TARMAC DELAY SURVEILLANCE AND MITIGATION SYSTEM: REQUIREMENTS ANALYSIS FOR NEXTGEN

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Abstract

Several widely publicized incidents, in which passengers remained on an aircraft on the tarmac for up to 11 hours prompted the Department of Transportation (DOT) to issue a new rule designed to provide consumer protection to airline passengers. The rule mandates water/food/amenities for passengers on a plane for two hours, and an option to deplane after three hours. The rule also stipulates that airlines develop internal, auditable plans to meet the two/three hour clauses, and to report tarmac delays to the government for causal analysis.

The underlying premise of the rule is that causal analysis (and incentives of fines) will enable elimination of the phenomenon. This approach assumes that the issue is not inherent to the design of the system-of-systems (e.g. span-of-control and availability of information), and that phenomenon that occur in-the-tails of the distribution are homogeneous and have finite causes.

An analysis of the roles and responsibilities of the stakeholders involved in the Tarmac Delay phenomenon identified "gaps" in the authority and availability of information to critical stakeholders that are inherent to the "design" of the "system." Further, since the Tarmac Delay phenomena occurs in-the-tails of the distribution, it is not likely that the causal analysis will eliminate this phenomenon in a reasonable time-frame. An alternate approach is to provide a "safety-net" tool to stop the gap. The requirements for the tool, described in this paper, perform real-time operations oversight by monitoring flights on the tarmac and identifying those flights that are forecast to exceed time thresholds (e.g. two/three hours). With access to the tool, stakeholders with the authority can take mitigation actions. A prototype, web-based, tool is described. The implications of this approach to rule making are discussed.

Introduction

The DOT defines a "Tarmac Delay" as an event "holding passengers on a flight on the ground before taking off, or after landing, with no opportunity for its passengers to deplane" [1]. The definition identifies two hours as the threshold at which the passengers should be provided with food, water and lavatory service. The definition identifies three hours as the threshold at which the passengers should be allowed to deplane. In the last decade there have been several widely publicized incidents in which passengers were on flights for extended periods with degraded comfort including the absence of food and service amenities, and were unable to deplane.

Although the occurrence of these events is very, low [2][3] the severity of the delay can be high. On a national level the highest incidence of tarmac delays was 0.02 percent of the annual flights (1,654 flights) that occurred in 2007, the busiest air travel year on record. In 2009, with curtailed scheduled flights, tarmac delays were recorded on 0.01 percent of flights (903 flights). Flights departing the New York airports were the worst offenders. For the period 2005 – 2009, the probability of a flight experiencing a tarmac delay of greater than 2 hours was 0.54% and the average tarmac delay for flights on the tarmac for more than 2 hours was 158 minutes per flight.

Legislation to address this issue, known as the "Passenger Bill of Rights," failed to pass in 2000, 2001, ands 2007. Voluntary airline industry initiatives increased awareness, but had little impact on performance (see Figure 1).

In 2009 [4], the Department of Transportation (DOT) issued a rule specifically designed to protect airline passengers from excessive tarmac delays. The rule: (i) set thresholds for passengers rights of two hours for food, drink and amenities, and three hours for deplaning, (ii) requires airlines to develop *contingency* plans that can be audited by the DOT, (iii) requires airlines to assign personnel responsible

for responding to customer complaints, (iv) mandates that the airlines report tarmac delays to the DOT (for post-operations analysis), and (v) enables the DOT to levy fines on the airlines using existing DOT financial penalty rules.
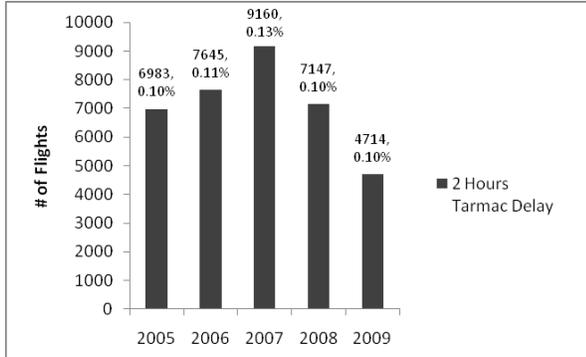

Figure 1. Percentage of flights experiencing a Tarmac Delay 2005 to 2009

The underlying philosophy of the rule is that by causal analysis (and incentive of avoiding fines), the stakeholders (i.e. airlines) will be able to make changes in operational procedures to eliminate the phenomenon. This approach does not take into account that this phenomenon is the result of the actions of distributed, autonomous, adaptive agents operating in large, complex networked system. First, the stakeholders may not have the information or authority to resolve the problem. Second, the phenomenon takes place in- the-tails of the distribution and likely is the result of large number of causes.

