Control by Permission: A Case Study of Cooperative Problem Solving in the Interactions of Airline Dispatchers with ATCSCC

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A 7-hour focus group session was held to explore issues concerning the interactions between airline operations control (AOC) and staff of the Air Traffic Control Systems Command Center (ATCSCC). This session was organized with three goals in mind:

- **To gain insight into the nature of the distributed and cooperative problem-solving activities that arise in the interactions of the airlines with ATCSCC.**
- **To identify the successful aspects of these interactions and to better understand the nature of underlying factors contributing to those successes.**
- **To identify areas for potential improvement.**

Four factors were identified as contributing to successful cooperative problem solving: development of a shared understanding of goals and constraints, distribution of responsibilities, incorporation of feedback and process control, and staff selection. In addition, several areas for improvement

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were identified, including education, information exchange, policies and practices, work assignments, and computer support.

INTRODUCTION

The current air traffic management (ATM) system is a hybrid system that includes examples of:

- Management by directive (in which, for example, traffic managers simply inform dispatchers regarding the weather route approved for a flight).
- Management by permission (in which there is a default preferred route, but there is a process for dispatchers to request approval of an alternative nonpreferred route).
- Management by exception (in which the dispatcher can file a flight plan under the expanded National Route Program (NRP) without requesting permission from the ATM system, and changes to that plan will generally be made only by exception when a problem is detected by a controller after the flight is en route) (Sheridan, 1976, 1987, 1992).

This paper focuses on issues regarding cooperative problem solving (Brown, 1986; Davis and Smith, 1983; Durfee et al., 1989; Hoc et al., 1995; Jones and Mitchell, 1995; Orasanu, 1991; Orasanu and Salas, 1993; Rasmusen et al., 1991; Robertson et al., 1990) based on management by permission. The nonpreferred route program (FAA Advisory Circular 90-91) is used to explore these issues (FAA, 1992). The discussion is based on the results of a 7-hour focus group session held to explore issues concerning the interactions between airline operations control (AOC) and staff of the Air Traffic Control Systems Command Center (ATCSCC). This session was organized with three goals in mind:

- To gain insight into the nature of the distributed and cooperative problem-solving activities that arise in the interactions of the airlines with ATCSCC.
- To identify the successful aspects of these interactions and to better understand the nature of underlying factors contributing to those successes.
- To identify areas for potential improvement.

Focus Group Participants

Two ATC Coordinators and eight Dispatchers from seven airlines participated in the focus group. To provide an additional perspective,

one airline Captain also attended. Two experienced staff members from ATCSCC represented Central Flow Control.

Dispatchers are employees of their respective airlines, and work at the operations control centers for those airlines. Under Federal Aviation Regulations (FAR) 121, a Dispatcher (along with the pilot in command) is jointly responsible for the preflight planning, delay and dispatch release of a flight. The Dispatcher is also responsible for:

"(1) Monitoring the progress of each flight;
(2) Issuing necessary information for the safety of the flight; and
(3) Canceling or redispatching a flight if in his opinion or the opinion of the pilot in command, the flight cannot operate or continue to operate safely as planned or released."

From the airlines perspective, the Dispatcher is also concerned with factors such as cost, timeliness, and passenger comfort.

ATC Coordinators are also airline employees who work at their AOC centers. They are typically experienced Dispatchers who work in a special role as liaisons with ATCSCC and the En route Centers. Thus, they engage in discussions with specialists within the ATM system and with the Dispatchers responsible for particular flights. Collectively, these AOC and FAA staff work to identify flight plans that will achieve an airlines business objectives (such as maintaining the airlines schedule or reducing fuel costs) while ensuring safety and overall effective use of the capacity of the National Airspace System.

ATCSCC is the strategic planning organization for the ATM system, dealing with the AOC staff (often through the airlines ATC Coordinator) and with the En route Centers to plan daily traffic (including replanning of flights to deal, for example, with weather or airport problems). ATCSCC has a number of specialist positions for dealing with specific components of this strategic planning, including a position to deal with airline requests for route changes for particular flights.

Methods

Three researchers moderated the focus group discussions, with assistance from three graduate students. All discussions were tape recorded.

Several general questions were posed by the moderators to stimulate and focus discussions:

- How successful was the initial NRP (as defined under FAA Advisory Circular 90-91) for different airlines? Are there areas for improvement?

