May 14, 2018

Ali Bahrami
Associate Administrator for Aviation Safety
Federal Aviation Administration
800 Independence Ave SW
Washington, DC 20591

Dear Ali,

The Performance Based Operations Aviation Rulemaking Committee (PARC) is pleased to submit to you the attached document, entitled *Satellite Voice Project Report*. This report describes two operational evaluations of satellite voice (SATVOICE) communications as a supplemental or alternative technology to high frequency (HF) voice communications and includes results of those evaluations.

Based on those results, and in light of recent infrastructure upgrades at New York and San Francisco RADIO, the PARC has determined that SATVOICE communications with those aeronautical radio stations meets the Required Communication Performance 400 (RCP400) specification as defined in ICAO Doc 9869, *Performance-based Communication and Surveillance Manual*. Accordingly, the PARC recommends that the FAA:

(1) remove the restrictions in the United States Aeronautical Information Publication (AIP) on SATVOICE communications in order to enable it as an approved long range communications system (LRCS) for communicating with air traffic control (ATC) via New York and San Francisco RADIO; and

(2) advocate that all ICAO signatories, where infrastructure so permits, remove restrictions on SATVOICE communications to harmonize this new operational philosophy globally.

The PARC appreciates your continued support of its activities and invites you to discuss any aspects of these recommendations at your convenience. The PARC also respectfully requests the FAA to provide us with a formal response to these recommendations. We thank the PARC Communications Working Group (CWG) – particularly its SATVOICE Tiger Team led by Tony Rios of Avionica – for its diligence in completing the report and the PARC participants for their continued support.

Sincerely,

Mark Bradley
Chairman, PARC

Cc: Mark Steinbicker
Chris Hope
Merrill Armstrong
Mike Matyas
Jon Pendleton
John McCormick

Satellite Voice Project Report

12 March 2018

Prepared by:

Performance Based Operations Aviation Rulemaking Committee

Communications Working Group (PARC CWG)

Version 1.0

Executive Summary

The FAA Performance Based Operations Aviation Rulemaking Committee Communications Working Group (PARC CWG) Satellite Voice Tiger Team conducted an operational evaluation of satellite voice communications (SATVOICE) from September 2014 to April 2015 that encompassed three Flight Information Regions (FIR): Oakland Oceanic, New York, and Gander. Further to this initial operational evaluation, JetBlue Airways, in cooperation with various offices in the FAA Flight Standards Service, Iridium®, FAA New York Air Route Traffic Control Center (NY ARTCC) and New York RADIO, conducted a more fulsome operational evaluation within the New York - West Oceanic Control Area off the east coast United States.

The purpose of the initial evaluation was to support a recommendation to the FAA for approval of changes to the present HF voice equipment configuration requirements, and to establish a standard for "Post Implementation Monitoring". The purpose of JetBlue's evaluation was to gather the necessary data to further support the recommendation. However, JetBlue's evaluation differed from the initial operational evaluation in that it included FAA NY ARTCC participation using the FAA's Advanced Technology Oceanic Procedures (ATOP) flight data processing system and, in doing so, provided a more direct correlation to true, real world SATVOICE operations.

Both evaluations measured the performance of SATVOICE against the ICAO Required Communications Performance (RCP) standard for High Frequency (HF) voice, RCP400 as specified in ICAO Doc 9869,second edition, and relevant for SATVOICE.

Based on the results of both evaluations, the PARC CWG recommends accepting Iridium and Inmarsat SATVOICE for ATS Voice Safety Services beyond temporary master minimum equipment list (MMEL) relief. Further, the PARC CWG has developed recommendations on acceptable combinations of dual long-range communications systems (e.g, SATVOICE & HF, "1+1") . Section 5 of this report provides a full set of recommendations.

A summary of key findings include:

- In the aggregate, SATVOICE actual communications technical performance (ACTP) Transaction Time (TT) criteria was met with 95.4% of clearance attempts completed within 320 seconds.

- In the aggregate, SATVOICE actual communications technical performance (ACTP) Expiration Time (ET) criteria fell slightly short with 98.33% of clearance attempts completed within 370 seconds.

- With technical and process improvements identified and applied, ACTP TT and ET criteria was eventually exceeded with 100% of clearance attempts completed within 320 seconds by the end of the evaluation program.

Foreword

The Performance-Based Operations Aviation Rulemaking Committee (PARC) is an FAA-sponsored activity that operates according to the Administrator's authority under 49 USC 106(p)(5). The PARC comprises members from the FAA and the aviation community at large, provides recommendations to FAA's Senior Management for action and implementation. The PARC has been effective over the last decade in implementing RNAV/RNP. In 2005, the PARC established the Communications Working Group (CWG) to address a number of issues related to the implementation of aeronautical communication systems. These systems included, among others, the future air navigation system (FANS) 1/A, the aeronautical telecommunication network (ATN), and satellite voice communications.

The PARC CWG is committed to applying the performance-based concept, which aims to leverage existing capability and maximize benefits by:

a) Enabling cost-effective alternatives, using different technologies and existing capabilities, that meet business needs in a timelier manner;

b) Providing performance-based criteria to demonstrate aircraft equipment and capability without technological or implementation-specific constraints; and

c) Enabling different levels of service in common airspace to a fleet of aircraft with varying capability and performance.

The PARC CWG develops recommendations that directly support matters that relate to the FAA's regulatory criteria and guidance material for implementation of voice and data communications within the U.S. National Airspace System (NAS). However, the PARC CWG recognizes that global harmonization is crucial to the success of any State or regional implementation initiative. As such, the PARC CWG prepares Coordination Drafts for broad review and solicits input on such matters of interest to the aviation community. For more information on PARC CWG activities please contact either Michael Matyas (Michael.Matyas@boeing.com), Jon Pendleton (jon.pendleton@delta.com), or John McCormick (jtmccormickiii@fedex.com).

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1. Background

In oceanic and remote airspace, flight communications have historically been conducted with high frequency (HF) radios, which are capable of transmitting and receiving air/ground communications for thousands of miles. Generally, HF communication centers, staffed with radio operators (ROs), are designated by Air Navigation Service Providers (ANSP) to relay communications for Air Traffic Control Services (ATS). By comparison, controllers use very high frequency (VHF) radios for direct communication with aircraft via line-of-sight coverage of approximately 200 miles and the radio transmission does not follow the curvature of the earth. Satellite, both for navigation (Global Navigation Satellite Systems, or GNSS) and for communications (Satellite Communications, or SATCOM), have gradually gained acceptance and are now an integral part of global communications, navigation, and surveillance (CNS) for air traffic management (ATM).

In 1995, the initial future air navigation system (FANS 1/A) leveraged these advances, with a communications package used in concert with modern navigation and surveillance systems. Aircraft with required navigation performance (RNP) and GNSS capabilities, could now navigate more accurately, and provide position reports via FANS 1/A controller-pilot data link communications (CPDLC) and automatic dependent surveillance – contract (ADS-C) using SATCOM, VHF, and HF data links. At the same time, aircraft became equipped with SATVOICE capability.

1.1. FAA Guidance & Implications

In 1996, the FAA recognized technological advances in communications by a rule change to Title 14 Code of Federal Regulations (CFR) sections 1.1 and 121.351 that included use of a new term "Long Range Communication System" (LRCS). 14 CFR section 1.1 defines LRCS as "A system that uses satellite relay, data link, high frequency, or other approved communication system which extends beyond line-of-sight." Examples of systems that meet this definition are HF voice, HF data link (HFDL), SATVOICE and SATCOM data link.[1]

Current FAA regulations[2] address long-range communication requirements in terms of LRCS. FAA regulations require an aircraft on (extended) over water segments to have at least two operational LRCSs (unless a single LRCS is expressly authorized under the applicable regulations [e.g., 14 CFR section 121.351(c))].

Presently, HF voice is the only LRCS currently accepted for air traffic control communications in some areas. Therefore, in such "HF mandatory" areas, where the State of the Operator/ Registry requires two operational LRCSs, at least one must be HF-voice. In "HF mandatory" areas where the State of the Operator/ Registry expressly allows only a single LRCS, that system must be HF voice.

In 2007, Oceanic NOTAM guidance was updated to reflect New York RADIO's and San Francisco RADIO's ability to use SATVOICE in the event HF communications fail or are otherwise unavailable.[3] HF voice remains the primary communication means for communications between New York RADIO and San Francisco RADIO and aircraft in oceanic control areas delegated to the FAA for provision of air navigation services. Aircraft desiring to contact New York RADIO or San Francisco RADIO utilizing SATVOICE, could use ICAO Short Codes or direct dial phone numbers. For ATC Communications, direct dial phone numbers are not authorized; ground-to-air safety (ATC communications) calls must route through the Safety Switches of the Satellite Service Providers.

New York RADIO and San Francisco RADIO have used SATVOICE as an operational backup to HF voice to initiate communications from the ground to the aircraft on rare occasions when HF voice communications cannot be established in a timely manner and the aircraft is so equipped. SATVOICE may be used for either ATC or AOC (Company) communications.

Furthermore, in October 2014 the FAA issued OpSpec B045, which addressed SATVOICE operations in the West Atlantic Route System (WATRS) airspace. This OpSpec removed the 30-minute limit on VHF communications gap as long as "the aircraft [has] an operative satellite voice (SATVOICE) radio, or the maintenance history on the specific aircraft is tracked and the minimum equipment list (MEL) history in the past 30 days indicates no more than two failures of the high frequency (HF) radio system." [4].

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[1] In March, 2018, the FAA plans to implement Performance-Based Communication and Surveillance (PBCS), which sets required communications performance (RCP) standards for LRCSs. RCP 240 will be mandatory for application of certain separation standards used in oceanic airspace.

[2] Except Part 91, which refers to "HF radio."

[3] This guidance has been moved to the U.S. Aeronautical Information Publication, ENR 7.

1.2. NAT-Satvoice Trial for SATVOICE in the NAT Region

In 2007 the ICAO North Atlantic (NAT) region Satellite Voice Task Force (SVTF) group and a limited number of airlines conducted a trial named, "NAT-Satvoice Trial" to assess the feasibility of using SATVOICE for routine ATS communications via radio operators. This was a major achievement, never before conducted, which involved enhancements to radio station PSTN access equipment, CSP networks, the adoption of a unique priority for ATS calls displayed with the development of procedures in the form of guidance material, for radio operators and crews. The trial was conducted between May 01st, 2007 and August 31st, 2007 involving the five main radio stations in the NAT-region: Santa Maria, Gander, Iceland, New York and Shanwick. The purpose of the SATVOICE trial was to:

a) Gain operational and technical experience with SATVOICE.
b) Assess SATVOICE as an alternative means of voice communications in the event of situations such as poor HF propagation.
c) Validate air crew and radio operator procedures.

