

Andrew J. Ryan

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PaperTitle: *Modeling Distributed Human  
Decision-Making in Traffic Flow  
Management Operations*

Author(s): Keith C. Campbell, Wayne W.  
Cooper, Daniel P. Greenaum,  
Leonard Wojcik

Air Transportation -- Dr. Donohue

This paper describes the Intelligent agent-based Model for Policy Analysis of Collaborative TFM (IMPACT). The agent-based tool was created by Mitre in an attempt to help understand the value of increased information and collaboration between airlines and the air traffic management (ATM) authority. Their results show how collaborative decision-making can produce clear gains for all airlines and for the system as a whole. By employing agents as the actors representing the users and airlines, each actor can be individually programmed to display their unique characteristics and the manner in which they make decisions.

The primary motivation for analyzing the effect of collaboration and information sharing is to improve economic gains. While the economic consequences of delay for airlines varies (depending on the type of flight: feeder or shuttle, international or domestic, large plane or small plane) all airlines feel a negative economic impact due to delay. Currently, under Collaborative Decision Making (CDM) the FAA controls the arrival rate and airline planners determine *which* flights will be given priority. Impact takes a look at how increased information sharing, both among airlines and between airlines and the FAA, can enhance the current process.

Three baseline scenarios were modeled for analysis by IMPACT:

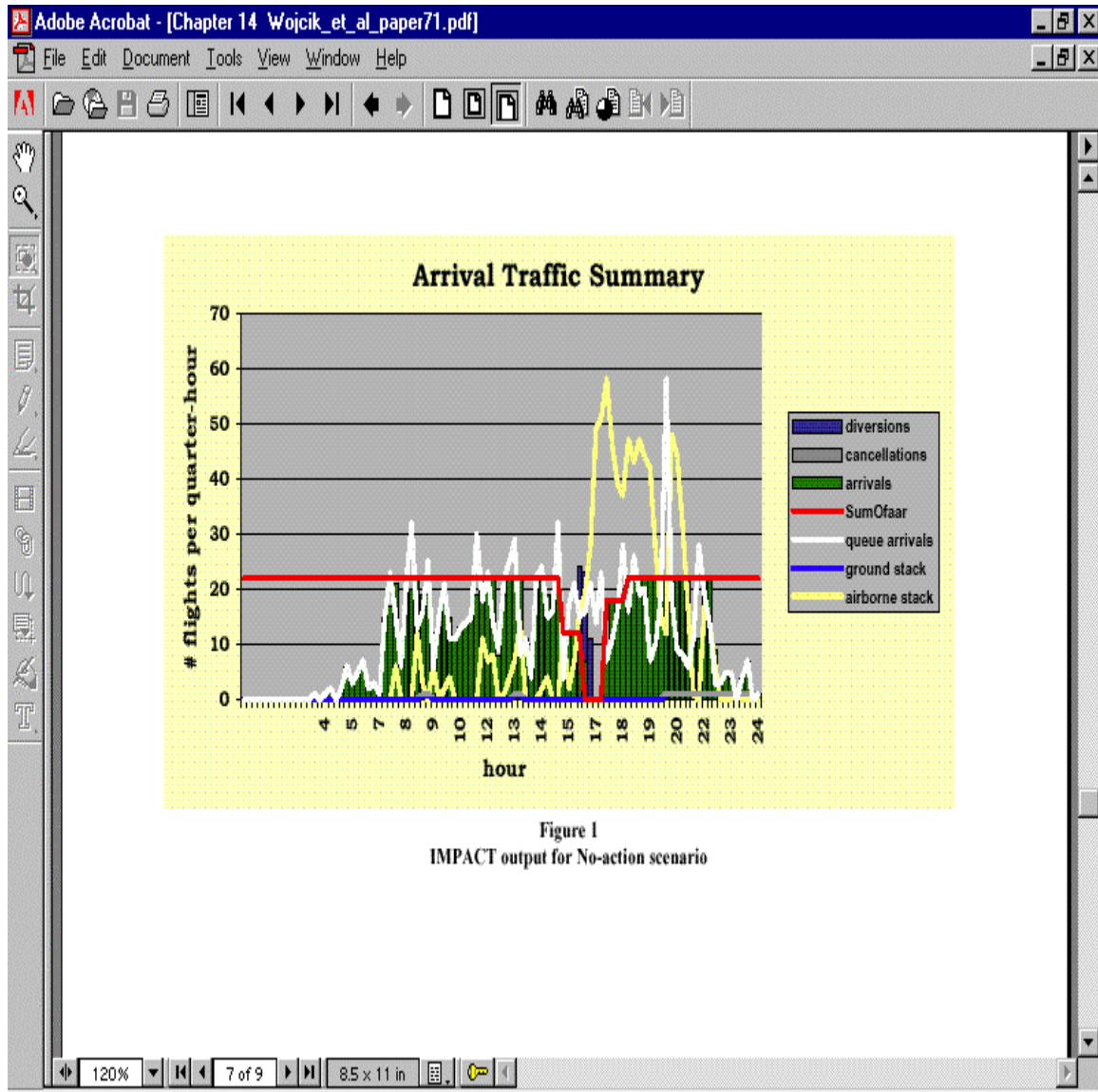
- 1. No-action** [*represents operations in the early 1980s*] – the airlines send schedule flights to the affected airport with no change in departure times. The FAA takes no action in response to the situation. Thus the agents remain dormant, taking no action (making no decisions).
- 2. Ground Delay Program (GDP)** [*represents decision making after GDP's were introduced but prior to CDM*] – FAA responds to a future anticipated capacity reduction by issuing GDP. Airlines cancel, substitute, exchange, and delay flights within their schedules. Since there is no CDM involved, agents cannot share information with each other.