- What are the most effective and efficient ways for Dispatchers and ATCSCC staff to interact?
- What are the functions of an ATC Coordinator?
- Are there different situations that call for different forms of interaction?
- What are examples of the most significant problems that currently arise in ATCSCC interactions with the airlines? What are potential solutions to these problems? What are the most effective ways to initiate such changes?

The findings are described in terms of:

- Procedures and factors contributing to *successful* interactions between airlines and the ATM system.
- Areas for improvement and for future research.

SUCCESSFUL AIRLINE-ATCSCC INTERACTIONS

The key insight offered by the focus group was that, in the evolution of ATCSCC and its interactions with airline staff, certain new procedures have been developed and integrated in such a way as to encourage cooperation between FAA and airline staff. The goal in adopting these procedures has been to improve the efficiency and timeliness of flights while maintaining or improving safety, thus resulting in lower costs and better service for passengers and cargo delivery. The factors influencing the effectiveness of these new procedures, though, appear to be fairly complex.

As a case study of such an evolutionary process, the focus group delved into the procedures for requesting and approving nonpreferred routes. The evidence that this evolution has been successful is quite strong. For example, one airline reported that in one year, they requested 15,279 nonpreferred routes, 75 percent of which were approved, saving 13,396,510 lb of fuel.

Requests Nonpreferred Routes

As part of the NRP, many commercial airline flights (involving those city pairs for which FAA preferential routes have been established) have been assigned a preferred route. Individual airlines can, however, request alternatives to these routes. These requests can be for reasons of weather avoidance or efficiency (reducing costs or improving arrival times). Requests for weather avoidance are given priority, since some alternative plan must be approved (although this alternative could be delaying the flight or having it land at an alternative destination). Requests based on efficiency may be denied for a variety of reasons.

Requests for nonpreferred routes must be submitted to ATCSCC via teletype. The ATCSCC staff member responsible for such requests then contacts the necessary En route Centers by phone to see whether they can accommodate the request. (Some requests, or portions of requests, may match a list of nonpreferred routes that can be automatically approved without contacting the affected Center.) If a request for a segment of a route is denied by a Center, that Center may suggest an alternative.

Once all of the affected Centers have been contacted, the ATCSCC staff member contacts the ATC Coordinator or Chief Dispatcher at the requesting airline (or an individual Dispatcher at some airlines) by phone or teletype to convey its approval, proposed modification, or disapproval. The reasons behind a proposed modification or disapproval may also be given. Finally, the relevant Dispatcher at the airline must concur with the ATC Coordinator that the approved route is viable.

Factors in the Success of Nonpreferred Routes

As indicated by the above example, the nonpreferred route program has been quite successful. Interestingly, this success has been achieved even though the technologies used for this particular program have for the most part been rather "unsophisticated." This raises an interesting question: What factors have contributed to the success of this program? The answers may provide useful guidance for future changes in procedures and policies and the introduction of technological support. The following four factors seem to have contributed[1]:

- Development of a shared understanding of goals, problems, constraints, and solutions
- Distribution of responsibilities to a number of different individuals
- Incorporation of feedback and process control loops into the system
- Creation and staffing of the ATC Coordinator position

Shared Understanding. If team members are to work together efficiently and effectively, it is important that they share goals and understand what their fellow team members are trying to do, how they are doing it, and why they have arrived at particular conclusions (Orasanu, 1994). This need for understanding applies both at a general level and at the level of a particular decision.

[1] It should be noted that Advisory Circular 90-91 has now been superceded by a new program. However, as will be discussed in the conclusion, the generalizations developed based on this case study continue to be applicable when evaluating a variety of FAA programs and procedures defining the interactions of AOC with the ATM system.

Although there is room for improvement (to be discussed later), the success in shared understanding that has been achieved thus far appears to be due to several factors:

Task Allocation. If an ATCSCC staff member is assigned the task of approving or disapproving routes as his or her sole responsibility on a shift, that individual is likely to adopt as a personal goal finding ways to get nonpreferred routes approved (rather than simply following some rote procedure to decide whether a route can be approved). In addition, because the individual is focusing on this one task, he or she is more likely to develop an understanding of the motivations and behaviors of the ATC Coordinators or Dispatchers making requests.

Similarly, assigning ATC Coordinators the task of interacting with ATCSCC makes it more likely that these individuals will develop an understanding of the procedures and constraints facing the ATCSCC specialist. Equally important, because a relatively small number of individuals is involved in direct communications (at ATCSCC and the airlines), those individuals are more likely to develop an understanding of each other and a sense of shared goals.

