Developing a Model for Joint Infrastructure Investment

Michele Steinbach, MITRE CAASD

Stephen Giles, MITRE CAASD

Introduction

The Federal Aviation Administration (FAA), in conjunction with MITRE's Center for Advanced Aviation System Development (CAASD), is developing operational concepts and working with stakeholders throughout the aviation community to assess the business case for investment in air/ground data communications capabilities by the Aeronautical Data Link System (ADLS). The "next generation air transportation system", as envisioned by the Joint Planning Development Office (JPDO) in its integrated plan [JPDO, 2004], will rely on data link communications to improve the accuracy and timeliness of information exchanged between the ground and the aircraft. This vision of the future requires a responsive air traffic management system that can adapt to a changing environment while reducing costs and improving operational efficiency. ADLS can provide the technological foundation for this system, but without a convincing business case that technology will not be implemented. The pressing need for National Airspace System (NAS) modernization is tempered by the financial limitations of all stakeholders in the current business environment.

In the course of conducting a benefit-cost analysis for investment in ADLS, a CAASD team is creating a model to assess investments made jointly by the FAA and airspace users. [MITRE, 2004a] By establishing a common basis for understanding the costs and benefits accruing to each of the investing stakeholders, the model supports synchronized decision-making.

This paper has two goals: First, it will describe current benefit-cost analysis practices in order to understand the criteria for investment decision-making used by stakeholders in the NAS modernization process. Second, it will show how the ADLS benefit-cost model addresses the information needs of all stakeholders in a comprehensive and transparent way. The conclusion is that this model can assist the FAA, airspace users, and other industry stakeholders in evaluating a business case for infrastructure investment that satisfies the requirements of all investors in a resource-constrained environment.

FAA Investment Analysis Practice

ATO Business Considerations

When the Air Traffic Organization (ATO) of the FAA identifies a performance gap in the provision of air traffic services, it begins a process to identify potential solutions and to choose a means for addressing that performance gap. The methods and programs chosen can have a large impact on the ATO budget now and into the future: now, because of the initial acquisition and investment costs, and into the future, because the program can affect the lifecycle cost of providing air traffic services for many years

The building block of the investment and acquisition process is the benefit-cost analysis. The results of the analysis should be a recommendation to the decision-makers on whether a program should be undertaken. When the FAA conducts a benefit-cost analysis to support investment decision-making, it is required to include the impacts—in terms of both benefits and costs—on all stakeholders. The recommendation is based on the calculation of a net present value (NPV); NPV analysis is a discounted cash flow technique for evaluating the economic costs and benefits of a program or project. The NPV is the standard criteria specified by OMB for deciding whether government programs can be justified on economic principles [OMB, 2004b]. All other things being equal, the alternative with the highest positive net present value is the one that should be chosen [FAA, 2004a].

Model Characteristics

The ADLS Benefit-Cost Analysis Model

In working with the FAA to develop a benefit-cost analysis for en route ADLS investment, the CAASD team is creating a model specifically designed to be comprehensive and transparent and to address the information needs of all stakeholders. In addition to calculating all the criteria required by OMB and the FAA, the model has the following features and attributes:

- It estimates annual cash flows for each stakeholder, to show the year by year tally of costs incurred and benefits realized.
- It calculates costs and benefits at the system level as well as at the level of individual investing stakeholders.
- It assesses the impact of performance, costs, and benefits for all stakeholders of various implementation schemes, measured at the air route traffic control center (ARTCC) level.
- It enables the analyst to conduct "what if" exercises to evaluate the impact of changes in fleet mix, equipage levels, incentive schemes, and any other variable modeled in the analysis.
- It models all assumptions and estimates in a way that is transparent and easily modified to support assessments of alternatives.
- Variables in the model can be described as point estimates or as a range of values with a probability distribution.
- FAA investment and life-cycle costs are maintained as separate cash streams, in order to assess impacts on current and future FAA budgets.
- It enables sensitivity analysis to assess variable impacts on the outcome.

The model was developed using Analytica® by Lumina Decision Systems [Lumina, 2004].