1.3. PARC CWG Satellite Voice Project Plan

In 2008, the PARC CWG initiated development of a Satellite Voice Project Plan with the purpose to:

a) Collect SATVOICE communication performance data for comparison to and validation of the RCP 400/VRO specification.
b) Provide collected data to the PARC CWG in support of a recommendation to the FAA for approval of changes to the present HF voice equipment configuration requirements.
c) Establish a standard for "Post Implementation Monitoring."

The resulting Satellite Voice Project Plan was used in two operational trials. First, as detailed in section 1.4, a proof-of-concept evaluation was performed with a single flight to validate the project plan. Then, the Satellite Voice Project Plan was used to execute a more extensive operational trial as detailed in section 1.5.

1.4. PARC CWG "Proof-of-Concept" Evaluation in Pacific Region

In order to verify the data collection framework associated with the aforementioned Satellite Voice Project Plan, a "Proof of Concept" flight was evaluated in December of 2011. A Hawaiian Airlines B767-300 equipped with an Avionica, Inc. satLINK system was used as the platform for the "Proof of Concept" flight in the Pacific. SATVOICE was used to generate data points for:

a) Comparison to RCP 400/VRO Specification.
b) Confirmation that all required data can be collected with minimal manual manipulation.
c) Identification of potential changes to improve process.

All clearances, position reports, and safety of flight communication were conducted via HF radio or via CPDLC. The use of SATVOICE for the "Proof of Concept" flight was an addition to the use of CPDLC and ADS-C and did not preempt the use of data link.

During the proof-of-concept evaluation, 5 SATVOICE contact events were completed and the timing data of each RCP 400/VRO allocation segment was recorded. As a result of the evaluation, the data collection framework defined in the Satellite Voice Project Plan was confirmed. In addition, the data points collected confirmed that the evaluation SATVOICE calls were within the RCP 400/VRO specification allocations.

1.5. PARC CWG Operational Evaluation

In September of 2013, PARC CWG recognized the need for a dedicated subcommittee to lead operational evaluation of the Satellite Voice Project Plan. Therefore, a ”Tiger Team” was established to evaluate the requirements and execute the project plan.

On the PARC CWG/32 meeting, the Tiger Team recommended the following Project Plan deviations:

a) Replacing ATC with Airline dispatch while maintaining RCP 400/V_{RO} measurements.
b) Sending Type B “AGM” messages via the ARINC ground network “AviNet” instead of using Ocean 21 system / connectivity.

The alternative plan proposed by the Tiger Team scaled readily without increasing ATC workload. Furthermore, the feasibility of AviNet as an alternate to ATOP’s test message input was validated with various Beta customers. Therefore, the operational evaluation followed the proposed alternative plan; processes and operational evaluation results discussed throughout this Satellite Voice Project Report correspond to the executed operational evaluation.

1.6. JetBlue WATRS+ Operational Evaluation

Further to the PARC CWG Operational Evaluation, in February of 2017, JetBlue coordinated the participation of FAA NY ARTCC, various FAA Flight Standards offices, Iridium, and New York RADIO (with services provided under FAA contract by Rockwell Collins ARINC) to begin a full operational evaluation in the U.S. WATRS+ airspace. The primary objective was to substantiate, through objective data gathering and analysis, the operational feasibility of using SATVOICE as a primary means of voice communications, via radio operator, for ATM functions and safety services in lieu of HF. The full operational evaluation would also specifically measure the RCP of Iridium SATVOICE used for communications with New York RADIO to facilitate policy changes recognizing SATVOICE as a valid LRCS.

For the full operational evaluation program, JetBlue targeted the N.Y. West Oceanic Control Area (OCA). JetBlue Airways has extensive operations in that OCA, using a Single Long-Range Communications System, expressly authorized per FAA Operation Specificaiton (OpSpec) Paragraph B045.

1.7. ICAO Guidance

In April of 2011, the Air Navigation Commission, acting under delegated authority, of amendment to the *Regional Supplementary Procedures* (Doc 7030/5) allowed the use of SATVOICE in Bodo Oceanic, Gander Oceanic, New York Oceanic, Reykjavik, Santa Maria Oceanic and Shanwick Oceanic control areas, for aircraft with approved equipment. Aircraft with approved aeronautical mobile satellite (route) services (AMS(R)S) voice communications [ICAO Annex 10 refers to SATVOICE as (AMS(R)S) voice communications], may use such equipment for additional ATS communications capability, provided the following requirements are met:

a) The equipment shall be approved by the State of the Operator or the State of Registry.
b) The equipment shall be operated in accordance with the provisions of the respective AIPs for the corresponding airspace.
c) Pilots shall operate SELCAL in, or maintain a listening watch on, the assigned HF frequency.

d) AMS(R)S voice communications should be made to aeronautical stations rather than ATS units unless the urgency of the communication dictates otherwise.

Note 1 – AMS(R)S voice communication initiated due to HF propagation difficulties does not constitute urgency. Dedicated AMS(R)S voice telephone numbers (short codes) for air-ground radio facilities and air traffic control facilities are published in national AIPs where approved.

Note 2 – AMS(R)S voice is a not a replacement for ADS-C, CPDLC or HF communications, but rather a means of reducing the risk of communications failure, improving the safety of operations and alleviating HF congestion. AMS(R)S voice provides an additional discrete communications medium and potential MEL relief as States, approving reduced carriage requirements for HF radio, may allow aircraft to operate with only one serviceable HF radio.

Note 3 – In all cases, for ATC Communications, direct dial phone numbers are not authorized; calls must route through the Safety Switches of the Satellite Service Providers. That is, AMS(R)S voice communications conducted with aircrafts with approved equipment must also be routed through Safety Switches.

1.8. SATVOICE Today

Further to ICAO approvals supporting the use of Satellite Voice Communications, in July 2012, The ICAO Inter Region Satellite Voice Task Force published the first edition of the Satellite Voice Guidance Material (SVGM) manual. This First Edition of the SVGM was further approved by the North Atlantic Systems Planning Group (NAT SPG) and by the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG).

The SVGM provides guidance and information concerning SATVOICE communications for aeronautical use and is intended to facilitate the uniform application of ICAO Standards and Recommended Practices (SARPs) contained in Annex 2 — Rules of the Air and in Annex 11 — Air Traffic Services, the provisions in the Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444) and, when necessary, the Regional Supplementary Procedures (Doc 7030). More specifically, the SVGM is intended to maximize operational benefits of SATVOICE implementations by promoting seamless and interoperable SATVOICE operations throughout the world.

Some regulatory authorities, such as the FAA, via its MMEL Policy Letter 106, have granted operators dispatch relief whereby the aircraft may be dispatched for a limited period with only a single HF radio system and an operational SATVOICE system. Although temporary dispatch relief is available, AIP guidance and other regional regulators in most oceanic areas around the world still require aircraft to be equipped with two operational HF radios in order to dispatch the aircraft.

2. Prerequisites and Requirements

2.1. General

In accordance with established PARC CWG procedures, participants agreed to provide information and data necessary to substantiate the goals of the project. The evaluation took place from September 2014 to April 2015.

SATVOICE performance data was obtained from New York RADIO, San Francisco RADIO, Iridium, and Inmarsat. The following performance parameters were measured for each flight:

a) RCP 400/V_{RO} Operational Performance
b) RCP 400/V_{RO} Monitored Performance
c) Queue Performance
d) Airspace Segment Performance

As noted in the project plan, although the underlying technology would lend itself to a conversational mode of communications, such use can create misunderstanding and confusion. Therefore, when using SATVOICE, normal conventions were followed in accordance with standard ICAO phraseology, as defined in Annex 10, Volume II, Chapter 5, and Doc. 8400.

2.2. Aircraft Operators

Aircraft operators participating in this project complied with the following criteria:

a) Collaborated with the PARC CWG SATVOICE tiger team and developed advisory information to distribute within their respective flight operations department to:

   1. Ensure that all personnel concerned were aware of SATVOICE concepts and procedures associated with the use of SATVOICE.

   2. Detail the purpose of the evaluation and the expectations of flight crews participating.

b) Assessed operational requirements, and assured policy and procedures were established and incorporated in appropriate company documents, including:

   1. Ensuring that each participating aircraft was provisioned to use Iridium or Inmarsat SATVOICE with either Rockwell Collins or SITA in their roles as communication service providers.

   2. Procedures relative to the use of SATVOICE in accordance with ATC communication procedures, including its use in relationship to other means of communication (e.g., CPDLC/ADS-C, FMS WPR, Oceanic clearance, etc.).

   3. Contact information for the Radio Stations.

   4. Procedures when SATVOICE fails en route.

   5. Procedures for reporting problems associated with SATVOICE to their service provider and the PARC CWG.

   6. Accommodating problems with specific aircraft identified during the active evaluation.

c) Provided a list of aircraft registration numbers and make and model of installed SATVOICE equipment.

Note: Participation in this project did not relieve the operator of the responsibility to ensure that the aircraft was fully equipped for oceanic communications as prescribed for the airspace operated in or the State of registry for the aircraft or operator.

2.3. Flight Deck SATVOICE System

Aircraft operators were responsible to ensure flight deck SATVOICE systems were FAA approved in accordance with the following:

a) The flight deck SATVOICE communication system meets the criteria of AC 20-150A, Satellite Voice Equipment as a Means for Air Traffic Services Communications, or equivalent, with special attention to:

   1) Capability to preempt a lower priority call.

   2) Integration with the aircraft's flight deck audio systems.

b) The flight deck SATVOICE system is capable of enabling the flight crew to initiate calls using the appropriate priority level.

c) The satellite data unit (SDU) meets the interface requirements of AEEC/SAE 741 and RTCA DO 262C.

2.4. Radio Operator (Rockwell Collins)

The Radio Operator participating in this project was required to meet the following criteria, collaborate with the PARC CWG tiger team, and develop advisory information to distribute within their respective communication centers to:

a) Provide RCP 400/V$_{RO}$ data points S3, S4, and S5 in a format that can be easily used for evaluation.

Note: The RCP 400/V$_{RO}$ specification is detailed in Appendix A.

b) Establish procedures for radio operators to collect individual call data associated with flights participating in the evaluation. Data collected by RO's will include, as appropriate:

1) Voice Quality: Voice quality measurement recorded on a scale from 1 to 5 where the first 5 measures loudness and second 5 measures clarity (e.g., 5X5, 4X5, 3X3…).

2) Dropped calls: Calls that connected and then subsequently drop.

3) Failed Calls: Calls that never connected and did not receive a "Subscriber Message."

4) Busy Signal: Calls that received a "Subscriber Message" that stated the user was not available.

5) Queue Delay: Calls that were delayed due to a large number of messages in the RO message queue.