Communication Channels. Although decisions about nonpreferred route requests are sometimes communicated to an airline by teletype, much of the communication is via telephone. This allows for much richer interactions, increasing the likelihood that a shared understanding of the process will develop. It also makes the development of personal ties more likely, enhancing cooperation.

Distribution of Knowledge. If individuals are to work as an effective team, they must share certain knowledge. Otherwise, unnecessary questions are asked, and time must be spent on providing detailed explanations. A good example of this is the behavior of ATC Coordinators in generating nonpreferred route requests. Because communications about route requests involve discussion of why requests have been rejected, the ATC Coordinators begin to learn what routes are viable. They therefore begin to limit their requests appropriately. One of the ATC Coordinators commented on this process:

> When we started this, even Central Flow didn't know where all the choke points were. But as we pressed the system and said, "Now we want to fly over here," we'd call the Albuquerque Center and they'd say: "Well, you can't go eastbound over St. John at 4 o'clock in the afternoon." Well, that was tribal knowledge in the Albuquerque Center. The tribe expanded to include Central Flow; Central Flow expanded the knowledge to the airlines and we began to build better routes. So rather than having to fly a 2000 mile route because it didn't work at one point, we began joggling around and making routes that were smarter. Originally we'd

> call and they'd say no. But then it became: "Well, if you would just do this, if you'd just make this minor adjustment in your flight plan, we could probably do this." It became a much more collaborative effort.

Requiring Explanations. Communicating by phone makes it easy to request and receive explanations. Such explanations serve three purposes. First, they help develop the necessary shared understanding of problems and constraints. Second, they help control the process, since decisions that lack support are discouraged or can be detected. (This second purpose is discussed in more detail later.) Third, they encourage cooperative problem solving since once both parties understand the problem, they can work together to consider other solutions.

Distribution of Responsibilities. A second factor contributing to the successful cooperation achieved by the program appears to involve the distribution of tasks. Four groups of individuals are directly involved in selecting nonpreferred routes: staff at the En Route Centers, the nonpreferred route specialist on duty at ATCSCC, ATC Coordinators at the airlines, and Dispatchers at the airlines. Other groups, such as staff meteorologists at the airlines and at ATCSCC, also provide input to these decisions.

As discussed above, the structure of the communication links among these groups affects the development of shared knowledge and the sense of teamwork. In addition, because each individual has a different set of primary goals and responsibilities and makes use of different sources of data, the system provides checks against bad decisions. The Dispatcher in charge of a flight, for example, may conclude that the approved nonpreferred route is questionable in terms of weather. Similarly, the ATC Coordinator may point out that a route proposed by ATCSCC is impossible because of fuel constraints. Because tasks, information, and workload are distributed (with some redundancy), it is more likely that good solutions will be discussed and poor solutions detected.

Feedback and Process Control. There are several ways in which data or input is used to improve performance.

Unjustified Route Rejections. Both the airlines and ATCSCC believe there are times when an En Route Center specialist will reject a route without adequate justification. The focus group participants pointed out that the airlines need to understand possible reasons why a Center specialist might reject a route, such as concern over workload. While understanding such concerns by Center personnel, however, ATCSCC does monitor for unreasonable rejections of requests. To reduce such problems, ATCSCC will "constantly talk [with

that Center] to try to find periods of time when they can be more flexible." As part of this process, ATCSCC will:

> through observation of their operations, check the number of times they say no along a particular route of flight . . . [and take] pictures [of the ASD] at the time that the requested flight would have come through there. We're taking pictures to guarantee that they're not blowing smoke, and we will forward these pictures back to the facilities manager and say: "This is consistently happening. Please tell us why. We don't see it here."

Requests for New Automatic Route Requests. A second example of feedback within the system involves the identification of nonpreferred routes that can be automatically approved upon request:

> The NRP has been expanded four times. They're still looking to expand them. How are they picked? The airlines gave a list of like 250 or so. The airlines were requested to submit a list through the ATA [Air Transport Association] and to prioritize them. The ATA looked at how many times a given city pair was submitted and reprioritized them.

Thus, ATCSCC periodically asks the airlines, through the ATA, to submit a list of routes that they would like added to this set of automatic approvals. The airlines submit their preferences to the ATA, which develops a combined set to submit to ATCSCC. ATCSCC then evaluates this set and selects those requests that are feasible for inclusion on the list of automatic approvals. This feedback process provides the airlines and ATCSCC with a mechanism for obtaining more efficient approval of routes that are both safe and efficient.