This paper describes a stakeholder analysis of flight operations in the NAS and identifies how the span of control, limits in information availability, and the division of responsibilities amongst the distributed, autonomous agents can result in "tarmac delays." An alternate "safety-net" approach is proposed that provides stakeholders with the authority, but without the information, a tool. The tool enables critical stakeholders to monitor and detect tarmac delays and take real-time mitigation actions. Candidate users of the tool include: staff at the Air Traffic Control System Command and Control Center, Airline Operations Centers, airline airport Station Managers, or third party assigned monitoring responsibilities. A prototype user-interface is shown in Figure 2.
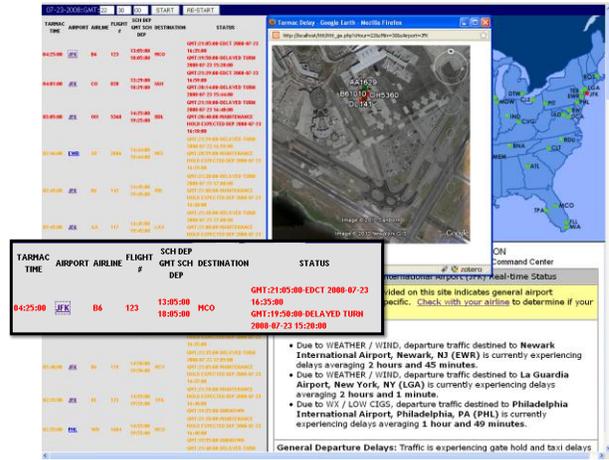

Figure 2. Web-based tool for real-time monitoring and detection and forecasting of "tarmac delays" to facilitate real-time mitigation actions.

This paper is organized as follows: Section 2 provides a definition of "tarmac delays" and a summary of the statistics and history of tarmac delays. Section 3 provides an overview of the "tarmac delay" rules. Section 4 describes a stakeholder analysis. Section 5 describes the requirements and the design of a web-based tool. Section 6 concludes with implications of this tool, the rule, and future work.

Tarmac Delays: A Brief History, Statistics, & DOT Rule

The DOT classifies situations in which were passengers on an aircraft parked on the tarmac with no means of deplaning for more than 2 hours as a "tarmac delay" [4]. The new DOT rule codified as Title 49, United States Code, 2009 was developed in response to a continuing occurrence of these events.

In January 1999 a Northwest Airlines flight from the Caribbean arrived in Detroit 22 hours late and then was kept on the tarmac for seven hours. Settlement of class action lawsuit of $7.1 million was reached between Northwest Airlines and the passengers stranded at Detroit during the snowstorm. Congress and the Clinton administration put in place some regulations but failed to pass legislative proposals including one that would require airlines to pay passengers kept waiting on a runway for more than two hours.

In December 29, 2006 121 flights inbound to Dallas-Fort Worth were diverted to regional airports due to severe lightning and a tornado warning. Several flights were diverted to nearby Austin and remained on the tarmac at Austin for several hours. Two flights, American Airlines Flight 1424 (SJC-DFW) and Flight 1348 (SFO-DFW), stranded passengers for eight hours on the tarmac.

One month later, on a slow news day, February 14, 2007 (Valentine's Day), the media had a hey-day reporting on JetBlue's 12 flights had tarmac delays of over 3 hours (including one flight that held passengers for 11 hours) when a snowstorm curtailed operations at JFK. What did not receive as much media attention was nation-wide tarmac delays of 125 flights on that day including 10 Delta flights at JFK, 27 US Airway flights at Philadelphia, and 11 US Airways flights at Pittsburgh.

In response to these incidents the DOT Inspector General recommended that airlines be required to set a limit on the time passengers have to wait out travel delays grounded inside an airplane. The DOT proposed requiring airlines to have contingency plans for stranded passengers that would force the airlines to include contingency clauses in their "contract of carriage."

A panel set up by the government of airline industry representatives considered the issue for 11 months before releasing a report in November 2008 that offered guidelines for what a model airline response plan should look like. Neither those guidelines nor the DOT proposed rule contained a specific limit on how long passengers can be kept waiting before being allowed to return to a gate.

