2013

Perceived Usefulness of Planned NextGen Capabilities by Air Traffic Control Tower Controllers

Jon Holbrook

Ray Oyung

Kari M. Gonter

Bonny Parke

Rebecca Collins

See next page for additional authors

Authors
Jon Holbrook, Ray Oyung, Kari M. Gonter, Bonny Parke, Rebecca Collins, and Bettina L. Beard

PERCEIVED USEFULNESS OF PLANNED NEXTGEN CAPABILITIES BY AIR TRAFFIC CONTROL TOWER CONTROLLERS

Jon Holbrook
San Jose State University
Moffett Field, CA

Bonny Parke
San Jose State University
Moffett Field, CA

Ray Oyung
San Jose State University
Moffett Field, CA

Rebecca Collins
San Jose State University
Moffett Field, CA

Kari M. Gonter
San Jose State University
Moffett Field, CA

Bettina L. Beard
NASA Ames Research Center
Moffett Field, CA

The Next Generation Air Transportation System (NextGen) is an ambitious collaborative effort between government agencies and industry to increase the capabilities of the current air traffic system. Under NextGen, tools are being developed to support air traffic controllers in many aspects of their jobs. However, budgetary constraints, unanticipated technological hurdles and other challenges to implementation make it unlikely that every NextGen tool in development will find its way into future air traffic control facilities. Information is needed to prioritize NextGen tool development to ensure that the tools that will provide the most benefit can be implemented in the appropriate facilities. Toward this end, a web-based survey was conducted of 174 air traffic control tower controllers to identify the perceived usefulness of 10 planned NextGen tower capabilities designed to provide or support: departure metering at the ramp, taxi routing, departure runway assignments, departure flow management, runway scheduling, runway configuration management, integrated arrival/departure scheduling, enhanced surveillance, electronic flight data, and tower data communications. Along with brief descriptions of each of the planned capabilities, surveyed tower controllers were asked to indicate the extent to which each capability would help them in their job and affect capacity, efficiency, flexibility, predictability and safety at their airport. Results indicated that different NextGen capabilities were perceived as useful across different tower facilities. Implications for the prioritization of NextGen tool development are discussed.

The FAA's Next Generation Air Transportation System (NextGen) is a transformational plan to enhance air traffic operations through the introduction of advanced automation. The FAA has identified numerous capabilities that it plans to automate for Air Traffic Control Tower (ATCT) operations by 2018. Computational simulations of these capabilities suggest that some of the metrics (operational efficiency, capacity, flexibility, safety, predictability and environmental enhancements) used to show NextGen success can be achieved theoretically. However, most of the algorithms under development are still too immature to be tested or have not been tested with humans in the loop (Beard, Johnston and Holbrook, 2013). Our overarching goal is to develop an additional metric, a measure of human performance, that must be measured before FAA stakeholders can claim success.

Although air traffic controllers and traffic management coordinators will be the primary users of the new automation, their participation in NextGen decisions has been limited (GAO, 2009). Previous National Airspace System (NAS) modernization efforts have shown that insufficient input and buy-in by the users of new systems can delay certification and at times result in unintended application of the new systems. The approach taken here was to obtain ratings from ATCT controllers of how helpful they think NextGen improvements would be to their job (the human performance estimate) as well as to operational capacity, efficiency, safety, flexibility and predictability. To reach a large sample size and broad range of facility types, we distributed a survey that could be accessed and taken over the internet. Based on other research at NASA (Beard, Parke, Holbrook, & Oyung, in preparation; Holbrook, Puentes, Stasio, Jobe, McDonnell & Beard, 2011) we hypothesized that controllers would give lower ratings to suggested improvements to automate their more complex cognitive tasks and decisions and higher ratings to those improvements that would enhance their awareness of the situation.