6) No Answer: Calls that were not answered after three (3) attempts.

Note: An "RO Message Table" in Appendix B has been developed by Rockwell Collins and the PARC CWG representative to accommodate these requirements.

2.5. Communication Service Providers (CSPs): Rockwell Collins and SITA

Individual CSPs followed or updated their existing established procedures to notify their contracted customers when service conditions change, i.e., service outages, degraded performance, restoration of service.

2.6. Air Traffic Services Units (ATSUs)

No ATSU participation in this project.

It is noted that while the Satellite Voice Project Plan included ATSU participation, the operational evaluation was modified to replace ATSU with Airline dispatch in order to avoid increasing ATC workload.

2.7. Satellite Service Providers (SSP): Inmarsat and Iridium

SSPs participating in this project provided performance data to the PARC CWG tiger team in their role as communication service providers that provide SATVOICE services to aircraft operators.

2.8. Required Technology Implementation and Updates by Key Stakeholders

The evaluation commenced once key stakeholders completed required technology updates. Many of the required updates were identified in the "NAT-Satvoice Trial for SATVOICE in the NAT Region." The key stakeholders that performed systems updates were:

a) Rockwell Collins as an Aeronautical Station incorporated the following updates and capabilities prior to the start of the evaluation:

   1) The Voice switch update implemented by ARINC in 2012, facilitating "one touch dialing", was reviewed for training purposes for more extensive use by the radio operators.

   2) Additional Aeronautical Information System Replacement (AISR) feed information allowing visibility of the ICAO 2012 flight plan with the satellite hexcode.

   3) Additional dedicated SATVOICE phone lines to accommodate higher call volume.

   4) Complete programing to allow filtering of call data for purposes of the Satellite Voice Project operational evaluation.

b) IRIDIUM, Rockwell Collins and SITA: in their roles as communication service providers provisioned safety SIM cards and distributed safety SIM cards to their aircraft operator customers, as requested by the aircraft operator.

c) AVIONICS MANUFACTURERS: Completed software updates and accommodated changes incurred by the Iridium "Safety Switch" implementation.

d) OPERATORS: Distributed training materials to reflect the changes incurred by the Iridium ATS "Safety Switch" implementation.

e) PARC CWG: The PARC CWG tiger team coordinated with stakeholders providing call data to assure data fields were accommodated for evaluation purposes and applicable to the RCP 400/V_{RO} specification.

3. Project Description

3.1. General

The evaluation took place from September 2014 to April 2015.

Furthermore, the evaluation was executed throughout three regions:

a) Oakland Oceanic Flight Information Region (FIR)
b) New York Oceanic FIR
c) Gander Oceanic FIR

Each operator identified flights that normally operate with SATVOICE equipment in each region, then performed evaluation SATVOICE calls to the identified flights. As noted, the original project plan was modified so that the SATVOICE contact request was initiated by the aircraft operator's Dispatch group and sent to Rockwell Collins RO. The RO then communicated with the aircraft via SATVOICE and sent an "ACK" message to dispatch upon completion. The SATVOICE contacts were in the form of a basic "radio check" with the crew confirming the call as satisfactory or un-satisfactory. The contact requests followed the normal HF SELCAL check typically done by each flight when transitioning to an oceanic route. Furthermore, six (6) data points per SATVOICE contact were collected, instead of the originally planned five (5). The collected data points were used to delineate the measured parameters of the RCP 400/VRO specification.

3.2. Measured Performance Parameters

To collect SATVOICE communication data for comparison to the RCP 400/VRO specification, each identified flight received at least one SATVOICE call from a radio operator.

The operational evaluation collected data from each call to allow measurement of the following parameters from the RCP 400/VRO specification detailed in Figure A-1:

a) **RCP 400/VRO Operational Performance:** defined by RCP 400/VRO specification data points **A to Z**.
b) **RCP 400/VRO Monitored Performance:** defined by RCP 400/VRO specification data points **S3 to S6**.
c) **Queue Performance:** defined by RCP 400/VRO specification data points **S3 to S4**.
d) **Airspace Segment Performance:** defined by RCP 400/VRO specification data points **S4 to S6.**

3.3. The Three Step Operational Evaluation Process

The project involved a Three (3) Step Operational Evaluation Process:

a) Step 1: Dispatch "REQ" to Rockwell Collins RO.
b) Step 2: Rockwell Collins RO SATVOICE to and from Aircraft.
c) Step 3: Rockwell Collins "ACK" to Dispatch.

The following illustration summarizes the Three Step Operational Evaluation Process.

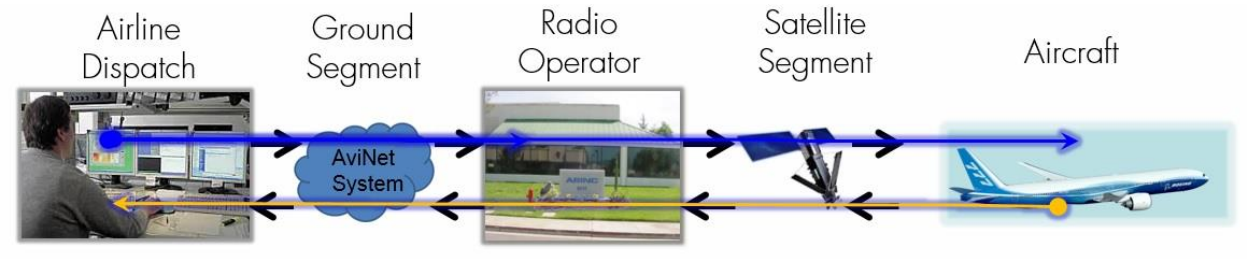

Figure 3-1 – Three Step Operational Evaluation Process

Furthermore, RCP 400/V_{RO} specifications in Figure A-1 are used throughout this report to discuss the operational evaluation process and results. RCP 400/V_{RO} allocations for this project are summarized on the illustration below. Data points A, S3, S4, S5, S6, and Z were recorded for each SATVOICE call.

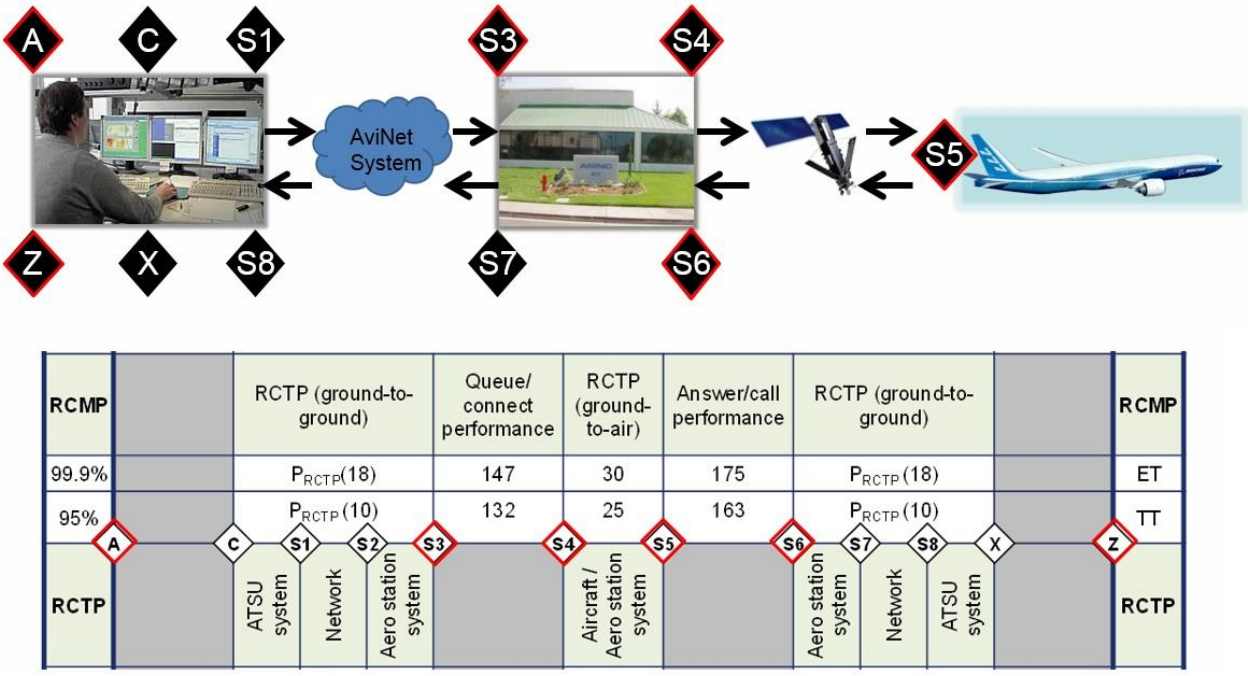

Figure 3-2 – RCP 400/V_{RO} & Three Step Operational Evaluation Process

3.3.1. Step 1: Dispatch "REQ" to Rockwell Collins RO

From the list of flights provided by the PARC CWG representative, an airline operator verified SATVOICE equipage for each flight on the day of operation. Aircraft equipage was determined by comparing the provided flight numbers to an internal database with the aircraft registration in the ICAO flight plan. If the aircraft was equipped with SATVOICE capability, a free text "Request Message" (REQ) for a "SATVOICE Test Call" (SVTC) was sent to the Rockwell Collins RO using AviNet system any time after the flight passed the oceanic FIR entry waypoint. At this event, **data point A** is generated and recorded.

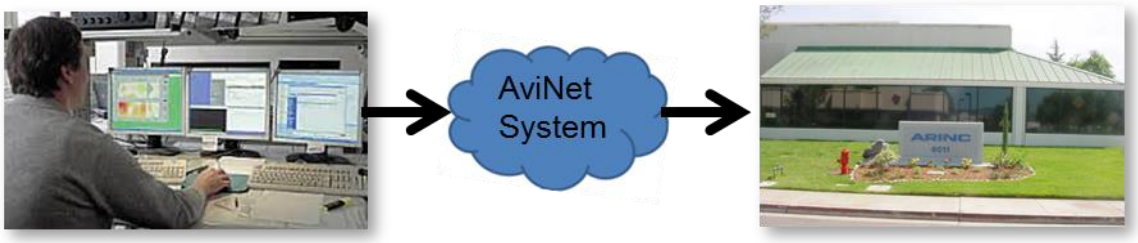

Figure 3-3 – Step 1: Dispatch to RO

In addition to the normal data, the "REQ" message was expected to contain:

a) The flight number and aircraft registration, /AN N592HA (the correct registration was identified on the day of the flight).
b) SV for SATVOICE, indicating the return message from Rockwell Collins RO should request a voice contact, not CPDLC.
c) REQ SVTC, indicating a request for a "SATVOICE Test Call."

An example of the "REQ" free text message from an airline operator is detailed below.