During this period, 2005 to 2009, the frequency and severity of tarmac delays remained unchanged (Figure 1). A study of "tarmac delays" at the three major New York airports yielded the following statistics[3];

- the probability of a flight experiencing a tarmac delay greater than 2 hours is 0.54%

- the average delay experienced by the passengers that were delayed more than 2 hours, was 158 minutes with a maximum time of 435 minutes (more than 6 hours),

- June, July and August are the worst month for tarmac delays. Sixty four percent the tarmac delayed flights occurred in these months.

- flights outbound to Chicago O'Hare (8%) were the most likely to experience "tarmac delays,"

- An estimate of the average total cost to the airlines as a result of tarmac delay regulations at New York area is $43,859 per year or $476 per tarmac delayed flight.

These results indicate that tarmac delays are a rare phenomenon, but when they do occur they can impact passengers in a significant manner. The costs of the delays can be absorbed by the airlines and do not provide sufficient incentive to modify airline schedules or build necessary capacity reservoirs to handle these operational situations.

Most recently, in August 8 2009, Continental Express Flight 2816 en route to Minneapolis was diverted to Rochester, Minnesota, due to thunderstorms. Forty-seven passengers were unable to deplane and were kept for 6 hours on the tarmac. The Department of Transportation fined Continental Airlines, ExpressJet Airlines and Mesaba Airlines $175,000 for their roles in a nearly six-hour tarmac delay in Rochester, Minn.

In December 2009 Secretary of the Department of Transportation, LaHood, rewrote the proposal of his predecessors at the DOT, added a firm time-limit and other protections, and made the proposal a final rule. The 1st Session of the 111th Congress amended title 49, United States Code, to ensure air passengers have access to necessary services while on a grounded air carrier, and for other purposes [1]. The rule identifies responsibilities for three takeholders:

Air Carrier Responsibilities: The legislation calls for the Air Carrier to develop "Plans" to implement at a minimum the following:

- provide for the *essential needs of passengers* on board including: adequate food and potable water, adequate restroom facilities, cabin ventilation and comfortable cabin temperatures; and access to necessary medical treatment.

- submit a proposed contingency plan to the Secretary of Transportation that identifies a *clear time frame under which passengers would be*

permitted to deplane a delayed aircraft after 3 hours have elapsed.

The option to deplane shall be offered to passengers at a minimum not less often than once during each successive 3-hour period that the plane remains on the ground. The right to deplane shall be waived if the pilot of such aircraft reasonably determines that the aircraft will depart or be unloaded at the terminal not later than 30 minutes after the 3 hour delay; or the pilot of such aircraft reasonably determines that permitting a passenger to deplane would jeopardize passenger safety or security.

These rules apply to flights that are diverted, or have returned to a gate following push-back.

Not later than 30 days after any flight experiences a tarmac delay lasting at least 3 hours, the air carrier responsible for such flight shall submit a written description of the incident and its resolution to the Aviation Consumer Protection Office of the Department of Transportation.

The plan shall be made available to consumers on the Internet Web site of the carrier or by other means.

Airport Responsibilities: The legislation calls for Airports to develop "Plans" to implement at a minimum the following:

Airport Plans- Each airport operator shall submit a proposed contingency plan under that contains a description of: how the airport operator will provide for the deplanement of passengers following a long tarmac delay; and how, to the maximum extent practicable, the airport operator will provide for the sharing of facilities and make gates available at the airport for use by aircraft experiencing such delays.

Department of Transportation Responsibilities: Not later than 6 months after the date of the enactment of this section, the Secretary of Transportation shall review the initial contingency plans submitted and approve plans that closely adhere to the standards.

The Secretary may assess a civil penalty under section 46301 against any air carrier or airport operator that does not submit, obtain approval of, or adhere to a contingency plan submitted under this section.

The Secretary of Transportation shall establish a consumer complaints hotline telephone number for the use of air passengers.

The DOT may appropriate funding to carry out this section, which sums shall remain available until expended.

Can this Rule Prevent Tarmac Delays?

The new DOT rule places full responsibility on the airlines to avoid "tarmac delays" by establishing contingency plans for all airline functions. The plans explicitly address what to do in the event of a tarmac delay. The rule also requires airlines to report the details of tarmac delay events for causal analysis and corrective actions.

Responsibility is also placed on the airports, in their role as "public utilities." to assist airlines and provide the necessary resources and infrastructure.

The rule does not take any steps to *prevent* the occurrence of tarmac delays through real-time monitoring and mitigation actions. The underlying assumption of the rule is that the tarmac delay phenomenon is a systemic failure that can be corrected. This approaches fails to recognize that the tarmac delay phenomenon:

(i) occurs in the tails of the flight delay distribution and is therefore not likely the result of normal operations with homogeneous causes

(ii) is the consequence of interactions between distributed, adaptive, autonomous agents operating in a complex network each with limited span-of-control, and limited access to information.