Top-Level Model Structure

At the lowest level of detail, the ADLS model is comprised of four connected modules, as shown in Figure 1 - ADLS Benefit-Cost Analysis Model Top-Level Structure. These modules model the behavior of the major stakeholders: the airlines and other airspace users, and the Air Traffic Service Provider (ATSP). In addition, the modules calculate costs and benefits from the perspective of the airlines, the ATSP, and the communication service provider (CSP). Each module can be broken down into input elements, functional relationships, and output. The boxes labeled “Results SX” house the calculations and results for alternative implementation scenarios. All constants and indices used in the model are collected in the “Constants and Indices” module. This feature makes it possible to trace the impact of any input change throughout the model. In the following sections, each module of the model will be described in more detail.

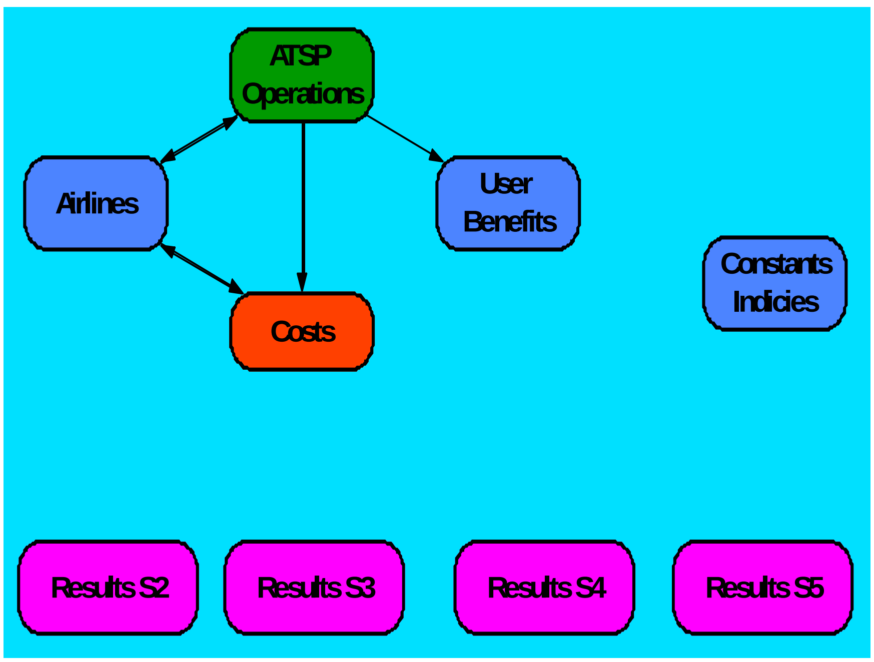

Figure 1 - ADLS Benefit-Cost Analysis Model Top-Level Structure

Airlines Module

There are three sub-modules within the “Airline” module, illustrated in Figure 2 - Airlines Module The airline equipage sub-module calculates the total number of aircraft projected to be equipped with ADLS by airline for both forward-fit and retrofit circumstances. The model input comes from a CAASD-developed forecast of airspace user fleet evolution [MITRE, 2004b], as well as information provided by airspace user representatives. [Giles and Lowry, 2004] The model hypothesis is that ADLS benefits are a function of aircraft equipage, and this sub-module gives airspace user-specific details about expected equipage levels to use as an input into the calculation of benefits.

The fleet sub-module provides an alternate means to calculate the total number of aircraft equipped by category of aircraft—large commercial, regional, general aviation (GA), and military. This sub-module changes the NAS-wide equipage rates with a single user input, instead of the airline-by-airline inputs needed for the airline equipage module. The total aircraft operations sub-module uses inputs from the fleet and ARTCC equipage sub-modules (found in the ATSP module) to determine the capacity change arising from ADLS. It calculates, by high and low altitude categories, the percent of operations in each center by ADLS-equipped aircraft, based on the proportion of operations attributed to each airline. By using specific airspace user inputs and calculating changes in en route capacity by center, this module provides a high level of fidelity. The complex structure of the NAS cannot be adequately described by a single, system-level analysis. Costs and benefits accrue differently across the system and among airspace users—this module enables the analysis to reflect this fact.