Direct Immediate Feedback. The above two examples of feedback processes involve delayed feedback. Perhaps the most important form of feedback, however, whether between an ATCSCC specialist and an ATC Coordinator or between an ATCSCC specialist and an En Route Center specialist, occurs by talking on the phone about an immediate concern: "A phone call is more valuable because you exchange ideas. . . . It's interactive." Such interactions help tune the process, identifying problems and promoting change. As one ATCSCC specialist put it: "As long as you [the airlines] keep making the demands that you're making, you're going to force me to reevaluate the way I do business."

ATC Coordinator Position. The creation of the ATC Coordinator position at many airlines to handle interactions with ATCSCC is a fourth factor in the success of this program. One previously discussed benefit of having an ATC Coordinator is the ability of such a specialist to better understand the goals, problems, and constraints of the

staff with whom the airlines deal at ATCSCC. The importance of such understanding was highlighted by two comments from ATC Coordinators:

> When you're making these phone calls it's sometimes a bad day. They don't want to have a phone call where the first 5 minutes is an education process and then tell the Dispatcher why he can't have it this way.
>
> The ATC guys [Coordinators] have got the ATC background to be able to discuss it [with the Command Center].

The importance of developing and maintaining a friendly, cooperative working relationship was illustrated by comments highlighting problems that may arise when there is no ATC Coordinator. One Chief Dispatcher noted:

> Any time we've said, "You go ahead and do it and let one of the Dispatchers call [ATCSCC directly]," 9 times out of 10 we get a Dispatcher on the phone demanding: "You [ATCSCC] are going to do this. This is the way I'm going to do it and don't tell me I can't." It does nothing but blow all of the rapport we've built between us and Central Flow because now everybody is mad.

A second benefit from the use of ATC Coordinators is increased efficiency:

> What we did at our airline, and part of it was a complaint from System Command that they had 3 people calling about the same problem, that's why we decided to go through a focus [through an ATC Coordinator]. There's nothing wrong with a Dispatcher saying: "I've got this problem," and if you're busy, if it's something you think he can handle, delegating the phone call to him. But then you know he's assigned and it's just 1 person making one contact on that one issue, instead of maybe 3 or 4 different people with flights through that area. It just didn't seem workable. They had a legitimate complaint there.

Both of these benefits, however, appear to be due not only to the creation of such a position for handling interactions with ATCSCC, but also to careful selection of individuals to fill the position. Several participants indicated that Dispatchers are not arbitrarily picked to become ATC Coordinators. In making this selection, the Dispatcher's personality, communication and negotiation skills, and understanding of the ATC system are all considered.

Possible Enhancements and Research Issues

Some of the issues raised in the focus group discussions can be handled simply by communicating them to the relevant groups. Others can be considered short-run enhancements that require some development and evaluation of fairly obvious solutions. Still others call for

more extensive research to better understand the nature of the problem and explore alternative solutions.

Practices Inconsistent with FAA Policies. One example of a problem discussed by the focus group is a concern among Dispatchers that the ATM system sometimes asks them to file flight plans that cannot be followed because of weather or other problems:

> You cannot tell people to file a flight plan that legally the Dispatcher must brief the pilot he cannot take—even if he gives him two flight plans and he says: "This is the one I filed for you but this is the one you should fly." It puts us in a very difficult situation.

Thus, the problem arises when ATM staff ask Dispatchers to file a flight plan that either cannot be followed (e.g., because of bad weather) or may become unavailable (e.g., because of missile tests). The FAA traffic manager apparently assumes that an alternative path will be selected once the aircraft is airborne. The Dispatcher, however, is forbidden by FAR 121 from releasing such a flight when its flight plan is known to be infeasible.

The Dispatchers did note that "Central Flow has been very helpful in trying to change the mindset of the Centers who are saying: 'Well, just file the pref and we'll take care of it after you're in the air.'" Nevertheless, the airline representatives view this as a very serious continuing problem.

An ATC Coordinator noted:

> The example we get, and really I have no idea why we will get an advisory out from Washington saying: "We are rerouting traffic this way but don't file it. File the preferred route." I figure: What do you mean? If you're rerouting traffic, why can't I file a flight plan where you're rerouting the traffic? I can't put it on the preferred route because the preferred route takes you right through the thunderstorm activity and yet you're telling me all the traffic is being rerouted this way. Yet if I go to file it that way you'll turn it down.