Whereas with enough time it may be possible to reduce the tails of the distribution through data collection and causal analysis, a simpler and faster approach may be to install a system to perform real-time monitoring of tarmac delays to identify and forecast individual flights that could end-up in a tarmac delays and to address those issues in real-time.

Stakeholder Analysis

This section provides an analysis of the stakeholders involved in the process of managing flights that end up with Tarmac Delays. Figure 3

provides an overview of the stakeholders involved in Tarmac Delays. Table 1 summarizes the stakeholders, their roles and responsibilities, their authority to mitigate tarmac delays, automation support for tarmac delay detection/mitigation, and "gaps" in the system.

A flight involved in a tarmac delay involves the following stakeholders:

The <u>flight-crew</u> of the tarmac delayed flight are in voice and digital communication with the airline dispatch, ramp/ground control. The flight-readiness of the aircraft is determined by the flight-crew (with assistance from dispatch). Tarmac delays may be a flight-crew decision for "maintenance" reasons. For the flight to change position on the airport surface, move into the departure runway queue, or proceed to a gate, the flight-crew must get a "clearance" from ramp or ground control.
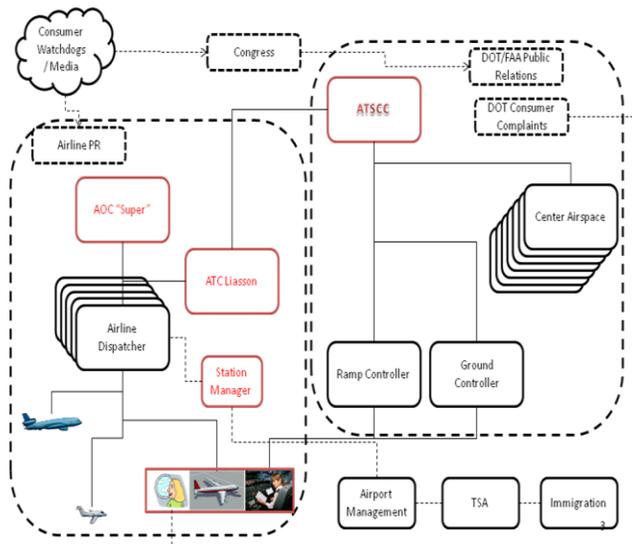

Figure 3. Stakeholders and their reporting and communication channels.

To approve of a flight departure or arrival, <u>ramp/ground control</u> are issued a "flight strip" for each flight that indicates that the flight is authorized to depart or proceed to a gate. Ramp and ground control are responsible for only the flights in their jurisdiction. They do not cause tarmac delays.

Although the controllers can see the flights from the tower window, this position does not include automation to keep track or detect tarmac delayed flights. There are no formal mechanisms for a controller to mitigate a tarmac delayed flight. When

the request for clearance from the flight is received and is consistent with the information on the flight strip, the controller can authorize the movement of the flight.

The Air Traffic System Command and Control Center (ATSCC), located in a bunker near Washington D.C., manages the flow of flights in the NAS. When the forecast number of arrivals at an airport in a 15 minute time period exceeds the capacity of the arrival runways at the airport, the Traffic Flow Management Unit (TFMU) will activate a Ground Control Program and assign individual flights an Expected Departure Control Time (EDCT). This action will cause flights to remain on the ground in a tarmac delay. Likewise, if there is forecast over capacity in the airspace, TFMU will activate an Air Flow Program (AFP) or a Miles-In-Trail (MIT) restriction and hold flights on the ground at their origin airports.

Ground hold delays from GDP, AFP, and MIT do not generally exceed two hours, however there are no rules in the slot allocation scheme that prevent a flight being assigned an EDCT in excess of 2 hours. This is one of the causes of tarmac delays. In some cases a flight may have an EDCT that is less than two hours, but by the time the flight makes its way through the departure queue the flight may have exceeded the tarmac delay threshold. Some airports (e.g. Philadelphia) have single lane taxiways for departure queues with limited entry points for a flight to "cut in line." Other airports (e.g. Dallas-Forth Worth) have multiple lane departure queue taxiways that enable switching the order of departing flights.

The National Operations Manager (NOM) oversees al ATSCCC operations. The TFMU manager oversees all TFM programs. These positions have accesss to the Collaborative Decision Making (CDM) software, Flight Schedule Monitor (FSM), that has the detailed information about all flight status. At this time, this tool does not alert the user to a Tarmac Delay situation.