Table 3-1 – Dispatch to RO Sample Message

	Date and Time	Flight #	Message	Information Sent from Dispatch to Rockwell Collins RO
Dispatch "REQ" to Rockwell Collins RO	12/19/2011 9:56:00	HAL1027	AGM	QU OAKAPXA FF AGM FI HAL1027/AN N592HA DT SFO SV D 190956 -REQ SVTC

3.3.2. Step 2: Rockwell Collins RO SATVOICE to and from Aircraft

When Rockwell Collins RO received the message, **data point S3** was generated and recorded. The RO processed queued messages until reaching the "ATCR SVTC" message for the aircraft. The RO used SATVOICE to contact the flight and comply with the "ATCR SVTC" message request. When the RO placed the message into its active working screen (top of the queue), **data point S4** is generated and recorded.

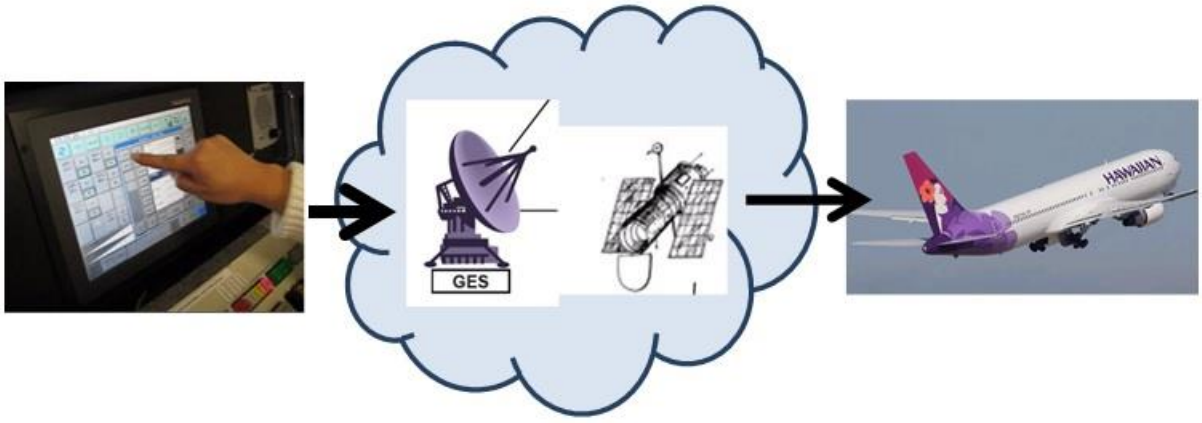

Figure 3-4 – Step 2-1: RO to Aircraft

The flight crew answered inbound calls on the SATVOICE system and complied with RO's request for "SATVOICE check." The moment the flight crew answered the inbound call generated **data point S5.** Upon completion of the call, **data point S6** was recorded.

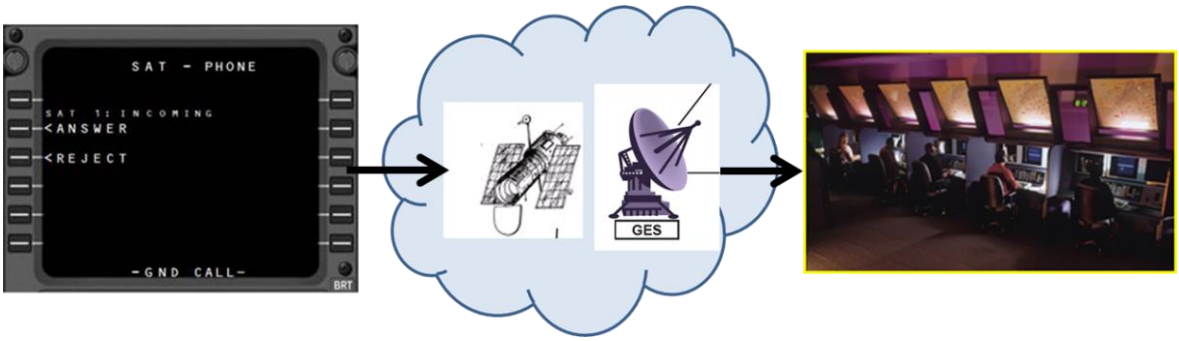

Figure 3-5 – Step 2-2: Aircraft to RO

The following is an example of communication between flight crew and RO:

Table 3-2 – SATVOICE Communication Sample

< Inbound Ground to Air call is indicated to the flight crew>	
Flight 1027	*Hawaiian 1027*
Rockwell Collins RO	*Hawaiian 1027, SFO Rockwell Collins, SATVOICE check,*
Flight 1027	*SFO Rockwell Collins, Hawaiian 1027 reads you 5 X 5*
Rockwell Collins RO	*SFO reads Hawaiian 1027 5 X 5 also, SFO Out*
Flight 1027	*Hawaiian 1027, Out*
<Flight Crew Ends Ground to Air Call>	

3.3.3. Step 3: Rockwell Collins "ACK" to Dispatch

Upon call completion, Rockwell Collins RO sent a free text message to Dispatch using AviNet system. **Data point Z** was generated when Dispatch received the "ACK" message.

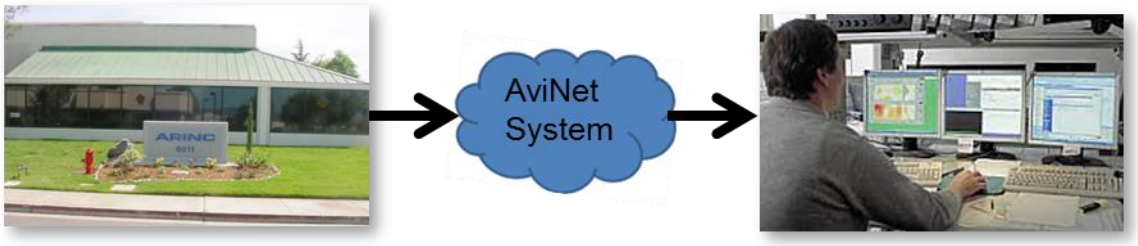

Figure 3-6 – Step 3: RO to Dispatch

The free text message used one of the formats detailed in the "RO Message Table" in Appendix B. The highlighted text below is an example of "ACK" message using a format from the "RO Message Table." Commas were used to delineate data to facilitate insertion into a database for evaluation.

Table 3-3 – RO to Dispatch Sample Message

	Date and Time	Flight #	Message	Information Sent from Rockwell Collins RO to Dispatch
Rockwell Collins RO "ACK" to Dispatch	12/19/2011 10:00:09	HAL1027	AGM	QU OAKAPXA SFOOOXA .SFOXGXA 191000 AGM FI HAL1027 MA7030 DT SFO SV D 191000 10 - ZOA87 HAL1027 ATCR SVTC OK, 1, 5x5, 0

3.4. Evaluation Limitations

With the stated goal of maximizing the volume of calls during the evaluation period while minimizing ATSU workload, the project plan was modified so that SATVOICE contact requests were initiated by the aircraft operator dispatch, rather than by the ATSU.

Because of this, SATVOICE contact request messages were not prioritized as routine ATSU messages. Instead, these test SATVOICE contact request messages were processed by Rockwell Collins' RO behind the routine ATSU messages. This prioritization caused increased message latency as the routine, operational ATSU messages were processed first.

Under normal operational conditions, both HF and SATVOICE contact requests originating from the ATSU are handled and prioritized identically and thus would experience identical queue latency. As such, HF latency timing should be substituted for the SATVOICE latency timing in the results that follow.

4. Operational Evaluation Results

This section will provide a detailed discussion of the Satellite Voice Project operational evaluation results.

4.1. Accomplishment Summary

During the operational evaluation period (Sep 2014 – Apr 2015) 384 calls were made, of which 251 were Iridium calls and 133 were Inmarsat calls.

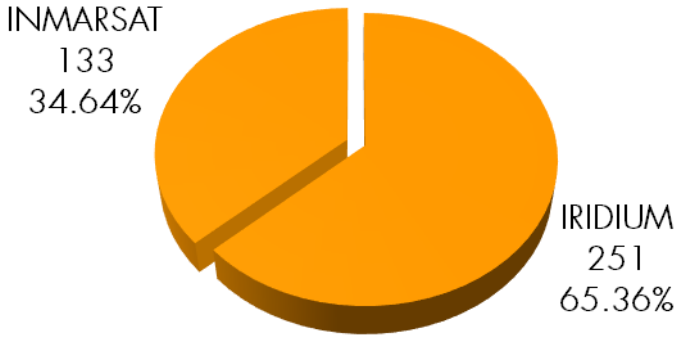

Figure 4-1 – Percentage of Iridium vs. Inmarsat Calls

A total of 111 aircrafts participated in the evaluation, of which 67 used Iridium and 44 used Inmarsat.

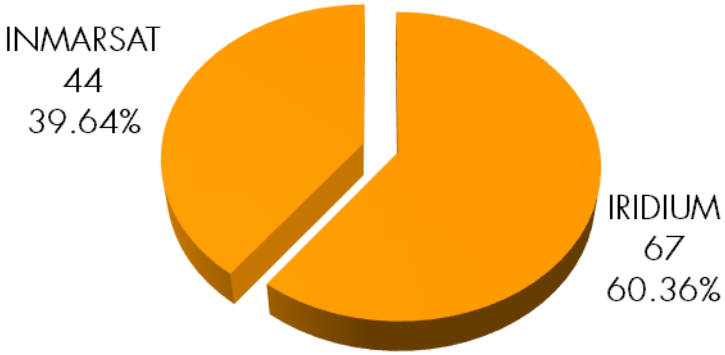

Figure 4-2 – Percentage of Iridium vs. Inmarsat Participating Aircrafts

4.2. SATVOICE Service Availability

4.2.1. Call Completion

Contact was completed for 324 of 384 (84.38%) calls. Completed call attempts are described on the following table:

Table 4-1 – SATVOICE Call Attempts vs. Completion Percentage

Attempts	1	2	3	4	5
% Complete	79.32%	93.21%	98.77%	99.69%	100.00%

4.2.2. Incomplete Call Completion

Contact not completed for 60 of 384 (15.63%) calls were due to the following:

a) "AIRCRAFT ID IS NOT RECOGNIZED" (ICAO_ID)

b) "SUBSCRIBER UNAVAILABLE" (NO_ANS)

c) Other or Not Reported (OTHER).

Table 4-2 – Incomplete Call Summary

Incomplete Call Summary		
ICAO_ID	19	4.94%
NO_ANS	29	7.55%
OTHER	12	3.12%

SAT logs indicate 371 of 384 (96.61%) calls reached aircraft flight deck.

4.3. SATVOICE Call Performance Summary

Note: All data point references to Figure A-1.

RCP 400/VRO Total Transaction Criteria (Z – A).