Method

Participants

Survey responses were received from 174 tower air traffic controllers. Data from 126 controllers were included in this analysis, because data from the remaining 48 respondents were incomplete. The included participants represented 52 tower facilities, including 16 Core 30 airports (i.e., airports identified by the FAA as those with significant activity serving major metropolitan areas and/or as hubs for airline operations). Participants from Core 30 airports represented 42% (n=53) of survey respondents, with the remaining 58% (n=73) of respondents coming from non-Core 30 airports. The tower facilities represented by the participants ranged in complexity across FAA facility levels 5 through 12.

All study participants were current tower air traffic controllers, 89% of whom were Certified Professional Controllers (CPCs), and the remaining 11% were CPCs in training, or developmentals. Participants varied in terms of their years of experience in air traffic control: 36 participants had less than 10 years of experience, 25 participants had 10-19 years of experience, and 65 participants had 20 or more years of experience.

Materials

Although a primary goal of this survey was to inform policy makers and technology developers about controllers' views on NextGen, the complexity of NextGen created a challenge for developing a survey that active-duty controllers could take and complete in their spare time. The FAA has proposed 82 technological or procedural changes for implementation in the 2015-2018 timeframe in the form of 31 Operational Improvements (OIs) and 51 associated OI-increments (https://nasea.faa.gov). To provide a more concise and manageable description of NextGen plans, our research team distilled these plans into the following 10 capabilities, which were described in terms of tools to support tower controllers' tasks,:

1. **Departure metering at the ramp** – This tool will suggest gate release or taxi times for individual aircraft to help meet scheduled departure times and/or traffic restrictions.
2. **Taxi routing** – This tool will suggest taxi routes for individual aircraft to help organize the physical queue of traffic in the movement area.
3. **Departure runway assignment** – This tool will suggest runway assignments for departure aircraft to help distribute traffic across available runways.
4. **Departure flow management** – This tool will suggest takeoff times and opening/closing of departure routes or fixes to help align with terminal and en route airspace Traffic Management Initiatives.
5. **Runway scheduling** – This tool will suggest queue-release sequences for departure aircraft, and landing or runway-crossing sequences for arriving aircraft to help organize the flow of traffic on runways.
6. **Runway configuration management** – This tool will suggest which runways should be used for arrivals and departures to help distribute traffic across available runways.
7. **Integrated arrival/departure scheduling** – This tool will suggest schedule and staging information for arrivals and departures to help provide dynamic flexibility for managing traffic.
8. **Enhanced surveillance** – This capability will track and identify vehicle and aircraft positions, as well as provide monitoring and alerting for runway incursions and taxi conformance through both cockpit and tower displays.
9. **Electronic flight data** – Electronic flight data will replace analog data (including paper flight strips) to provide immediate access to and sharing of up-to-date flight-plan and aircraft status information among controllers, airlines and automated tools.
10. **Tower data communication** – This tool will supplement voice communication by providing the ability to transmit automated terminal information, departure clearances and amendments, and taxi route instructions electronically between aircraft and controllers.

We also identified several metrics for evaluating these NextGen capabilities based on key operational metrics that NextGen was designed to enhance, as well as controllers' individual performance, including:

- **Your job** – Helping you carry out your work responsibilities
- **Airport capacity** – Maximizing the number of operations safely conducted in a given time period
- **Airport efficiency** – Minimizing delay in gate-to-gate operations
- **Airport safety** – Identifying and mitigating loss of separation and aircraft confliction risks
- **Flexible operations** – Adjusting operations as needed in real time

- **Predictable operations** – Providing consistent and dependable information to support planning

Participants for the survey were recruited through coordination with a NATCA representative, who vetted the survey and sent a link to the survey website to NATCA members by email.

Procedure

Upon visiting the survey website, participants were provided with a brief overview of the goals and content of the survey. They were reminded that their participation in the survey was voluntary, that the survey was anonymous, and that their data would be protected in accordance with NASA's privacy policy. No incentives or compensation were provided for participation.

Survey participants were asked to identify the perceived usefulness of the 10 planned NextGen tower capabilities described above. For each capability, controllers were asked to use a sliding scale from -5 to +5 to indicate the extent to which each capability would impact their job and affect capacity, efficiency, safety, flexibility and predictability at their airport. Controllers could view brief descriptions of each of the planned capabilities, as well as definitions of the operational performance metrics, by hovering over the capability or metric name with their cursor.