Airline Dispatchers, located in bunker-like secure building near the airline headquarters, have legal responsibility for the operation of the flight. Dispatchers have excellent information on the position of flights once they are airborne through the

Stakeholder (critical only)	Roles and Responsibilities (and Authority to Mitigate Tarmac Delays)	Ability to Monitor Individual Flight Status on the Surface	Gaps
Flight-crew	Operate the flight. Have final say on flight readiness and progress. Rely on dispatch to file flightplans, approve fuel, authorize flight, get gate assignment. Rely on air traffic control to provide clearance. Has no authority or mechanism to avoid tarmac delays.	Flight-crew know the status of their flight.	Fully aware of tarmac delay status of their flight. Does not have full knowledge of scope of TFM initiatives or status of airline network operations. Relies on contact with Ramp/Ground Controller and Dispatch.
Airline Dispatcher	Manages flights from gate-to-gate. Has full legal authority for operation of each flight. Has full legal responsibility for flight (e.g. violation of immigration laws, etc). Has authority, along with Supervisor, to prioritize airline flights.	Detailed trajectory information of flight while airborne. No information of position of flight on airport surface. Voice and data communication with flight-crew and Station Manager. Dispatch automation provides OOOI status of flight (gate-out, off, on, gate-in).	Does not have full knowledge of scope of TFM initiatives or status of airline network operations. Relies on contact with ATC Liasson. (In some circumstances) can be overloaded and must work highest priority items first. Can (temporarily) lose track of tarmac delay flights.
Airline Dispatcher – ATC Liasson	Coordinates airline dispatch requests with ATSCCC Traffic Flow Programs. Has authority to negotiate on behalf of tarmac delay flights, but may require cooperation of ATSCCC and other airlines.	See Airline Dispatcher, plus automation to support TMI "programs" (e.g. Flight Schedule Monitor)	Is not alerted of tarmac delay status of each flight. Does not have detailed knowledge of the status of individual flights. Does have access to TFM initiative data. Is not automatically alerted about tarmac delay flights.
Airline Dispatch/AOC – Supervisor	Oversees all airline dispatch operations. Monitoring "big picture" and airline trends. Not focused on individual flights. Has authority to prioritize airline flights.	See Airline Dispatcher, plus automation to support TMI "programs" (e.g. Flight Schedule Monitor)	Is not alerted to tarmac delay status of each flight.
Airline Station Manager (and Gate and Ground Personnel)	Coordinates ground support for all flights at gates. No explicit responsibilities for flights that have pushed-back or not gated-in. Has no authority to mitigate tarmac delayed flights.	No automation support. Has eyes and ears on the airport surface and contact with dispatch.	Is not alerted to tarmac delay status of each flight.
Ramp Controller	Coordinates flights push-back/gate-in and ramp trajectories. No authority with regard to mitigating tarmac delays.	Has flight strips for all flights on taxiways. In good visibility has eyes out the tower cab.	Flight strips provide indication.
Ground Controller	Coordinates flight trajectories on airport taxiway system. No authority with regard to mitigating tarmac delays.	Has flight strips for all flights on taxiways. In good visibility has eyes out the tower cab.	Flight strips provide indication.
ATSCCC NOM	Provides oversight of Traffic Management Initiatives at the ATSCCC. Has more of a NAS-wide responsibility than the TFMU (see below). Responsibility for flights involved a TMI "program." Has authority to intercede on behalf of airline in negotiation with other airlines and TFMU.	Has detailed information of all flights in a TMI "program"	Is not alerted to tarmac delay status of each flight. Has knowledge of excessive departure queuing at airports.
ATSCCC TFMU	Provides oversight of Traffic Management Initiatives at the ATSCCC. Responsibility for flights involved a TMI "program." Has authority to prioritize flights within the scope of rules of TMI's.	Has detailed information of all flights in a TMI "program." May only be assigned a sub-set of airports.	Is not alerted to tarmac delay status of each flight. Has knowledge of excessive departure queuing at airports.
Airport Management/Operations	Manage and operate the airport as a "public utility." Coordinate outsourced operations. Responsibility for emergency and abnormal operations. Has no authority with regard to tarmac delays. Under new DOT rule has some responsibility for providing resources and infrastructure to deplane passengers. Can support airlines, but not intervene in airlines operations.	No automation support. Has eyes and ears on the airport surface and contact with dispatch.	Is not alerted to tarmac delay status of each flight. May have knowledge of excessive departure queuing at airports.

