model has many advantages for organizing student knowledge gained in other courses as they make the first weather forecasts of their young careers. It also introduces them to the business side of weather forecasting, which has become more sophisticated as users learn how to account for the effects and impacts of the weather in their planning and daily operations. It was also shown that the model is adaptable to examine the potential impacts on the forecasting process from emerging technologies such as real-time weather to the cockpit. To study this problem it was necessary to modify the process model to include a dissemination step between the generation of tailored aviation weather products and their subsequent use by aviation decision-makers at multiple operational levels both on the ground and in the air. It was shown how the model can also be used to set up research questions regarding issues such as education and training of aviation professionals on the use of such products as real-time radar and satellite data for making in-flight decisions.

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