At first glance, this seems like a straightforward training or policy problem involving the En Route Centers directly, as well as the ATCSCC staff who are the intermediaries for route requests. Other comments, however, suggest that it is also a symptom of some deeper problems that merit study. These deeper problems involve attitudes, perceptions, and personalities, as observed by one Chief Dispatcher:

> On a very broad basis I think perhaps that the people at Central Flow and the Centers don't recognize that flight Dispatchers are very well trained professionals, that they are familiar with the field of aviation and with the language of aviation. I've had several experiences where I've called Centers or Central Flow or various traffic management offices

> around the country, and [been] talking also to people at the tower. Maybe I don't introduce myself clearly, that I am an airline employee, number one, and that I do work in flight operations, but they talk to you as if they're talking to somebody that was out on the street that doesn't know anything about aviation. By and large they're not familiar with whom they're talking to.

An ATCSCC participant responded to this concern as follows:

> I think that in the last 3 years, there has been a lot of education of both the users and the Centers. They're starting to see that and they're co-operating more, but it is personalities, believe me.

Consistency in Policies and Practices. There appeared to be some concern on the part of the airlines about consistency in the way ATM staff deal with situations. One example had to do with consistency in the approval of nonpreferred routes by Centers:

> I can go for a whole week and ask for a route on a specific city pair and get it approved. Then you get a shift change at the Center. Nothing has changed. The weather is exactly the same and now it's disapproved.

Training and Certification. In addition to issues about procedures and practices, participants expressed a general feeling that both Dispatchers and ATCSCC staff would benefit from additional training. For Dispatchers, this is in part a result of the outdated FAR 121.65. (FAA regulations concerning the training and certification of Dispatchers):

> The last time FAR 65 was rewritten was 1964. There was no Central Flow then.
>
> I think it would be a great benefit to new Dispatchers to benefit from your knowledge of how ATCSCC works, so that they don't have to make all the mistakes that they would make in a career.
>
> You don't have to limit that to new Dispatchers. I have a lot of senior Dispatchers that I'd love to send to Cleveland Center to sit down and watch their ASD.

> I went through both training processes [Dispatcher and ATC training]. I've done both and I'll tell you, I've met people who are Dispatchers, I've worked with them. I've met people who are air traffic controllers, I've worked with them. Eight out of ten of these people haven't got a clue what the other guy's thinking about, or what he's basing his decision on. I mean, when you see an air traffic controller saying: "Well, slow this guy down," they have no idea what the backward effect of that is on the guy flying the airplane or the people planning the trip. The same thing with the Dispatcher saying: "Well, I've only got 2 flights going to Chicago today, I don't see any big problem. Let's go." He has no idea that the guy working the sectors along the way may have a totally different look at that.

In terms of training for ATM staff (and note that much of this discussion has dealt with issues outside the realm of ATCSCC), one major concern expressed by the airlines was a lack of knowledge about the capabilities of different types of aircraft:

> Now and then we have incidents where ATC, somewhere along the chain of command, especially when someone establishes an airport arrival rate or something like that, it's not based on a good understanding of the category minimums for a runway that might be closed. We had a perfect example about 2 weeks ago. They came out with a 5 hour ground delay program for all arrivals into Detroit for the rest of the day and there was a misunderstanding at that Center about certain lights being inoperable. But ATC, or whoever made the decision, didn't know that doesn't affect CAT-1 and that's our dilemma.

> It seems to us that the FAA makes a lot of generalized decisions about what airplanes can do based on general knowledge. I know Newark is an example where unnecessary decisions are made about limiting runway use when there is a 15 knot crosswind.

Information Dissemination. Another major topic discussed was the exchange of information between the airlines and the ATM system. The first concern had to do with teleconferences. One ATCSCC participant observed:

> You should be on the other end of the line after these teleconferences. At the end of such a conference, we'll say: "OK, do you have any questions? No, no questions. OK, here's our plan, this is what we're going to do. We'll give you an update in a few hours. Bye." As soon as we hang up, here's [the phone ringing]: "This is so and so, and I wanted to talk to you about. . . ." Come on, let's bring it up with everybody, so we can . . . get all of the input that we need, because that problem may affect them [the other airlines] also.