In addition to rating the NextGen capabilities, controllers were given an opportunity to comment on improvements they would like to see in the tools and procedures they use today, as well as suggest new tools or procedures that would assist them in their job. Controllers also provided demographic data, including their current position, years they have worked in ATC, their 3-letter airport identifier and facility level.

Results

Controllers submitted 174 surveys, of which 126 were complete. Only data from the 126 completed surveys were included in the data analysis. Participants completed the survey in a median of 10 minutes, with a range from 4 to 279 minutes.

For each capability (e.g., departure metering at the ramp) and for each metric (e.g., airport capacity), t-tests were performed to determine if the mean value for that capability or operational metric differed from zero in either direction. For all statistical tests, significance was set at a = .05. T-test results are shown in Table 1.

Table 1.
T-test results for Capability and Metric to determine if mean ratings differed from zero.

	Mean (S.E.)	Statistical Test
Capability		
1. Departure metering at the ramp	1.01* (.15)	t(125) = 6.87, p < .001
2. Taxi routing	0.14 (.17)	t(125) = 0.80, p = .424
3. Departure runway assignment	0.23 (.17)	t(125) = 1.32, p = .189
4. Departure flow management	0.56* (.14)	t(125) = 3.84, p < .001
5. Runway scheduling	0.14 (.17)	t(125) = 0.81, p = .420
6. Runway configuration management	0.38* (.17)	t(125) = 2.23, p = .028
7. Integrated arrival/departure scheduling	0.75* (.16)	t(125) = 4.63, p < .001
8. Enhanced surveillance	1.60* (.13)	t(125) = 11.85, p < .001
9. Electronic flight data	1.31* (.15)	t(125) = 8.75, p < .001
10. Tower data communication	1.04* (.19)	t(125) = 5.48, p < .001
Metric		
Job	1.09* (.14)	t(125) = 7.67, p < .001
Capacity	0.73* (.12)	t(125) = 5.92, p < .001
Efficiency	0.97* (.13)	t(125) = 7.27, p < .001
Safety	0.74* (.12)	t(125) = 6.42, p < .001
Flexibility	0.02 (.13)	t(125) = 0.15, p = .880
Predictability	0.75* (.13)	t(125) = 5.95, p < .001

Note: * denotes significance at a = .05; S.E. = Standard Error

Survey data were also subjected to an analysis of variance (ANOVA) with within-subjects factors of Capability (10 levels, see above) and Metric (6 levels: job, capacity, efficiency, safety, flexibility predictability) and between-subjects factors of Experience (3 levels: 0-9 years [n = 36], 10-19 years [n = 25], and 20+ years [n = 65]) and Facility (4 levels: small non-hub [n = 48], medium non-hub [n = 25], medium hub [n = 27], and large hub [n = 26]). Levels of the Facility variable were determined by combining airport identifier and facility level data in the following way: non-Core 30 airports with facility levels 5-7 were identified as small non-hubs (e.g., GTF, TOL, FSM); non-Core 30 airports with facility levels 8-9 were identified as medium non-hubs (e.g., PDX, LGB, DAB); Core 30 airports with facility levels 8-10 were identified as medium hubs (e.g., IAD, MEM, PHX); and Core 30 airports with facility levels 11-12 were identified as large hubs (e.g., LAX, CLT, ORD).

Analyses revealed a main effect of Capability, $F(9,1026) = 12.83$, $p < .001$. Within-subjects contrasts revealed that participants rated Capabilities 1, 8, 9, and 10 higher than the overall mean rating, and Capabilities 2, 3, and 5 lower than the overall mean. A main effect of Metric, $F(5,570) = 30.76$, $p < .001$, was also detected. Within-subjects contrasts indicated that participants rated Job and Efficiency higher than the overall mean, and Flexibility lower than the overall mean. Analyses also showed a marginal main effect of Experience, $F(2, 114) = 2.30$, $p = .105$. Planned comparisons revealed that the mean rating by controllers with 20+ years (0.46) was lower than the mean rating by the controllers with 0-9 years of experience (1.03), $p = .043$. Mean ratings for controllers with 10-19 years of experience (0.92) did not differ from the other groups.