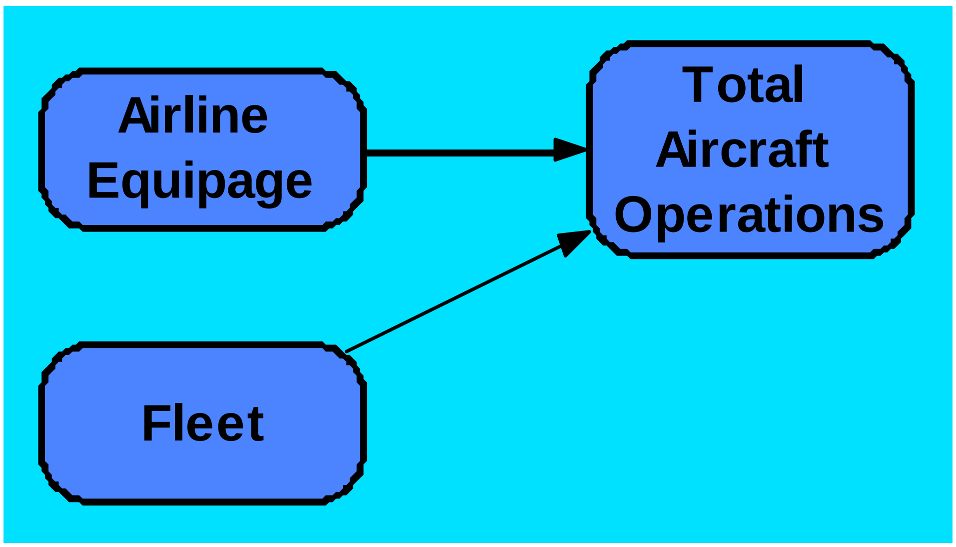

Figure 2 - Airlines Module

ATSP Operations

The ATSP Operations module is a complex connection of functional relationships that attempt to describe the methods by which capacity is added in the NAS in response to forecast demand. The model uses inputs from the FAA's terminal area forecast (TAF) assessment [FAA, 2004b] and a NAS-wide simulation of flight operations. This module forecasts flight hours and delays by en route center during the investment time horizon for ADLS implementation in the NAS. The ADLS alternatives are compared to a base case which assumes that without infrastructure investment, the FAA will continue to hire controllers and add sectors under the current operational concept in order to meet future traffic needs. The pace of sector growth and its relationship to demand is a key area of continuing research in development of the model. This module enables the analyst to examine impacts on en route centers as capacity changes are realized through ADLS implementation. Additionally, the quality of air traffic control service, measured in terms of delay avoided, is computed by the model. This module calculates the potential sector growth avoided, the change in flight delays, and the productivity and staffing level changes that result from ADLS implementation. FAA benefits can be described in terms of productivity increases or sector growth avoided.