Another problem with teleconferences is that by their very nature, the information exchange occurs at a fixed point in time. Problems arise if some people are not available or not included in the discussion. One proposal for dealing with the need for real-time information was to allow the air carriers to listen in on discussions at Centers:

> Talk about communication. One of the other proposals made at the meeting on Test Plan 92 [a proposal for improvements to the ATC system] was an open line concept, which would be basically a phone line that went from New York to LA. Anybody, air carrier or Center, could link up to this phone line, and the phone would be basically off the hook during the event so that we [would] know exactly what was going on at the station that was impacted as it was happening so that we could react much faster. Because the complaint was, the station calls Central Flow, tells them what they're doing. Central Flow types a message and sends it through the computer about what's happening. Well, that could take anywhere from 15 to 30 minutes. By the time the 30 minutes was up,

> the situation had changed again. Whereas with the open line concept, all you'd have to do is put a speaker on the line, and when Central Flow and the facilities got together to discuss what was going on, at that time the airline would hear what was going on and have that information now. It has never really materialized. I know that the delay task force at Chicago did some pricing on it, and I think they came up with about $6000 as the cost of a phone line to go from New York to California, and then it was going to cost each carrier somewhere around $150 to connect up to it. But it never materialized."

A complementary suggestion for providing access to real-time data involved the creation of a shared database:

> My boss will hate me for saying this, 'cause he loves telephone conferences. I think we have too many of them. The reason I say that is, the reason we have them is because operational information is not contained in a centralized database. If it was, there'd be a lot less talking. There is a whole lot of data that we all use differently, but it's the same data. We could all contribute, and then everyone would access the same database. Then the only time you'd have to confer is when you could add something to the information. What I'm saying is that, if Chicago has several runways closed and the acceptance rate is 36 an hour, that's data that doesn't need to be in a teleconference.
>
> But how do you put in your database Chicago just closed 27 left to plow it? Somebody has to input the data into that database, and if you've got a phone line sitting there or a phone off the hook and Howard just comes on and says, "We just closed 27 left for plowing," I know now. I don't have to wait for somebody to sit down input that data and then I don't have to go to another machine and pull that data up.

New Areas for Data Exchange. In addition to the discussion of how to disseminate information, there were general comments about the potential for exchanging new types of data and information. One important example of the potential value of increased information exchange is particular data the airlines have that would help in ATCSCC planning. As one ATCSCC participant put it: "With your participation in ground delay programs, you'd probably see at least a 30–40 percent across the board reduction in your delays if we had real time data from you." A Dispatcher supported this idea:

> I really feel it's to the advantage of both the airlines and the FAA if the FAA is working off a real time database and not working off the OAG. Many times we've had instances where there's been a ground delay program on a station, and we have sent all our cancellations in, and the program is still there and it still holds. It's still based on the assumption of a full arrival rate, everybody showing up, and we've wiped out half of our operation.

Similarly, participants indicated that ATCSCC and the En Route Centers have data that the airlines would find helpful:

> What we'd like to get back is capacity rates, what you expect the next hour to be like, how many actually landed the hour before, so we have some sense of what's going on.

> It seems to me that we never know what the Centers are doing. There's no communication between the Centers and the airlines. They should just send out a simple message [through ATCSCC] saying: "OK, New York Center—we're now keeping the flight plans for 5 hours." That way we would know that we didn't have to go back in and refile. If the Centers would simply tell us, it would save us a lot of work.

Computer Support. Two of the previous subsections focused on problems with information dissemination and data exchange. Additional problems arise because of inadequate or poorly designed tools for making use of available information. One example discussed at the meeting was the process for approving airline requests for nonpreferred routes. The discussion indicated that this inadequate computer support sometimes slowed the process and placed an extra burden on ATCSCC staff. A Dispatcher noted:

> It's pretty much a manual process [communication of ATCSCC with the En Route Centers to get approval for a nonpreferred route]. You send them [ATCSCC] a message, and they pick up the phones and call the Centers and they ask the Centers if they'll approve it. It's a time consuming method.

This lack of computer support also adds an extra burden to the training and performance of ATCSCC staff. An ATCSCC participant observed:

> We have a lot of new people who don't look at it [the requested flight plan for a nonpreferred route] and say: "This is the only part that you've got to approve." Now you've got seven Centers involved and you only needed to call one.