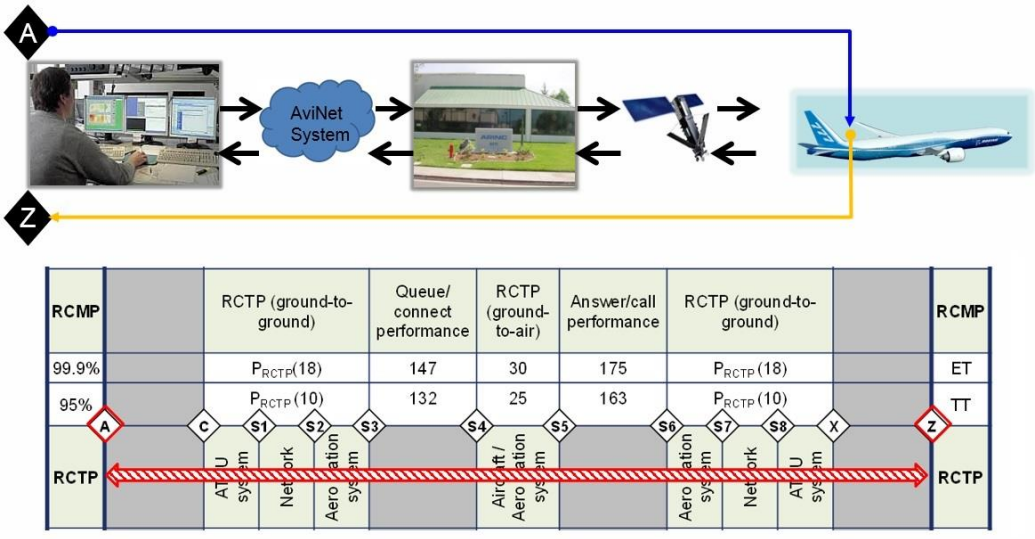

Figure 4-3 – SATVOICE RCP 400/VRO Total Transaction Criteria Illustration

a) TT (95%) = 350 seconds.

b) ET (99.9%) = 400 seconds.

As observable on the chart below, the SATVOICE call performance did not meet the RCP 400 TT and ET Total Transaction Criteria. Performance for the various segments was analyzed independently to determine where the nonconforming latency occurred. The subsequent section provides the SATVOICE performance analysis for each RCP 400/V$_{RO}$ segment. These analyses revealed an observance that, as detailed in Section 3.4, the prioritization of SATVOICE evaluation contact requests behind routine ATSU messages resulted in delays due to the queuing of SATVOICE contact requests at the RO (S3-S4). This limitation was determined to be unique to the evaluation methodology and would not occur in normal operations where the ATSU generated SATVOICE messages would be appropriately prioritized.

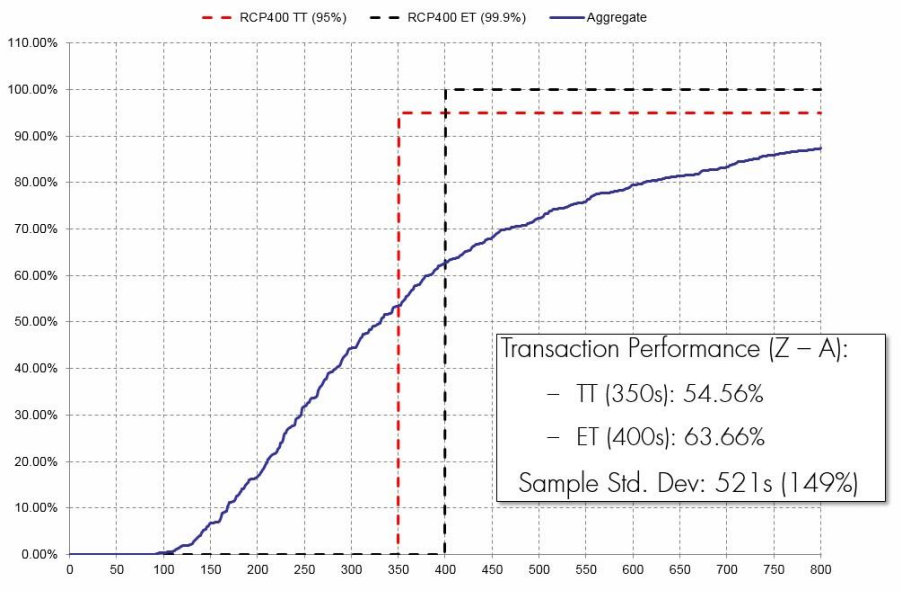

Figure 4-4 – SATVOICE RCP 400/V$_{RO}$ Total Transaction Performance Chart

4.4. SATVOICE Call Performance Analysis

Note: All data point references to Figure A-1.

The following sections provide an independent analysis of segments within the RCP 400/VRO total transaction path (Z – A).

4.4.1. RCP 400/VRO S6 – S3 Criteria (RO + GTA)

First, an analysis of the latency performance between the RO queue and airspace segments was detailed.

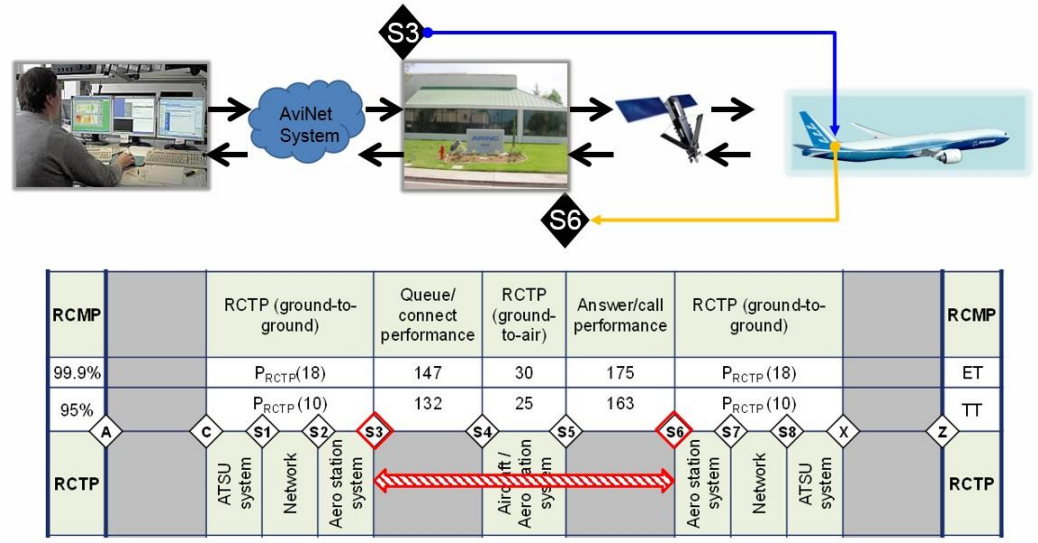

Figure 4-5 – SATVOICE RCP 400/VRO S6 – S3 Criteria Illustration

a) TT (95%) = 352 seconds.

b) ET (99.9%) = 320 seconds.

As observable on the chart below, the RCP 400/VRO S6 – S3 SATVOICE call performance did not meet the RCP 400 TT and ET criteria. As detailed in Section 3.4, queuing of SATVOICE contact requests at the RO (S3-S4) is understood to have increased the overall latency of SATVOICE voice contact requests. Prioritization of SATVOICE evaluation contact requests behind routine ATSU messages caused delays that would not occur in normal operations. To validate this understanding, further independent analysis of the RO queue versus airspace segments was performed and is detailed in the following sections.

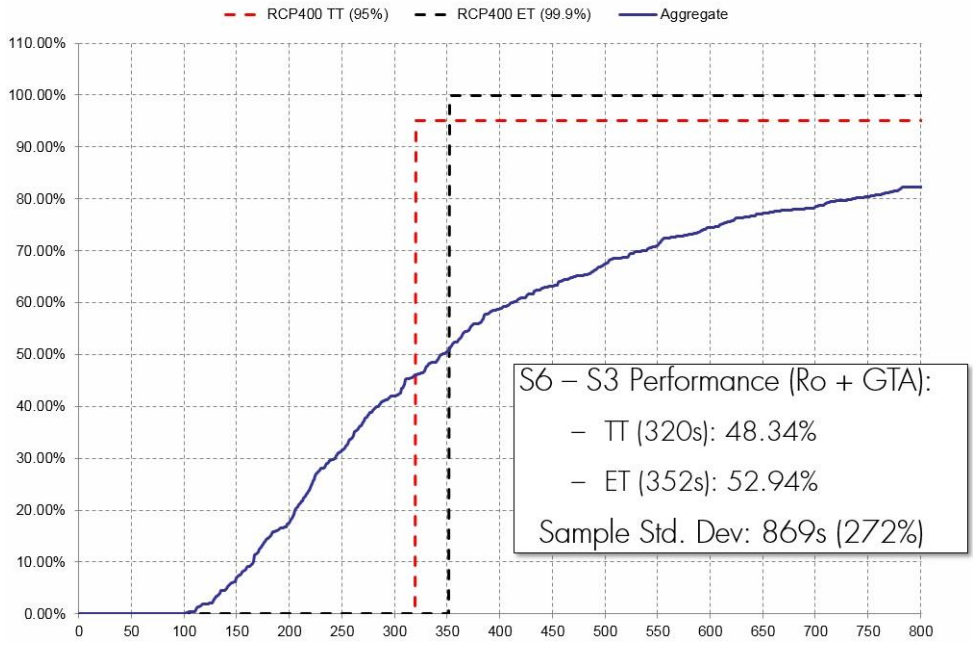

Figure 4-6 – SATVOICE RCP 400/VRO S6 – S3 Performance Chart

4.4.2. RCP 400/VRO S6 – S4 Criteria (Airspace Segment – AS)

Next, the airspace segment component was independently analyzed.