**3. Collaborative Decision Making (CDM)** [*represents the information sharing of the current CDM program in the US*] – same as GDP scenario above except airlines have information about each other's schedule.

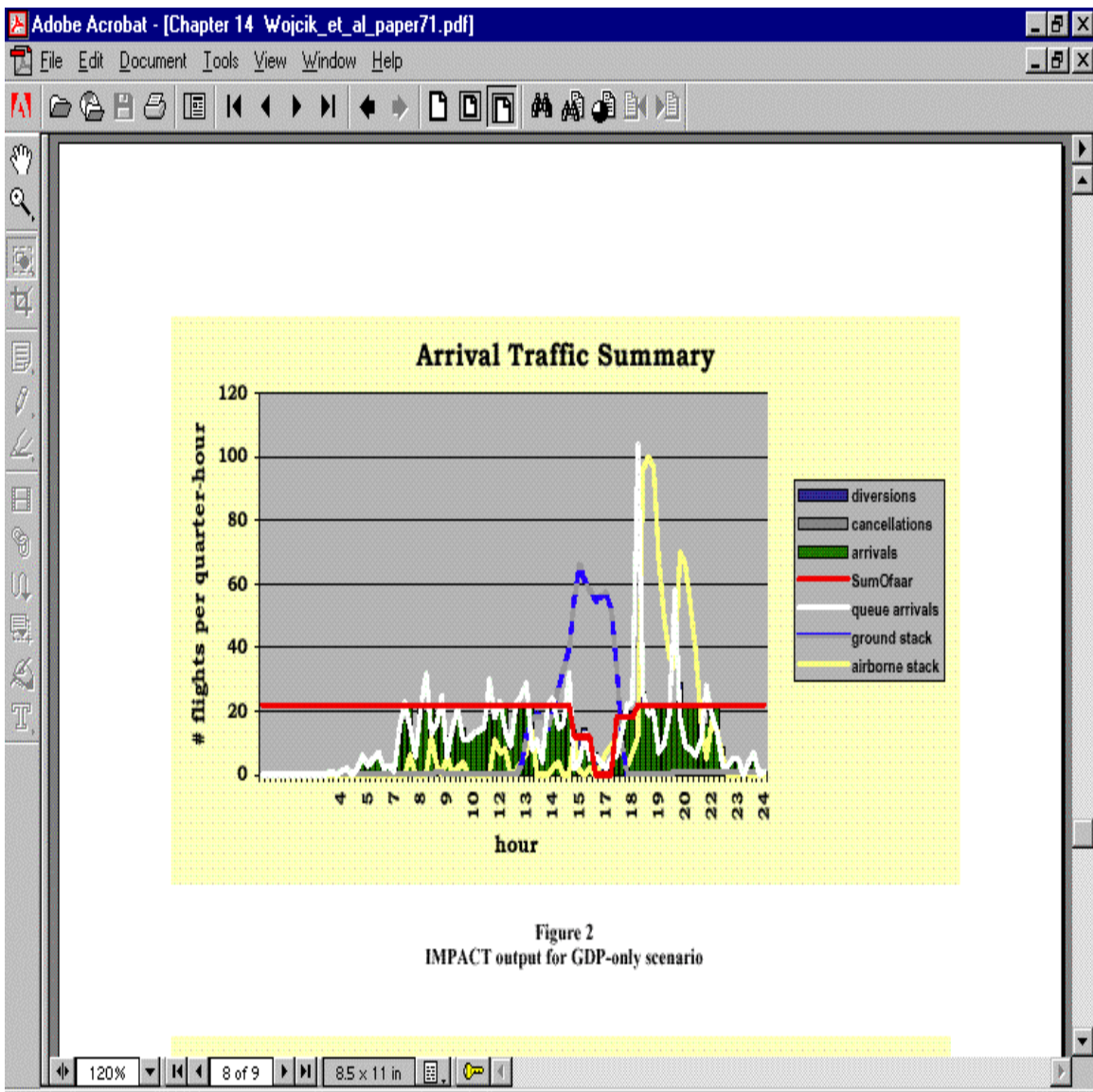
Additionally, these exclusive baseline scenarios can be compared to each other. So a comparison of a CDM scenario against no-action is possible.

### ***Sample Results***

As expected, delay times decrease as you move from a no-action scenario to a CDM scenario. Figures 1 through 4 denote this graphically.