As a second example of the need for better computer support, one Dispatcher noted that nonpreferred route requests are sometimes rejected or delayed because one fix did not work. He suggested: "If you had an automated route request, they could flag the fix that's the problem, and maybe have an automated fix replacement or route replacement for that small segment." Continuing with this idea, the Dispatcher noted:

> A phone call's time consuming. A picture is worth a thousand words. If they could transmit that to the airline saying: "Here's the problem; here's the possible solution, and let's take a look at what we have, what that saves and see if it's workable."

This suggestion involves several components. First, route requests

would be displayed on a computer screen where fixes or route segments that were unavailable could be marked by an ATCSCC staff member (or marked by the responsible Center and transmitted to ATCSCC). Second, possible route adjustments around that fix would be identified by the computer. (Alternatively, such deviations could be identified and marked on the computer by Center or ATCSCC staff.) Third, these results would be transmitted to the ATC Coordinator for display and consideration. In this way, the ATC Coordinator, ATCSCC specialist, and Center specialist could all look at the same display while talking to each other if further discussion were required.

Similarly, there is a need for traffic bottleneck forecasts so that an airline can make more informed decisions when selecting a route:

> Let me give you an example: Rosewood. That is 90% of the time a red sector. You file anything Jet 29 or anything that's going over Rosewood, they're not going to approve it. Forget it.

> Fort Worth has them too. Certain times of the day you can't go over certain fixes. That also changes, sometimes on a day to day basis. Sometimes you can do it on a Sunday and you can't do it on a Monday.

The significance of this need for information was highlighted by an example: "Last Monday we submitted seven requests on one flight before we could finally get a route."

Computer-supported communication of choke points was suggested as a solution:

> One thing that would aid us would be to give us the current ASD data, and give the airlines the ability to project where the red sectors are going to be and when they're going to be. That is, give us the ability to go out and plan to keep that sector from going red by what we do. If we had the ability to see that Rosewood is going to be red at this particular time then we aren't going to bother to ask you for that, which will cut down on the number of routes you'll have to revise. I'd be making the choices about which planes I'd be doing it with and also which way I want to go. How do we do the collaboration, that's the tricky part. The procedures, policies and the applications.

CONCLUSION

The purpose of this focus group session was to cast a wide net in order to identify and understand both areas of success and areas for improvement in the interactions of ATCSCC specialists and airline Dispatchers. The results provided insights on a broad spectrum of issues. Some caution should be applied, however, in interpreting

these results, since they are based primarily on a single 7-hour meeting.

In addition, it is important to maintain a proper perspective when reviewing the issues raised. It was clearly the view of both the airline and ATCSCC participants that, although there are areas for improvement:

- Changes in the interactions of ATCSCC with the airlines have shown major improvement in recent years.
- These successful changes have resulted from efforts to encourage cooperation between ATCSCC specialists and Dispatchers, allowing them to work together to develop solutions that increase safety, reduce costs, and improve efficiency. Thus, the methods underlying these successful changes should provide a model for initiating improvements in other areas.

Finally, it is important to consider the relevance of such findings given recent changes in the ATM system, such as the implementation of the expanded NRP (RTCA, Inc., 1995; Scardina et al., 1996). As an example, this revision of the NRP shifts from a paradigm based on "control by permission" to one base on "control by exception," as (subject to certain constraints) it allows the airlines to file user-preferred routes without requesting permission from ATCSCC. Even under this change in the locus of control, however, many of the concepts introduced here remain relevant. The ATM system still plays an active role in dealing with traffic bottlenecks, creating a continued need for mutual understanding and cooperation with AOC staff, as well as for improved information exchange. Yet it appears that in the transition from "control by permission" to "control by exception" under the expanded NRP, the cooperative exchange of knowledge and information has been reduced (leading one dispatcher to refer to the expanded NRP as "shooting ducks in the dark") (Hopkin, 1995; Lacher and Klein, 1993; Odoni, 1987; RTCA, Inc., 1994; Wambsganss, 1995). Furthermore, there are still many decisions made by the ATM system (such as ground delay programs and severe weather routing) that fall into the category of "control by directive" or "control by permission." Thus, it is potentially informative to look at the strengths and weaknesses of the original implementation of the NRP for insights to guide the implementation and refinement of new ATM programs (RTCA, Inc., 1995; Scardina et al., 1996).