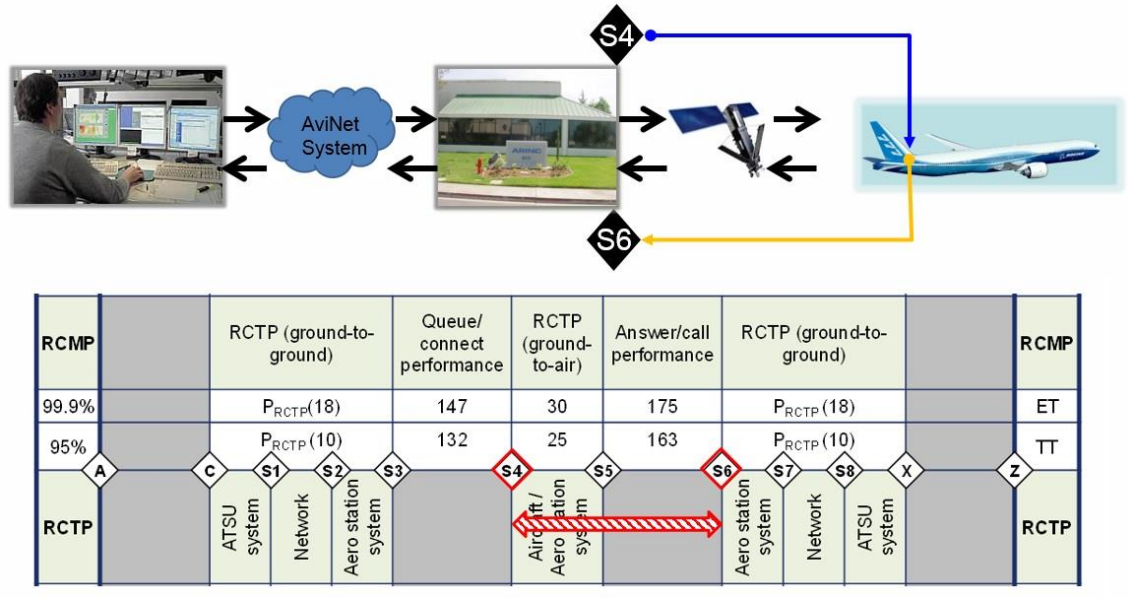

Figure 4-7 – SATVOICE RCP 400/VRO S6 – S4 Criteria Illustration

a) TT (95%) = 188 seconds.

b) ET (99.9%) = 205 seconds.

As observable on the chart below, the RCP 400/VRO S6 – S4 SATVOICE call performance met both the RCP 400 TT and ET criteria. This indicates that SATVOICE Airspace Segment performance meets RCP 400/VRO requirements.

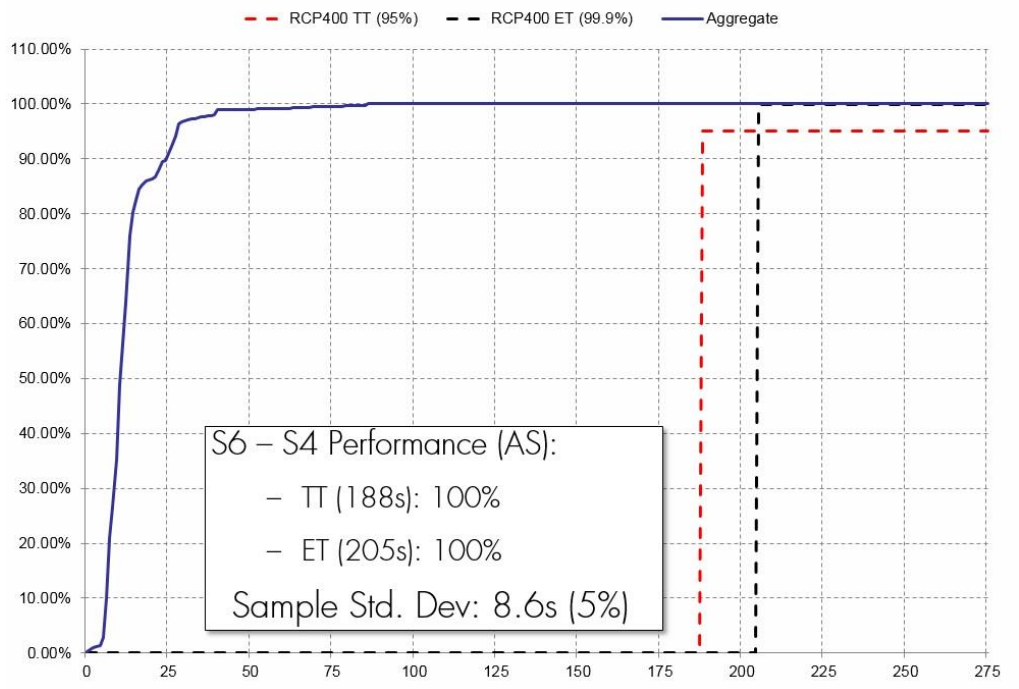

Figure 4-8 – SATVOICE RCP 400/VRO S6 – S4 Performance Chart 1

As observable on the chart below, the sampled RCP 400/VRO S6 – S4 SATVOICE call performance data has a standard deviation of 5%.

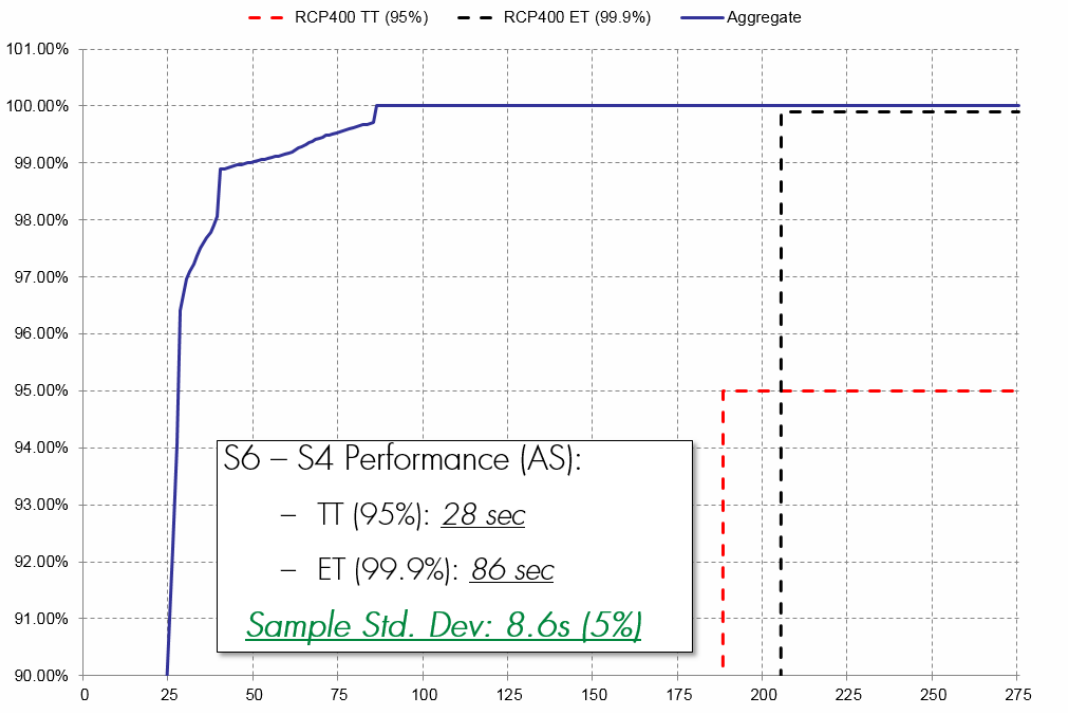

Figure 4-9 – SATVOICE RCP 400/VRO S6 – S4 Performance Chart 2

4.4.3. RCP 400/VRO S4 – S3 Criteria (RO)

Given the airspace segment met RCP 400 TT and ET criteria, the RO queue latency performance was analyzed next.

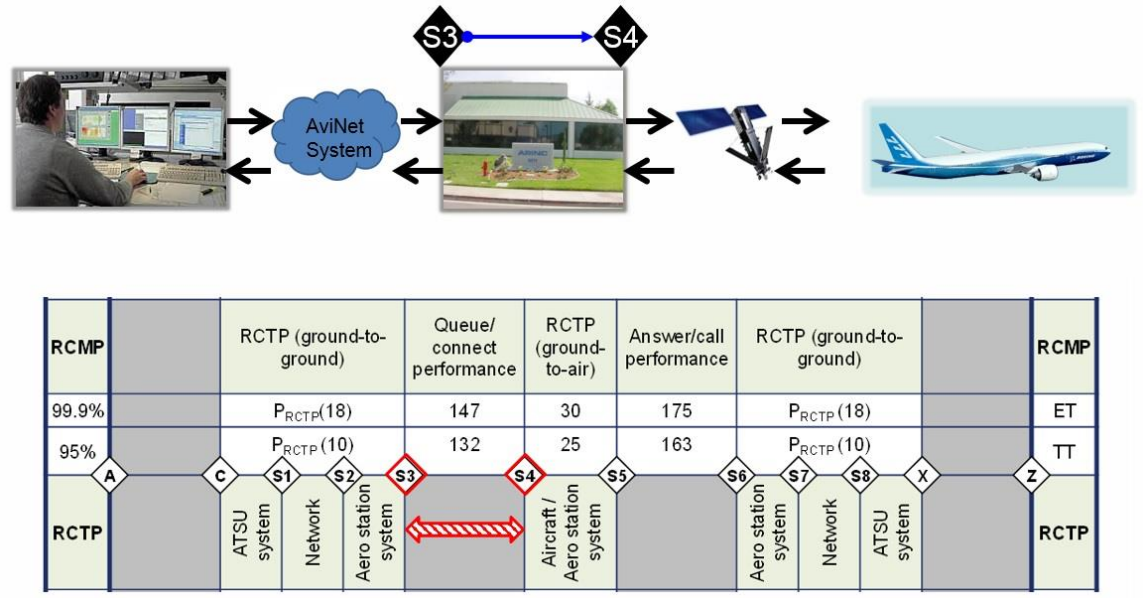

Figure 4-10 – SATVOICE RCP 400/VRO S4 – S3 Criteria Illustration

a) TT (95%) = 132 seconds.

b) ET (99.9%) = 147 seconds.

As observable on the chart below, the RCP 400/VRO S4 – S3 SATVOICE call performance did not meet the RCP 400 TT and ET criteria. As detailed in Section 3.4, prioritization of SATVOICE evaluation contact requests behind routine ATSU messages resulted in delays due to the queuing of SATVOICE contact requests at the RO (S3-S4). These delays would not occur in normal operations where the ATSU generated SATVOICE messages would be appropriately prioritized.