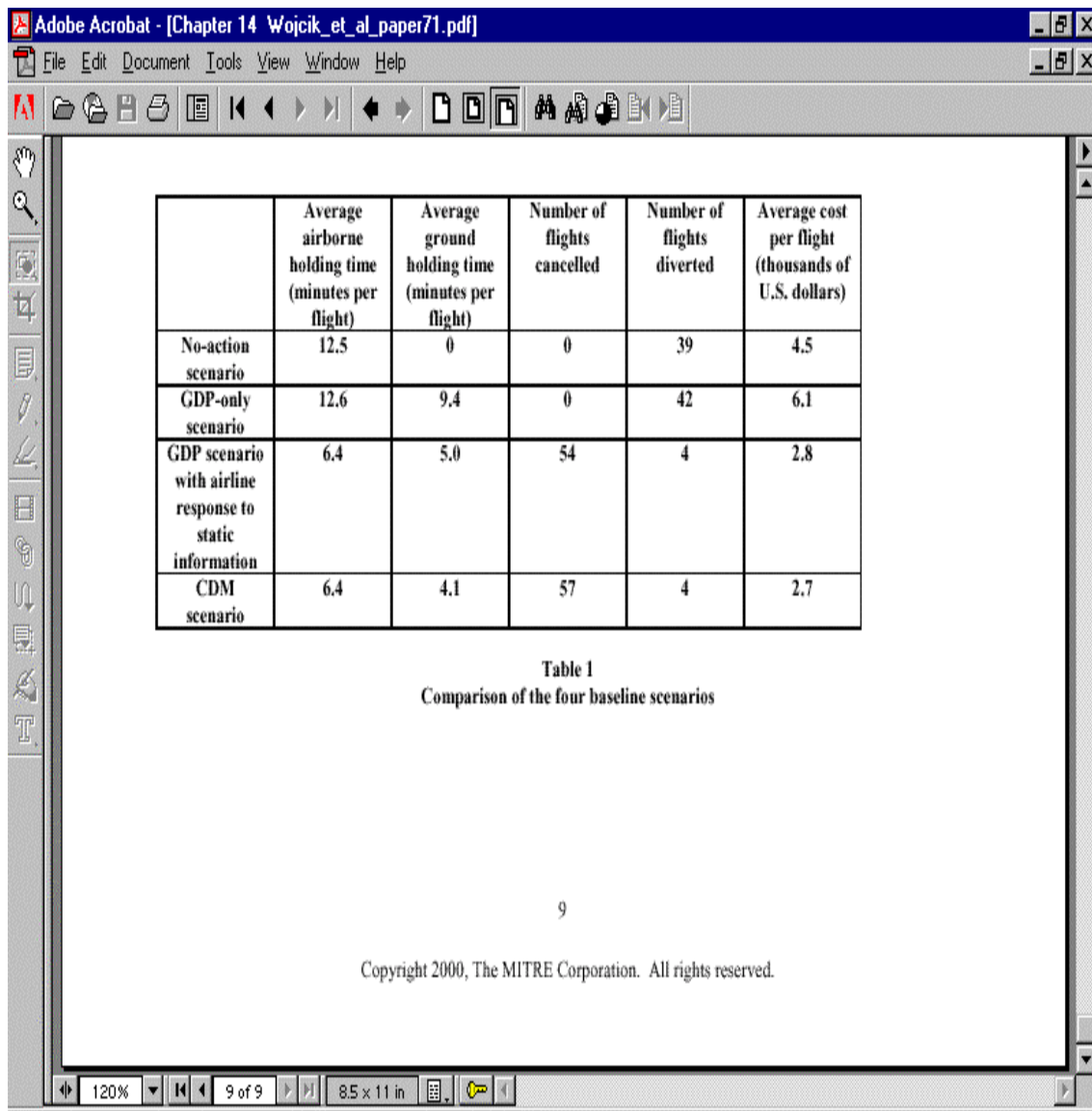


Without information sharing, delays are highest. It also creates the largest amount of airborne holding.



GDP eliminates the large airborne holding stack (instead issuing ground delays) but the stack for arrivals is larger after the GDP than it is for no-action.





Cost is highest in the GDP-only scenario. Without the ability to cancel/substitute, flights receive long ground delays, then excessive airborne holding, and are eventually diverted. These large delays followed by the eventual diversion create a very high cost for the airline agents.

In sum, the CDM scenario allows agents to adapt to the bow wave in a more effective manner than the other scenarios, so the delay is less. Information sharing permits agents to adapt and make optimal decisions based on the total picture. The end result of this is improved economic performance for the airline and the total system performance improves. While the conclusiveness of IMPACT may still be a question, it is undeniable that a ATM system with CDM elements will aid the economic performance of the airlines.

### ***Personal Comments***

As one who is genuinely interested in agent based computing, it is a pleasure to see actual results from this paradigm. By using agents to capture the decision making of airlines, IMPACT allows the user to model a wide array of possibilities and scenarios and calculate the economic impact for each decision. It would be an interesting experiment to turn IMPACT into a maximization tool and solve the problem in reverse. That is, given a scenario, what is the *best* way to satisfy the airlines' needs. If a pattern can be found from this exercise, it can be further examined and hopefully applied in future CDM tools.