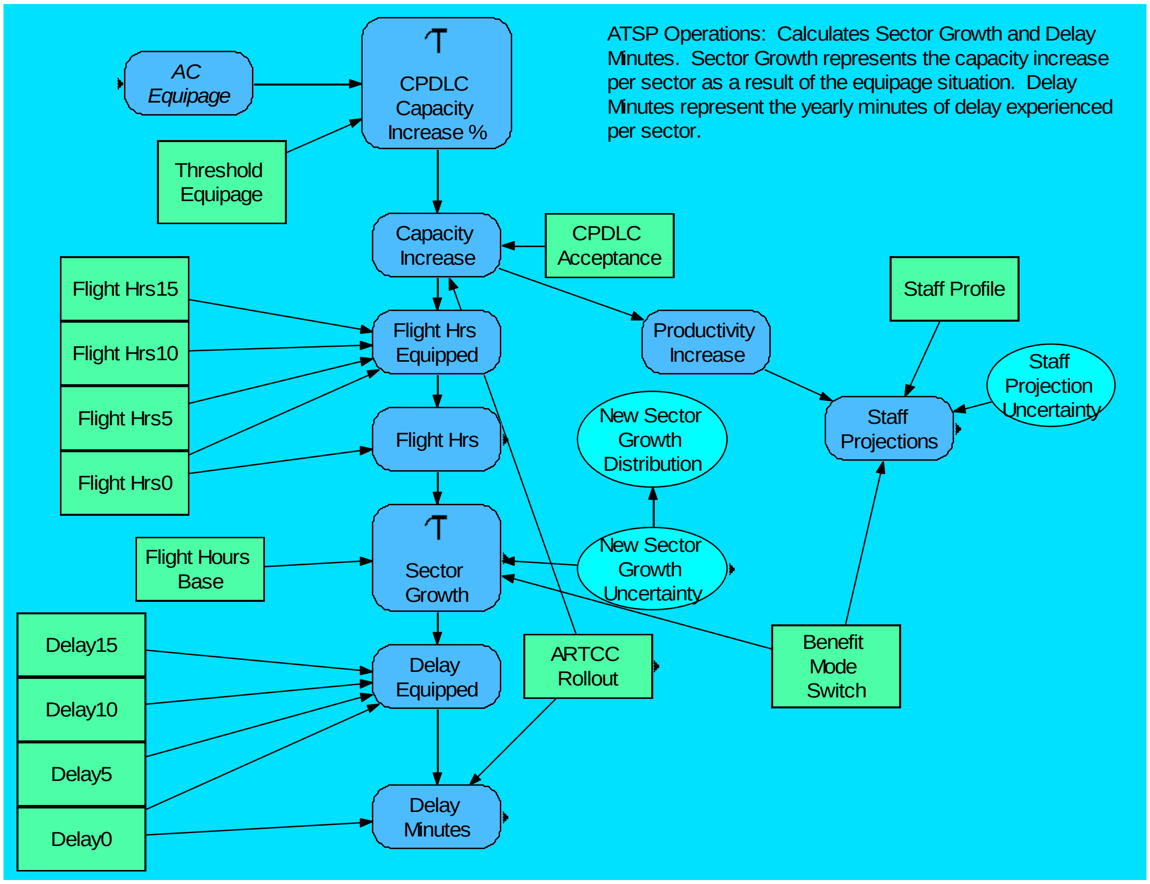

Figure 3 - ATSP Operations Module

Costs

The cost module evaluates costs from the perspectives of each of the stakeholders: the FAA, the airlines, and the communication service provider (CSP), who will develop the network for ADLS message traffic. This design feature enables clear traceability of assumptions and estimates for each investor. The module also sums the individual costs to calculate the total system cost, as required by FAA and OMB benefit-cost analysis guidance.

FAA investment costs and sector growth costs are categorized according to the FAA's work breakdown structure. This level of detail is useful for tracking operations and maintenance (O&M) dollars and facilities and equipment (F&E) dollars separately. FAA O&M and F&E dollars come from different sources in the budget, and incremental costs from both categories must be accounted for as separate funding streams. Airline costs include lifecycle training and equipment costs. Costs for the CSP include the installation and maintenance of the network for ADLS messages.

An output from the cost module is the change in ATO unit cost, calculated on both a per-flight hour and per-operation basis. This value shows the effect of different growth assumptions and scenarios on the cost of doing business in the ATO. The ATO has adopted the unit cost measure as a performance metric to gauge how efficiently it uses its resources. Like other modules in the model, the cost module has been purposefully designed to allow analysis of different strategies for infrastructure investment. The acquisition strategy is not specified in the structure of the model—it is the inputs that define the acquisition strategy being modeled.