Table 1 Summary of Critical Stakeholders involved in Tarmac Delays

Aircraft Situation Display (ASD). However, the Dispatchers have limited information on the location and status of flights on the airport surface. They know when the aircraft has pushed back from the gate and when it has taken-off, but not where it is or it's status between gate and runway. It is a time consuming and costly procedure for an airline dispatcher to radio a flight and gather this type of status information. [Note: the limited situation awareness of airport surface operations will be resolved with the introduction of ASDE-X.]. Airline dispatchers impact on tarmac delays: (i) they have a role in dispatching maintenance/fueling to a delayed flight, (ii) completing flightplan and airline paperwork to dispatch a flight.

One of the dispatch positions is "ATC Liasson." This position provides airline dispatch operations with information on Air Traffic Control plans and emerging situations (e.g. weather re-routes or Miles-In-Trail delays). The ATC Liasson position also coordinates with the Air Traffic System Command and Control Center (ATSCC) on planned Traffic Flow Management Initiatives, such as Ground Delay Programs and can provide information to ATSCCC on the status of a tarmac delayed flight or negotiate for an improved EDCT for a flight in a program. The ATC Liasson has access to the CDM tool that has detailed information on the status of flights in a program. They also have access to the airline dispatchers tools (see above).

Airline dispatch operations are monitored by "supervisors" that provide support and approvals to the individual dispatchers. Supervisors have access to the same information as the ATC Liasson and dispatcher.

Another airline representative is the Station Manager and the gate and ground staff. This group is responsible for the gate-in, turn-around, and gate-out operations. For departing flights, once an aircraft is pushed-back from the gate, the gate resources are shifted to the next incoming flight or to other gates. None of these personnel have the explicit responsibility or the means to track and status flights on the tarmac. For arriving flights, Station managers coordinate gate assignment and supporting ground crew and equipment. Station managers have direct voice and data communication with dispatch.

Airport Management is a background activity associated with operating an airport. This activity mostly involves operating any facilities directory operated by the airport, and coordinating activities outsourced to supply-chain vendors. All airports have the authority and the procedures to deal with emergency and abnormal situations such as severe weather, accidents, terrorism, etc. The airport does not have the authority to interfere with airline operations.

The Transportation Security Agency (TSA) along with U.S. Immigration Services have responsibilities of security and passenger/cargo processing. These two enterprises are part of the critical path of the supply chain in providing resources for departing and arriving passengers.

"Gap" Analysis

The two scenario classes that yield Tarmac Delays, "forgotten flights" and "excessive curtailed capacity" have one feature in common: the stakeholders that have the authority to address the situation, are working the system at a more abstract level and do not have information on the status of these flights. The stakeholders that do have the knowledge, do not have the authority.

Despite the best efforts to improve operations to avoid Tarmac Delays based on the required DOT analysis reporting clause, the gap between knowledge and authority remains and can only be filled by system-wide information.

A Tarmac Delay Surveillance and Mitigation System (TDSMS) is required to monitor, detect and mitigate Tarmac Delays.

System Requirements and Design

The objective of the Tarmac Delays Surveillance and Mitigation is system is to provide decision support for detection and mitigation of "Tarmac Delays." Operators of the system include, but are not limited to: NOM at ATSCC, ATC Liasson Airline, Dispatchers/AOC "Super," Airline Station Manager and staff, and Airport Management/Operations.

Functional Requirements

1. Detect all flights on tarmac in excess of <time threshold>

2. Provide information and status on these flights. Status includes airline updates on maintenance, ATC/TFM updates on Traffic Management Initatives, …

3. Provide contextual information (airport status, TMI status, …)

4. Provide alert for all flights on tarmac approaching <caution threshold> and <time threshold>

5. Provide operator with necessary contact information to initiate mitigation strategies

6. Alert responsible parties (via e-mail, text message, …) of tarmac delay

7. Provide airport "hot-spots" actual and forecast

8. Generate historical trend information

The specific functional requirements for each user of the tool are summarized in Appendix 1.

Performance Requirements

A five minute update rate of aircraft status is adequate of this purpose. Accuracy requirements should be sufficient to engender trust in the system.