A significant interaction of Capability by Facility, $F(27,1026) = 1.63$, $p = .022$, along with subsequent post-hoc tests, indicated that controllers from large hub facilities rated the impact of Capabilities 8, 9 and 10 lower than did controllers from small non-hub and medium hub facilities (see Figure 1).

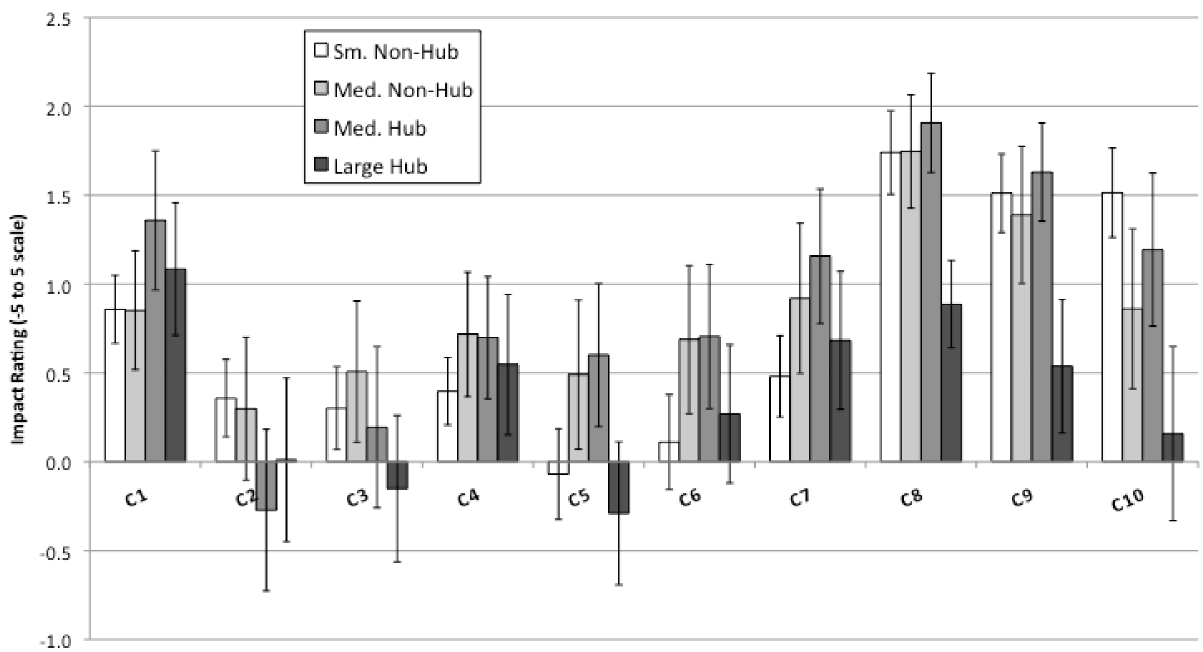

Figure 1. The interaction between Capability and Facility type indicated that controllers from large hubs gave lower impact ratings to Capabilities 8, 9 and 10. Error bars represent standard error.

A significant interaction of Capability by Metric, $F(45,5130) = 21.97$, $p < .001$, and follow-up post-hoc tests indicated that controllers rated the impacts of the operational performance metrics differently across Capabilities. This interaction is shown in Figure 2.