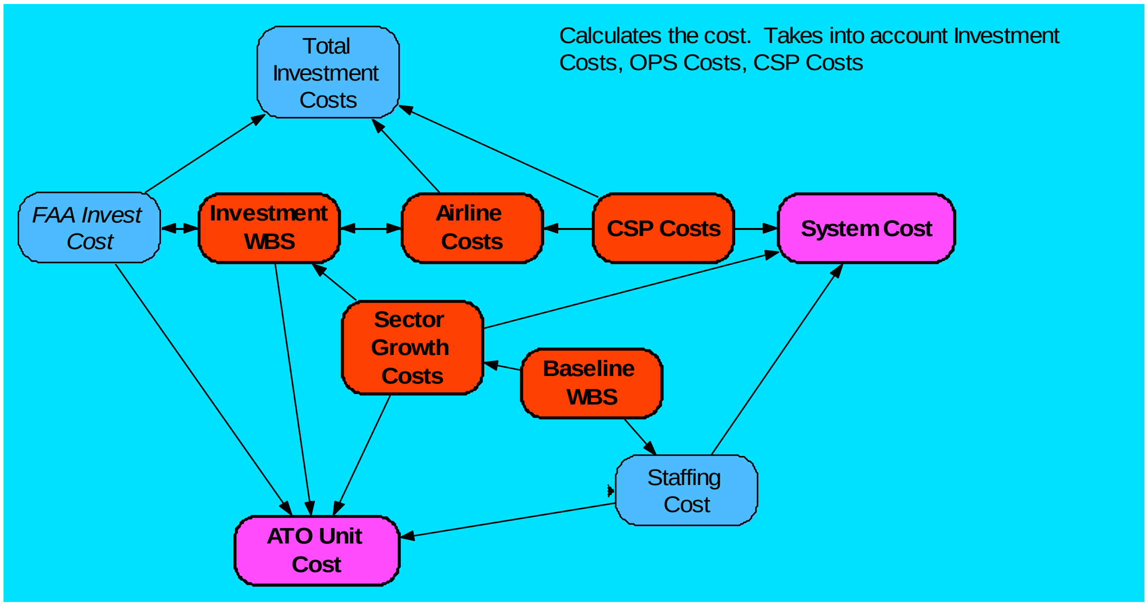

Figure 4 - Costs Module

User Benefits

As the name implies, this module is used to calculate the benefits to airspace users from ADLS implementation. The benefit metric under analysis is defined as commercial airspace user delays avoided due to increased efficiency in the provision of air traffic services in NAS airspace. The module uses inputs from Form-41 Airline Financial Reports and industry economic information to derive the direct operating costs used to value delay. For each investment scenario—S1, S2, etc.—the difference in delay minutes between the base case and an ADLS implementation case is calculated and converted into a cash flow. Since user benefits are computed in a separate module, the model facilitates partitioning of FAA and airspace user benefits calculations. The modular structure of the model contributes to the goal of engaging all stakeholders in the process of business-case development.

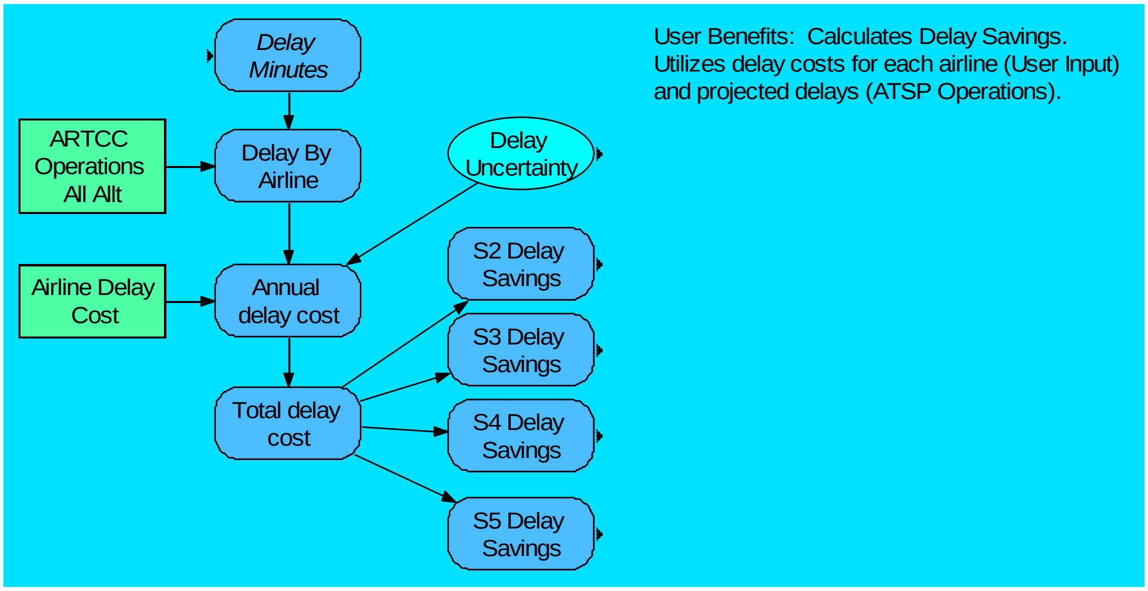

Figure 5 - User Benefits Module

Model Output

An important characteristic of a good benefit-cost analysis is the ability of the stakeholders to see and understand the assumptions and results. A joint investment analysis is an iterative process of research and refinement. The ADLS model supports this process with its ability to display information and communicate results that are central to the creation of a case for joint infrastructure investment.