Input/Output Requirements

Figure 4 provides an overview of the input/output requirements of the system. Physical aircraft status information is provided by the ARINC OOOI data, CDMNet ADL data, and ASDE-X data. These dataset are processed and are used to create the Tarmac Delay List. Traffic Flow Management (TFM) Traffic Flow Management Initiative (TMI) data is used to update flight status (where applicable). Also airline personnel, such as Dispatch, Station Manager, etc can update flight status information (e.g. maintenance status).
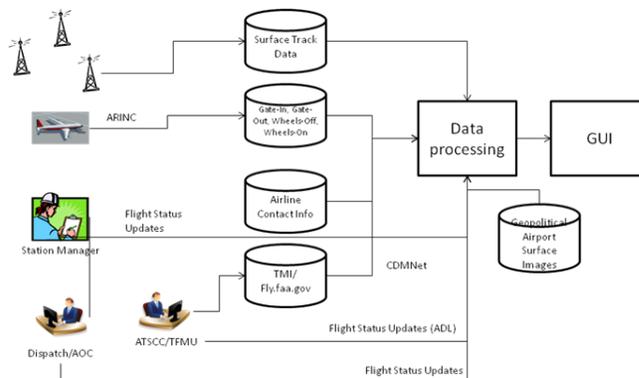

Figure 4. TDSMS Input/Output Requirements

Technology Requirements

The tool should be available for access on (a secure) web-browser. This will provide for multiple location access and simplify configuration management and control.

Design Requirements

The following design requirements have been identified and implemented in a prototype. The system shall include three simultaneous displays (Figure 5):

(1) a panel for a list of flights delayed on the tarmac for more than a specified threshold (e.g. 1 hour) for a specified set of airports.

(2) a panel for a geographic depiction of the airports in the NAS and current and forecast hot-spots for tarmac delays, and

(3) a panel for user selectable status information (e.g. FAA Airport Status Information, Surface Track data at an airport, statistics, …)
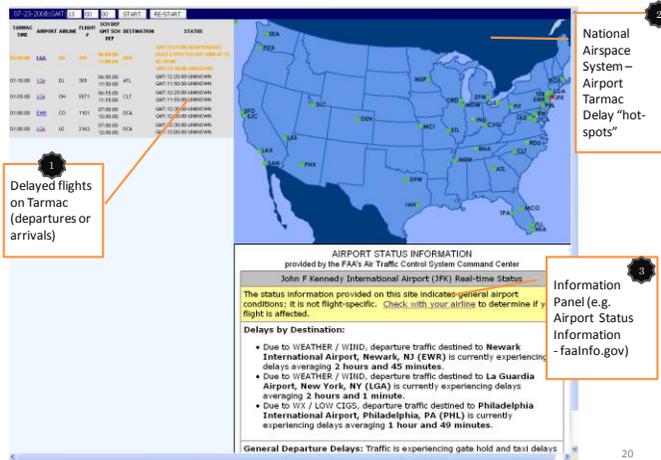
Figure 5. Graphical user-interface of TDSMS includes three panels: (1) a list of flights delayed on the tarmac for more than a specified threshold (e.g. 1 hour) (2) a geographic depiction of the airports in the NAS and current and forecast hot-spots for tarmac delays, and (3) user selectable status information (e.g. FAA Airport Status Information, Surface Track data at an airport, statistics, …)

Function buttons and displays can be configured by the user for display on the menu bar. The default display includes: GMT time and Local time.

Tarmac Delayed Flight List Panel

This panel includes a list of Tarmac Delayed flights. Flights are included on this list based on time spent on the tarmac after push-back and before lift-off, and after landing and before gate-in. Flights appear on the list when the Tarmac Delay exceeds a user-set threshold (e.g. 1 hour). Flights on the list are displayed a different color (e.g. orange) when the Tarmac Delay exceeds a user-set threshold (e.g. 2 hours). Flights on the list are displayed a different color (e.g. red) when the Tarmac Delay exceeds a user-set threshold (e.g. 3 hours).

The parameters displayed for each flight in the list are configurable and set by the user. A default layout, illustrated in Figure 6, includes the following parameters:

- Tarmac Time: time spent on the tarmac after push-back and before lift-off, and after landing and before gate-in

- Airport: location of flight

- Airline: operator of flight

- Flight Number: identification of flight

- Scheduled Departure/Arrival Time: shown both in GMT and Local Time.

- Destination or Origin: for arriving flights, the origin. For departing flights, the destination.

- Status: updates on status of the flight with expected time of departure/gate-in. Status updates can be provided by multiple sources including: CDMNet TMI "program" updates, airline dispatch, airline maintenance, airline Station, etc. Status field may display upto a user-specified number of entries. User selection can expand the number of entries.

Figure 6. Fields in the Tarmac Delay List

Each of the fields in the list can be selected resulting in ascending/descending ordering of the list by the contents of the field. Sequential ordering of fields can also be configured by the user.