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LIST OF ACRONYMS

AOC	Airline Operations Control
ASD	Aircraft Situation Display
ATA	Air Transport Association of America
ATCSCC	Air Traffic Control Systems Command Center
ATM	Air Traffic Management
FAR	Federal Aviation Regulations
NRP	National Route Program

REFERENCES

Brown, J. S. (1986), "From Cognitive to Social Ergonomics and Beyond," In D. Norman and S. Draper (eds.), *User Centered System Design*, Lawrence Erlbaum, Hillsdale, NJ, pp. 457–486.

Davis, R. and Smith, R. G. (1983), "Negotiation as a Metaphor for Distributed Problem Solving," *Artificial Intelligence*, 20, 63–109.

Durfee, E. H., Lesser, V. R., and Corkill, D. D. (1989), "Trends in Cooperative Distributed Problem Solving," *IEEE Trans. Knowl. Data Engineering*, 1 (1), 63–83.

Federal Aviation Administration (1992), *National Route Program*, Advisory Circular 90-91, ATM-100, April 24, Washington, D.C.

Federal Aviation Administration (1995), *National Route Program (NRP)*, FAA Order N7110.128 Free Flight, ATM-100, effective January 9, Washington, D.C.

Hoc, J., Cacciabue, P., and Hollnagel, E. (eds.) (1995). *Expertise and Technology:* Cognition and Human-Computer Cooperation, Erlbaum, Hillsdale, NJ.

Hopkin, V. D. (1995), *Human Factors in Air Traffic Control*, Taylor Francis, New York, NY.

Jones, P. and Mitchell, C. (1995), "Human-Computer Cooperative Problem Solving: Theory, Design, and Evaluation of an Intelligent Associate System," *IEEE Transactions on Systems, Man, and Cybernetics*, 25, 1039–1053.

Lacher, A. R. and Klein, G. L. (1993), *Air Carrier Operations and Collaborative Decision-Making Study*, MTR 93W0000244, The MITRE Corporation, McLean, VA.

Odoni, A. R. (1987), "The Flow Management Problem in Air Traffic Control," In *Flow Control of Congested Networks*, A. R. Odoni, L. Bianco, and G. Szego, eds., Springer-Verlag, Berlin.

Orasanu, J. (1991), "Information Transfer and Shared Mental Models of Decision Making," In *Proceedings of the Sixth International Symposium on Aviation Psychology*, Ohio State University, Columbus, OH, 272–277.

Orasanu, J. (1994), "Shared Problem Models and Flight Crew Performance," In *Aviation Psychology in Practice*, Johnston, McDonald, and Fuller, eds. Avebury, Brookfield, VT, 255–285.

Orasanu, J. and Salas, E. (1993), "Team Decision Making in Complex Environ-

ments," In *Decision Making in Action: Models and Methods*, G. A. Klein, J. Orasanu, R. Calderwood, and C. E. Zsambok, eds., Ablex, Norwood, NJ.

Rasmussen, J., Brehmen, B., and Leplat, J. (eds.) (1991), *Distributed Decision Making: Cognitive Models for Cooperative Work*, Wiley, Chichester, U.K.

Robertson, S., Zachery, W., and Black, J. (eds.) (1990), *Cognition, Computing and Cooperation*, Ablex, Norwood, NJ.

RTCA, Inc. (1994), *Implementing Air Traffic Management Through Government/Industry Partnerships-Accomplishments, Challenges and Opportunities*, Proceedings, RTCA 1994 Symposium, Nov. 30–Dec. 1, RTCA Inc., Reston, VA.

RTCA, Inc. (1995), *Final Report of RTCA Task Force 3—Free Flight Implementation*, RTCA, Inc., Washington, D.C.

Scardina, J., Simpson, T., and Ball, M. (1996), "ATM: The Only Constant is Change," *Aerospace America*, March, 20–40.

Sheridan, T. B. (1976), "Toward a General Model of Supervisory Control," In *Monitoring Behavior and Supervisory Control*, T. B. Sheridan, and J. Johannesan eds., Plenum, New York, NY, 271–282.

Sheridan, T. B. (1987), "Supervisory Control," In *Handbook of Human Factors*, G. Salvendy ed., Wiley, New York, NY.

Sheridan, T. B. (1992), *Telerobotics, Automation and Human Supervisory Control*, MIT Press, Cambridge, MA.

Wambsganss, Michael C. (1997) "Collaborative Traffic Flow Management," in *Air Traffic Control Quarterly*, Vol. 4, Issue 2, Air Traffic Control Assocation Institute, Inc., Washington, D.C.

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