One output of the model is an analysis of the sensitivity of the outcome to changes in the variable estimates. The sensitivity analysis is displayed in a tornado diagram that clearly shows the impact of several variables on the NPV output. An example case is illustrated in Figure 6 - Sensitivity of Input Factors Illustrated by Tornado Diagram The tornado diagram allows all stakeholders to see that model results are strongly influenced by input factors one through four. The bars are centered over the median NPV value. The width of the bar denotes the range of expected NPV as the identified parameter is varied over its defined range. By identifying the parameters with the greatest impact on the results, the model shows which relationships and variables warrant further research in order to reduce uncertainty about the outcome.

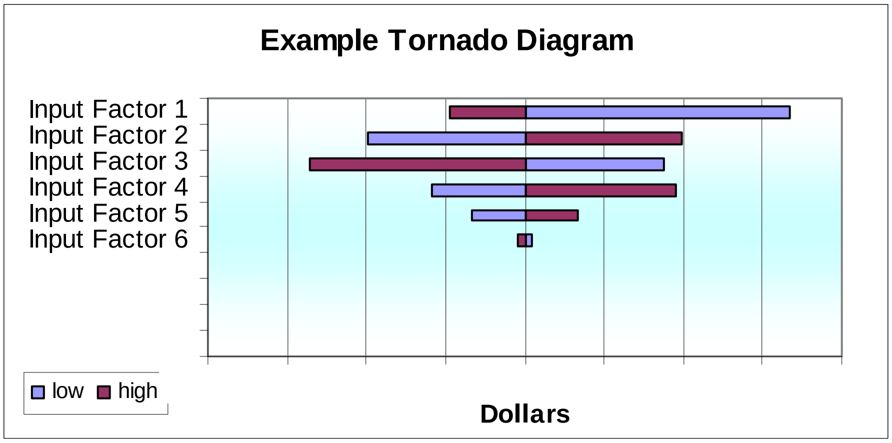

Figure 6 - Sensitivity of Input Factors Illustrated by Tornado Diagram

Another important output from the model is the impact the investment costs and benefits will have on annual cash flows of all stakeholders. In a resource-constrained environment, the time horizon for investment payback is critical. While an investment may produce a positive NPV over its 20 year lifespan, if the drain on funds in the early years is too great, a stakeholder may go out of business waiting for the benefits to outweigh the costs. Another factor to consider is whether making a particular investment choice effectively curtails other investment opportunities in the years before benefits begin to accrue. [Graham and Harvey, 2002] Figure 7 - Net Present Value of Discounted Cash Flows for Investing Stakeholders demonstrates a notional breakdown of incremental cash flows for each party. The individual cash flows demonstrate the important point that the incremental impact of the investment is different for each stakeholder. In a joint investment environment, it is critical that the FAA understand the airlines' and other players' expectations for the payback time horizon. The model can create this kind of diagram to facilitate information-sharing and discussion among all investors.