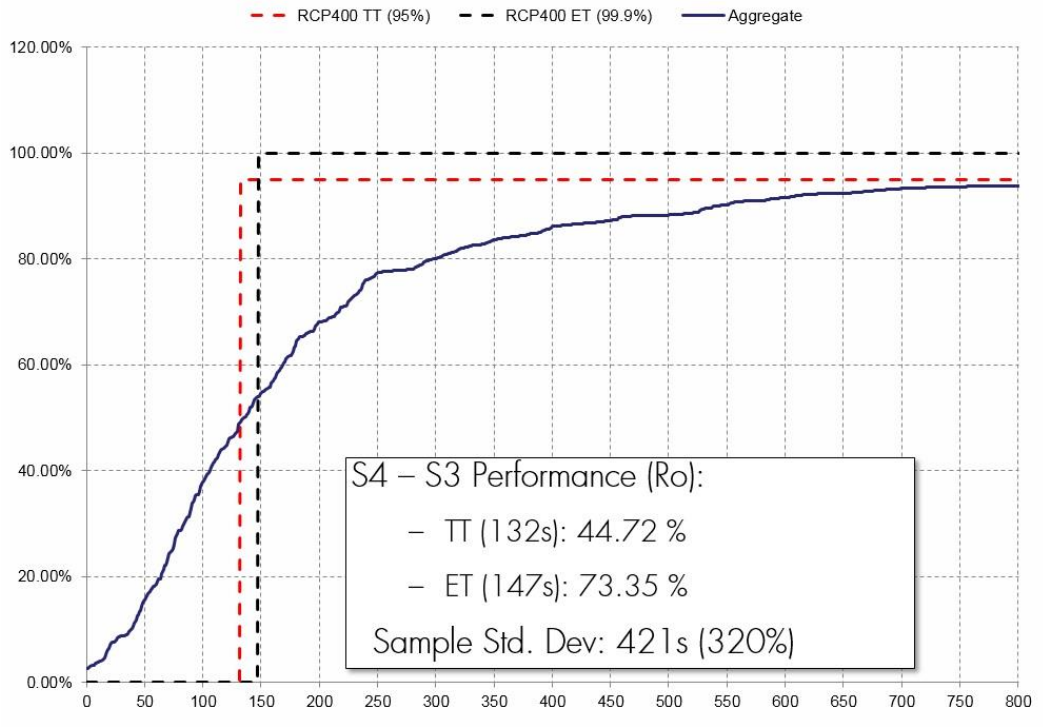

Figure 4-11 – SATVOICE RCP 400/VRO S4 – S3 Performance Chart

4.4.4. RCP 400/VRO S3 – A Criteria (G-to-G Segment)

To ensure the latency performance throughout all segments were understood, further analysis was performed on segments before and after the RO queue and airspace segments.

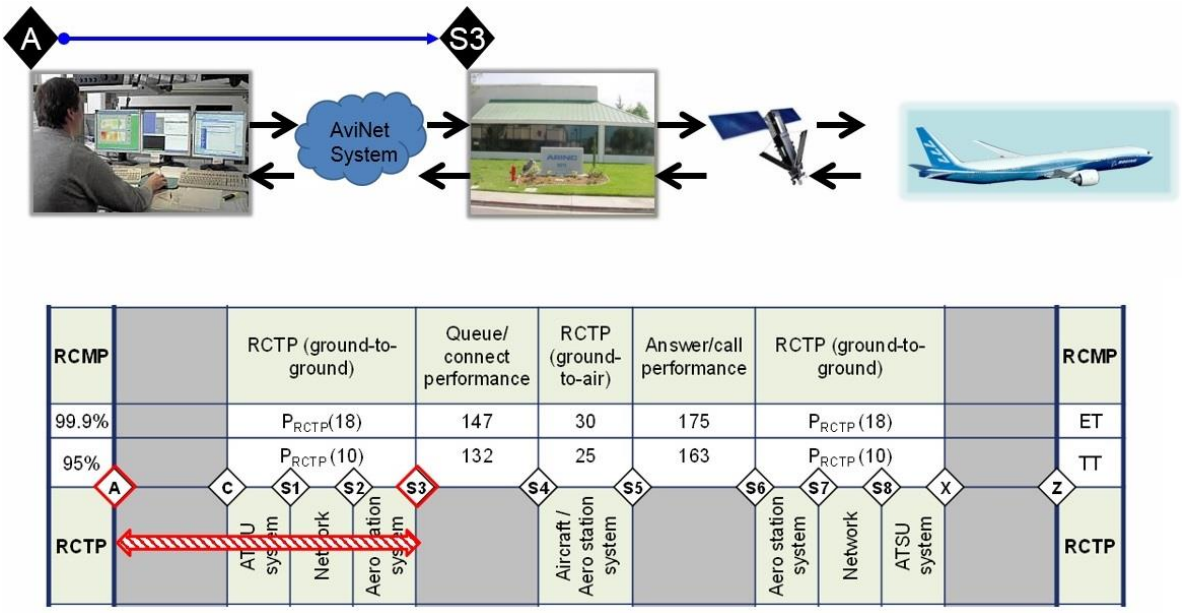

Figure 4-12 – SATVOICE RCP 400/VRO S3 – A Criteria Illustration

a) TT (95%) = 10 seconds.

b) ET (99.9%) = 18 seconds.

As observable on the chart below, the RCP 400/VRO S3 – A SATVOICE call performance did not meet the RCP 400 TT and ET criteria. It is understood that the timestamp of 'A' was manually recorded by the operator's dispatch personnel and was not synchronized with the time source at the RO where timestamp 'S3' is captured. Given the relatively small allocation for this segment (TT=10s, ET=18s), small variances in timing sources would have large effects in precision of results. Further, under normal operational conditions, both HF and SATVOICE contact requests originating from the ATSU are handled and prioritized identically. Therefore, the latency of these allocations would be identical to the performance of HF contact requests.

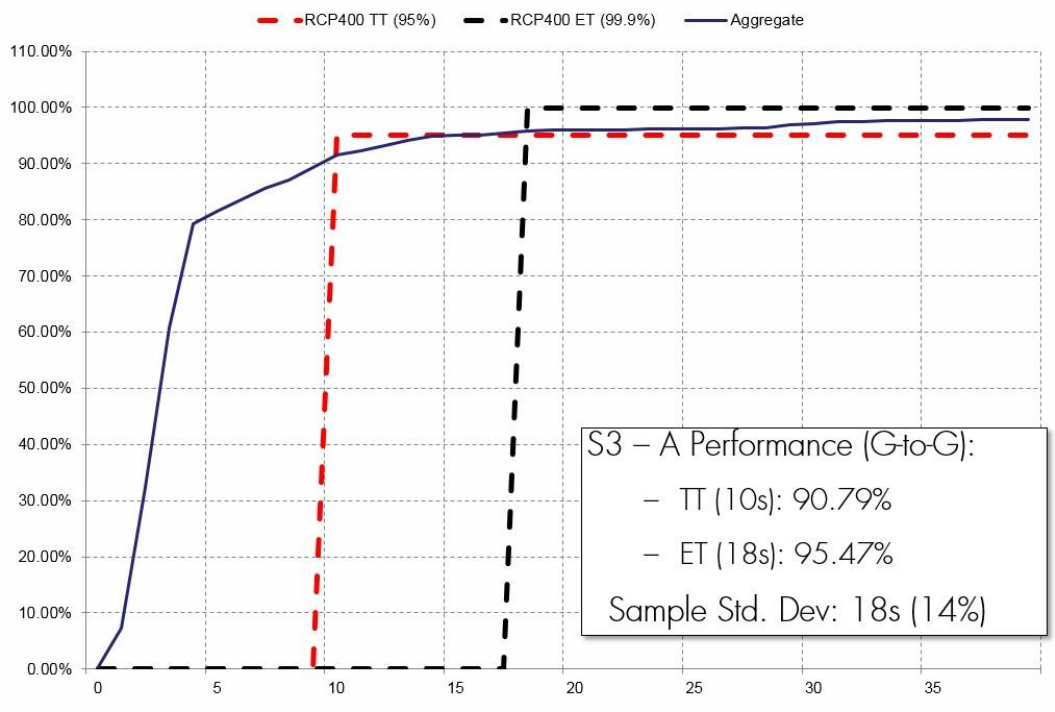

Figure 4-13 – SATVOICE RCP 400/VRO S3 – A Performance Chart 1

As observable on the chart below, the sampled RCP 400/VRO S3 – A SATVOICE call performance data has a standard deviation of 14%.

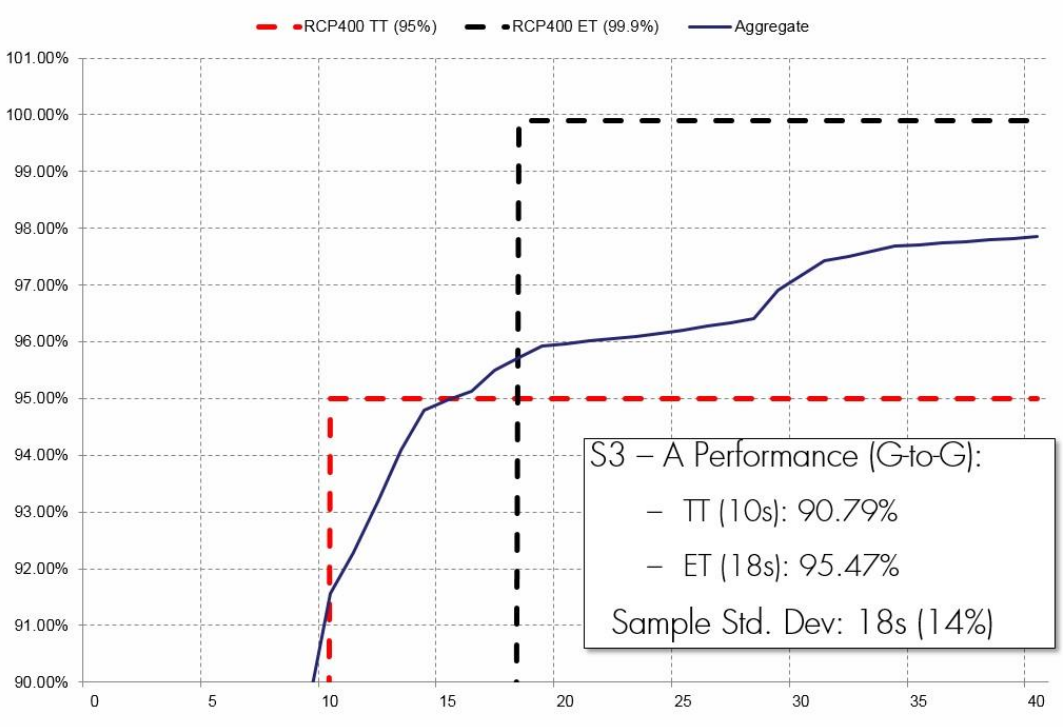

Figure 4-14 – SATVOICE RCP 400/VRO S3 – A Performance Chart 2

4.4.5. RCP 400/VRO Z – S6 Criteria (G-to-G Segment).

Finally, an independent analysis of the acknowledgment segments was performed.