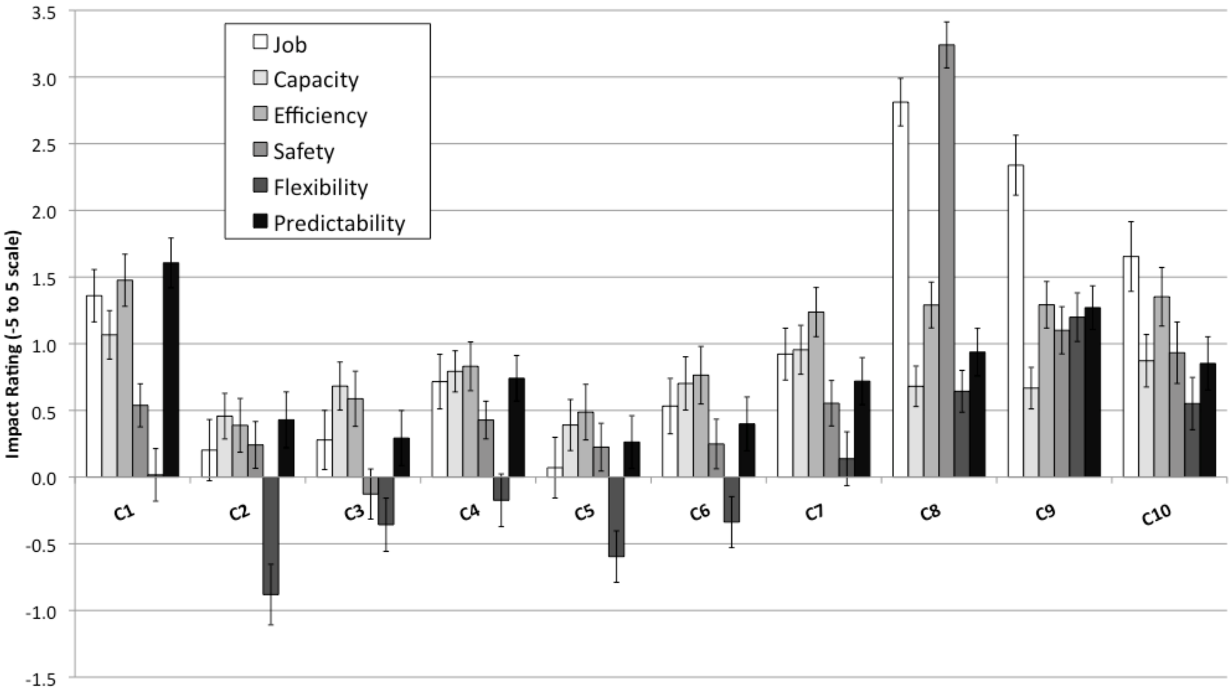

Figure 2. The interaction between Capability and Metric. Error bars represent standard error.

Significant differences across metrics within a Capability are depicted in Table 2. For each Capability, impact ratings for metrics highlighted in light gray were rated higher than those highlighted in dark gray. Metrics shown with a white (i.e., not highlighted) background did not differ from the highlighted groups.

Table 2.
Significant differences across metrics within each Capability are shown using light/dark gray highlighting.

Capability	Metric					
1. Dep. metering	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
2. Taxi routing	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
3. Runway assign.	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
4. Flow mgmt.	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
5. Runway sched.	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
6. Runway config.	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
7. Integ. arr./dep.	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
8. Surveillance	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
9. Elec. flt. data	Job	Capacity	Efficiency	Predictability	Safety	Flexibility
10. Data comm.	Job	Capacity	Efficiency	Predictability	Safety	Flexibility

Note: Metrics highlighted in light gray were rated higher than those highlighted in dark gray at a = .05.

Discussion

The 10 NextGen capabilities described above can be grouped into three categories: Capabilities that support tactical decision making by controllers (i.e., 1. Metering at the ramp, 2. Taxi routing, 3. Departure runway assignment[1], and 5. Runway scheduling); capabilities that support strategic decision making by traffic managers (i.e., 4. Departure flow management, 6. Runway configuration management, and 7. Integrated arrival/departure scheduling); and capabilities that support situation awareness (i.e., 8. Enhanced surveillance, 9. Electronic flight data, and 10. Tower data communication).

[1] Departure runway assignment is initially a traffic management task, but assignments can be changed by the controller based on the immediate tactical situation. Additionally, at smaller facilities, this function might be performed primarily by a controller.