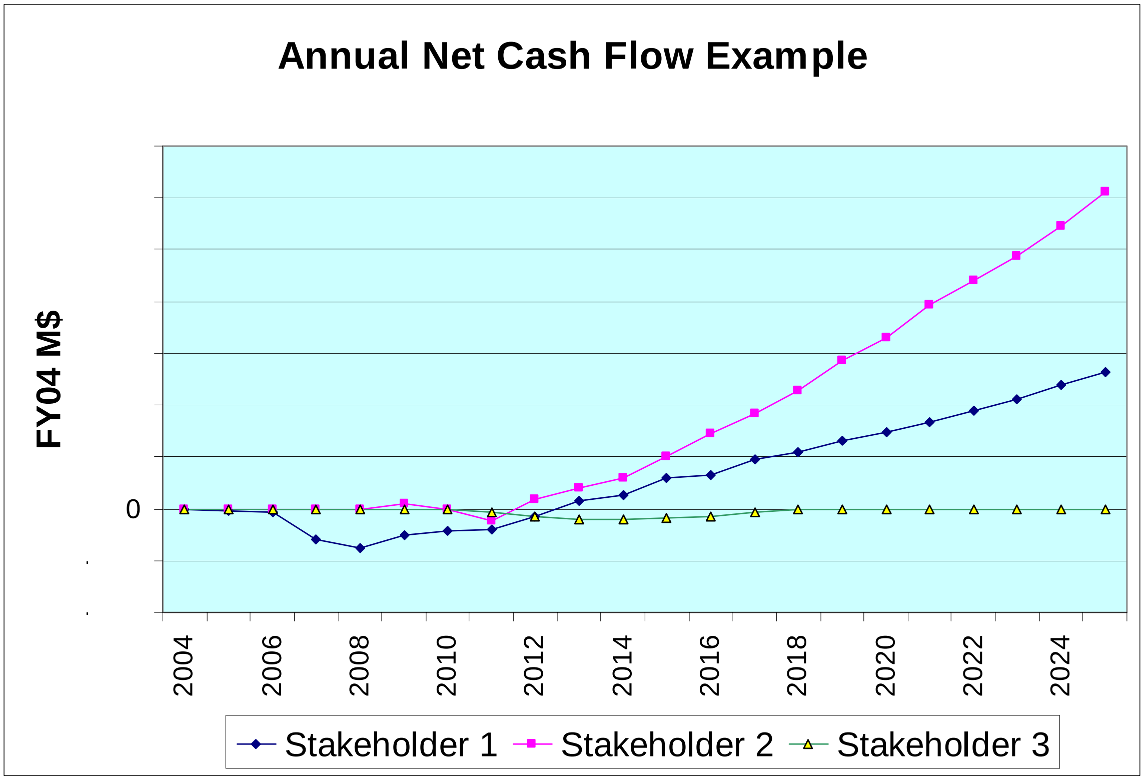

Figure 7 - Net Present Value of Discounted Cash Flows for Investing Stakeholders

Next Steps in Model Development

The ADLS model continues to mature. The CAASD development team is actively investigating measures of sector workload in order to more precisely define the impact ADLS will have on productivity and efficiency. The team is also working on defining the baseline sector growth mechanism in order to accurately describe the cost-avoidance benefits of ADLS. In the area of airspace user benefits, more work is needed to assess the impact ADLS will have on air carrier schedule predictability and airspace user access. Once these areas are more fully developed, the model could be used to evaluate other investments in NAS modernization that impact capacity, productivity, and efficiency.

Another area of investigation is the inclusion of real options analysis and modeling in the model. Real options analysis attempts to capture the value of future projects that are enabled by an investment. In the case of ADLS, for example, an initial investment in establishing an air-to-ground data network could lead to information-sharing applications beyond the simple passage of air traffic control messages from the controller to the pilot. Some of the value of those future applications could be allocated to the ADLS investment through real options analysis. Under current OMB requirements for benefit-cost analysis, real options analysis would be a complement to the standard NPV methodology.

In addition to these incremental changes to functionality, the CAASD development team is working with other activities within CAASD, airspace user representatives, and offices in the FAA Air Traffic Organization to validate the methodology employed in developing the model and the data evaluated.

Conclusion

An understanding of the considerations leading to synchronized investments in CNS/ATM capabilities by multiple aviation stakeholders is crucial to joint investment decisions for NAS modernization. Models such as the one described in this paper can increase the probability of success in joint government-industry investment partnerships. It is time to recognize that the barriers to coordinated financial decision-making are at least as daunting as any technological hurdles to NAS modernization. The aviation industry should dedicate similar effort and resources to overcoming both.

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Biographical sketches

Michele Steinbach: Senior economist/business analyst at The MITRE Corporation in the Center for Advanced Aviation System Development. Former US Naval Flight Officer trained in airborne communications and navigation on the EC-130 aircraft. BA in Political Science, Duke University, Durham, NC; MA in International Studies, Old Dominion University, Norfolk, VA; MBA, the College of William & Mary, Williamsburg, Virginia. Current areas of research and interest include airline business models, NAS infrastructure investment, and cost-benefit analysis.

Stephen Giles: Principal Staff at the MITRE Corporation's Center for Advanced Aviation System Development (CAASD); CAASD's lead system engineer for the Aeronautical Data Link System. BA in International Economics, University of Colorado,

Boulder; MS in International Finance, American University; and MS in System Engineering (in process), Johns Hopkins University.