Tarmac Delay "Hot Spots" Panel

This panel provides a view of the NAS. The display identifies Tarmac Delay "hotspots." The criteria for display and the colors can be configured by the user. In the default setting, an airport changes color to orange when the number of actual/forecast flights in a tarmac delay exceeds three. An airport changes color to red when the number of actual/forecast flights in a tarmac delay exceeds ten.

Selection of an airport on the graphic has two effects: (1) airport status information is displayed in the information panel, (2) only the flights at the selected airport are displayed in the flight list.

Status Information Panel

This panel provides information related to the status of the airport, status of the flight, or other status information. The information displayed in this panel can be configured by the user. For example Airport Status Information can be displayed.

Conclusions

The phenomenon of Tarmac Delays raises questions about the role of consumer protection, regulator responsibilities, stakeholder authority and system-wide information. Given that society designs, builds and operates large, complex adaptive systems:

1) Is it reasonable to expect non-normal event failures?

2) Can these failures be avoided by design?

3) Can these failures be legislated out of the system by mandate or by threat of fines?

4) If these failure cannot be avoided by design, is it reasonable to design an umbrella mechanism to detect and mitigate them?

5) What role does government as regulator of operations or consumer protection have in mitigating this situation?

Like all large, complex, systems composed of distributed and autonomous agents, the design and operations of the air transportation system and it's component air traffic control system inherently enables flights to experience tarmac delays. These delays can occur in two scenarios: (1) rare, but not unexpected events with reduced capacity requiring complex system-wide coordination, and (2) isolated events due to absence of protocol or breakdown in communications.

The first case is a rare, but not unexpected, event occurs (e.g. snowstorm) that requires system-wide coordination to reduce demand at key nodes to capacity (e.g. TFM programs). Small breakdowns in coordination and communication can result in unavoidable tarmac delays of a large number of flights. The 1999 snowstorm in Detroit and the 2007 Valentines Day snowstorm scenario at JFK are examples where the reduced capacity (i.e. gates) could not meet the demand. Some the steps taken to avoid this situation is better coordination to hold inbound flights at their origin airports to prevent overwhelming the limited resources and exacerbating the situation. Both the airlines and ATSCCC have roles in this change.

The other scenario is an isolated circumstance when coordination of the distributed parts of the system break-down and a flight is "forgotten." Examples of this scenario are the AAL 1348 flight at Austin and the Continental Express 2816 flight that required coordination between airline, airport, and U.S. Immigration.

In both cases, the stakeholders with the authority to address the situation were operating with "flow" information that does not reflect the tails of the distribution or individual flight information. Despite the best efforts to improve operations to avoid both of these scenarios, unless a change in the system information structure or a change in stakeholder authority is implemented the

Even if the issues with authority and information could be addressed, given that the system is a large, complex system whose behavior is derived from the actions of distributed, autonomous, adaptive agents, can phenomena in-the-tails of the distribution, such as "tarmac delays" ever be eliminated through causal analysis alone. And is the speed of causal analysis, through a regulatory process, reasonable.

References

[1] Camara of Representatives, *Airline Passenger Bill of Rights Act of 2009*, 111TH Congress, 1st Session: 2009.

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Acknowledgements

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Appendix I

Design Requirements for each User

	Stakeholder	Tarmac Delayed Flight List Panel	Tarmac Delay "Hot Spots" Panel (NAS Map)	Status Information Panel	Surface Track View (Google Earth)	Report Generation
AIRPORT - GATE	Airline Dispatcher	Filter by airport/airline	Nice to have	NO	Yes	Yes
	Airline Dispatcher – ATC Liasson	Filter by airport/airline	Nice to have	NO	Yes	Yes
	Airline Dispatch/AOC – Supervisor	Filter by airport/airline/flights	Nice to have	NO	Yes	Yes
	Airline Station Manager (and Gate and Ground Personnel)	Filter by airport/airline/flights	NO	NO	Yes	Yes
AIRPORT - RAMP	Ramp Controller	Filter by airport/ramp/flights	NO	NO	Yes	Yes
	Ground Controller	Filter by airport/area/flights	NO	NO	Yes	Yes
	Local Controller	Filter by airport/area/flights	NO	NO	Yes	Yes
ATSCCC	NOM	YES	YES	YES	No	Yes
	TFMU	YES	YES	YES	No	Yes
AIRPORT	Airport Management/Operations	YES	NO	NO	Yes	Yes
	Transportation Security Agency	No	Nice to have	No	No	Yes
	Immigration and Naturalization	No	Nice to have	No	No	Yes
OTHERS	DOT Consumer Protection	No	No	No	No	Yes
	Congress	No	No	No	No	Yes