Overall, the results of this study supported our hypothesis that controllers would rate most highly the capabilities that support situation awareness, and rate lowest the capabilities providing tactical decision making (i.e., those supporting complex cognitive tasks). Prior research indicates that controllers are disrupted and lose situational awareness when automation performs their tactical decision tasks (e.g., Holbrook, Hoang, Malik, Gupta, Montoya, & Jung, 2012). The capabilities providing strategic decision making primarily support traffic managers, and would have less direct impact on tower controllers. Controllers' high ratings on the Job metric for capabilities 8, 9 and 10 are consistent with the expected impact of tools that would enhance a controller's situational awareness. Interestingly, controllers at large hub facilities rated the capabilities that support situation awareness lower than did controllers from small- or medium-sized facilities. However, large hub controllers were also more likely to express concerns about heads-down versus out-the-window time in their comments, for example: "Controllers are already looking out the window less than they used to. New automation could make this worse." This issue of heads-down time is a concern for situation awareness tools that are tied to tower displays (e.g., ASDE-X, electronic flight strips).

Controllers gave relatively high ratings to Capability 1, departure metering at the ramp, even though it falls into the category of tactical decision support (and therefore has a greater potential to disrupt planning and controller situation awareness). This concern was perhaps acknowledged by controllers through a lower safety rating relative to the other metrics for that capability. However, Capability 1 received the highest ratings of any capability on the capacity, efficiency and predictability metrics, indicating that tower controllers see this as an area for high potential impact, particularly at airports with a higher volume of scheduled operations, as suggested by the higher ratings by hub over non-hub controllers. As one controller from a small non-hub facility stated, "I can see how these ideas will benefit the busier airports, but are not applicable to us due to our lower traffic volume."

Controllers were fairly consistent in giving low impact ratings for the Flexibility metric. Controllers also voiced this concern in their comments, for example: "Airlines have a hard time hitting a 10-minute EDCT window. The more exact we try to make it, the worse the outcome will be. There has to be a fudge factor for the system to work." This issue of flight crew compliance is critical for the success of NextGen algorithms, which rely heavily on aircraft meeting 4-D trajectories. The same capabilities (i.e., 8, 9 and 10) that support controller situational awareness should also support flight crew situational awareness, increase flight crew compliance with 4-D trajectories, and thus enable more successful implementation of the other NextGen capabilities.

This study helps to address a concern raised by the GAO (2009) that active air traffic controllers have not been appropriately involved in NextGen planning, and provides a glimpse at a potential indicator of the impact of NextGen enhancements on human performance.

Acknowledgements

We would like to thank NATCA NextGen representative Mel Davis for his support in survey development and distribution. This work was funded under Interagency Agreement #DTFAWA-09-X-80020 between NASA and the FAA. The FAA Human Factors Research & Engineering Group coordinated the research requirement and its principal representative acquired, funded, and technically coordinated execution of the research service.

References

Beard, B. L., Johnston, J. C., & Holbrook, J. (2013). NextGen operational improvements: Will they improve human performance? *Proceedings of the 17th International Symposium on Aviation Psychology*. Dayton, OH: The Wright State University.

Beard, B. L., Parke, B., Holbrook, J., & Oyung, R. (2013). Survey of human factors experts on the potential human performance risks and benefits of NextGen capabilities. Manuscript in preparation.

Government Accountability Office. (2009). *Next generation air transportation system: Issues associated with midterm implementation of capabilities and full system transformation*. GAO-09-481T.

Holbrook, J., Hoang, T., Malik, W., Gupta, G., Montoya, J., & Jung, Y. (2012). Reducing environmental impact while maximizing airport throughput: The consequences of introducing new operational goals with and without automation support in an air traffic control tower simulation. *Proceedings of the 4th International Conference on Applied Human Factors and Ergonomics,* 1819-1828. San Francisco, CA: USA Publishing.

Holbrook, J., Puentes, A., Stasio, N., Jobe, K., McDonnell, L., & Beard, B. L. (2011). How thoroughly do proposed NextGen mid-term operational improvements address existing threats? *Proceedings of the 16th International Symposium on Aviation Psychology*. Dayton, OH: The Wright State University.