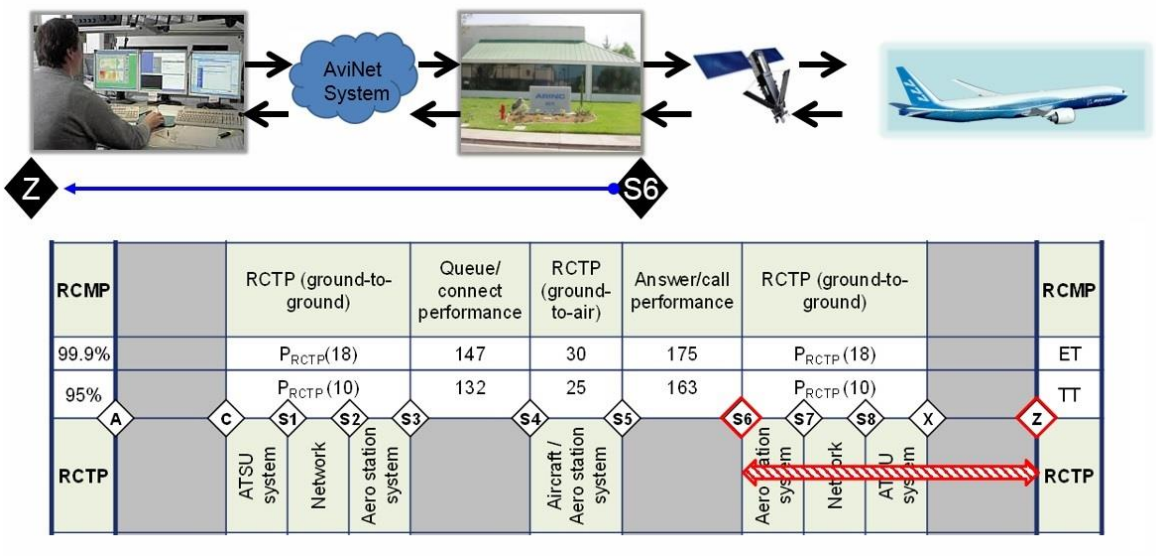

Figure 4-15 – SATVOICE RCP 400/VRO Z – S6 Criteria Illustration

a) TT (95%) = 10 seconds.

b) ET (99.9%) = 18 seconds.

As observable on the chart below, the RCP 400/VRO Z – S6 SATVOICE call performance did not meet the RCP 400 TT and ET criteria. Similar to segment S3 - A analyzed above, it is understood that the timestamp of 'Z' was manually recorded by the operator's dispatch personnel and was not synchronized with the time source at the RO where timestamp 'S6' is captured. Given the relatively small allocation for this segment (TT=10s, ET=18s), small variances in timing sources would have large effects in precision of results. Further, under normal operational conditions, both HF and SATVOICE contact requests originating from the ATSU are handled and prioritized identically. Therefore, the latency of these allocations would be identical to the performance of HF contact requests.

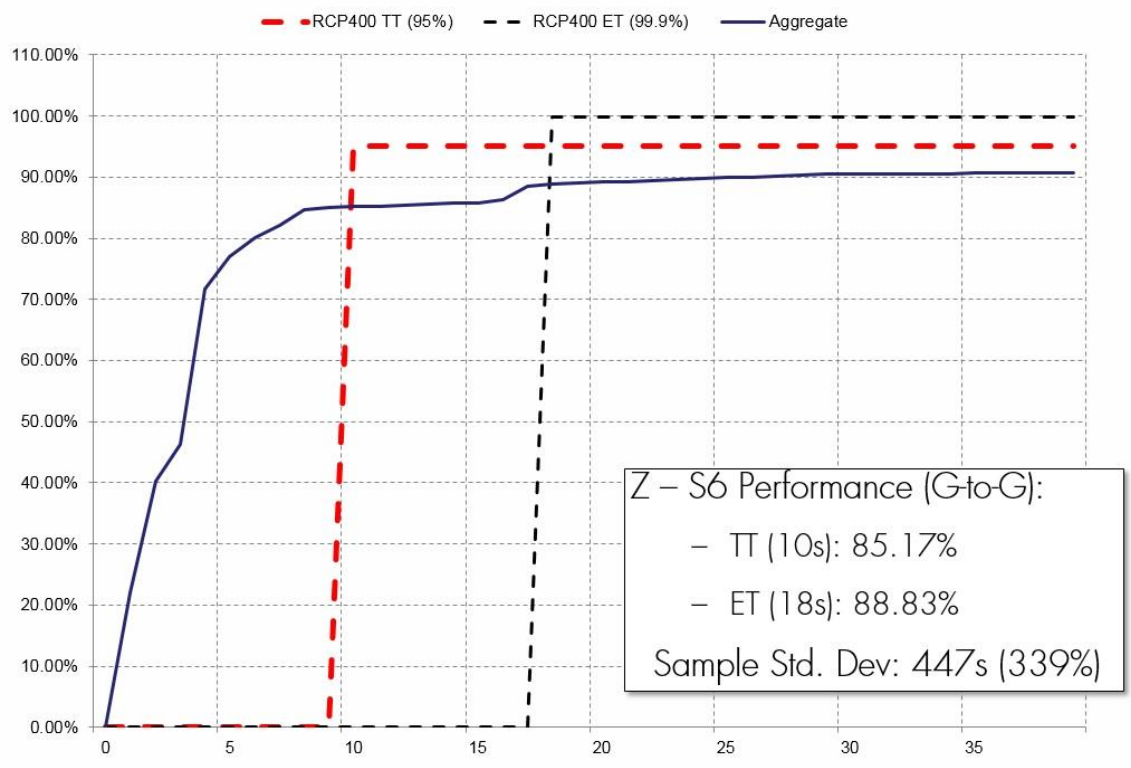

Figure 4-16 – SATVOICE RCP 400/VRO Z – S6 Performance Chart

4.5. SATVOICE Performance Summary

The Measured Service Availability of 84% includes Flight Crew response performance. Note that 96.61% of calls reached flight deck; flight crew did not answer a substantial percentage of calls. Thus, evaluation methods negatively affected total transaction time performance. Furthermore, SATVOICE ACTP exceeds allocation requirement: 95%: 28 seconds and 99.9%: 86 seconds.

SATVOICE ACTP Standard Deviation 8.6 sec (5%) indicates results are consistent and reliable despite small sample size. SATVOICE ACTP (S6-S4) exceeds allocations by 18x Standard Deviations. Also, the Extended RO queue performance is expected due to ATC prioritization at Radio Operator, a limitation in the test environment that would not be a factor in normal operations. Moreover, ATC REQ follows the same path whether HF or SATVOICE between (A-S4) and (S6-Z) allocations. SATVOICE performance is therefore expected to be equivalent to HF.

4.6. Lessons Learned

Throughout the evaluation, the tiger team identified several points for consideration.

1) To understand the flight crew response timing, additional logging could be added to capture the response time.
2) Notwithstanding logging of pilot response timing, we recognized the need for pilot training to improve answer / reject performance overall.
3) It was observed that manual time capture / entry added variances in data capture. Therefore an automated timestamp and collection process throughout allocation segments would reduce variances.
4) It was observed that routine ATSU contact request queue preemption added significant delays in evaluation.
5) As a result, a transition to ATSU testing or actual operations using SATVOICE should eliminate the unintended queue performance.
6) With standard HF voice operations, all callers can hear each other, providing situational awareness and a cadence of talking and waiting. Given the inability of SATVOICE callers to hear HF voice traffic, it makes for a smoother operation if SATVOICE calls can be handled by a separate RO, than the other HF ROs, if staffing levels permit.
7) Situational awareness is a key issue in flight safety. It is vital to be able to receive and parse high priority call info for annunciation to the call recipient, which will require some hardware and software modifications.

5. JetBlue Airways WATRS+ Operational Evaluation (Iridium)

5.1. Project Description

Further to the PARC CWG Operational Evaluation, JetBlue Airways, in cooperation with various offices in the FAA Flight Standards Service, Iridium®, FAA NY ARTCC and New York Radio (with services provided under FAA contract with Rockwell Collins ARINC®), conducted a data gathering campaign focused on the feasibility of authorization and thus utilizing SATVOICE as a primary means of long-range communication in lieu of High Frequency (HF) radio. This evaluation differed from the previous PARC CWG operational evaluations in that it included FAA NY ARTCC participation using the standard ATOP communications system. In doing so, the project provided a direct correlation to true, real world SATVOICE operations. Moreover, the inclusion of ATC for this evaluation avoided the limitations experienced during the PARC CWG operational evaluation.

The goal of the evaluation was to use SATVOICE within the existing provisions, afforded to HF radio, of FAA OpSpec paragraph B045 without an HF radio being installed or the sole HF unit placed on MEL deferral. All operations were operated in accordance with existing JetBlue FAA OpSpec B045 and MEL provisions and limitations.

5.1.1. General

The evaluation took place from August 20 2017 to October 20 2017 and followed a specific test plan which was reviewed and authorized by the JetBlue FAA Certificate Management Office (CMO) and FAA Flight Standards Air Carrier and Flight Technology and Procedures (AFS-200 and -400) Divisions. The test plan provided specifics on how the data gathering effort was conducted.

JetBlue Airways utilized their Iridium based, FANS equipped AIRBUS A321-231 series with L3 Communications® SATCOM systems. The routes utilized for the effort were all within the confines of the New York - West Oceanic Control Area off the east coast United States. New York Oceanic provided all air traffic management functions while New York Radio delivered voice communication transcripts to and from New York Oceanic in the identical manner as if it were conducted through HF communication.

The evaluation included all JetBlue Airways scheduled flights to the Caribbean with appropriately equipped aircraft. This strategy allowed for a wide variety of routes to be covered and tested multiple geographic points. Crew staffing was not adjusted for the flights involved allowing varying mixes of crew experience further adding to the authenticity of the data.

While all JetBlue SATVOICE aircraft were also equipped with FANS and provided electronic position reporting via ADS-C, Flight Deck Crews used SATVOICE for all ATM (position reports, weather deviations, etc.) and safety service requirements. These ATM and safety service SATVOICE communications were measured for continuity, availability, and integrity.

5.1.2. Measured Performance Parameters

SATVOICE performance was measured against the RCP 400 standard, as specified in ICAO Doc 9869, second edition, and relevant for SATVOICE. During the campaign, a total of over 5,200 SATVOICE messages were transmitted. Of these, 239 messages qualified as “relevant transactions” to be measured for RCP compliance. The relevant transactions are further explained in this report.

5.1.3. DATA ELEMENT SOURCES

The operational evaluation collected data from each SATVOICE transaction to allow measurement of the RCP 400/VRO Operational Performance defined by RCP 400/VRO specification. The sources of data were extracted from automated resources in order to maintain the objectivity of the evaluation as well as integrity and consistency. Sources of data included:

- Iridium® Satellite Communications
- ARINC Aeronautical Radio, Incorporated a Rockwell Collins Company
- New York Oceanic Advanced Technologies & Oceanic Procedures (ATOP) data

5.1.4. DATA ELEMENTS PRIMARY DATA SOURCE

The primary data source was obtained from ATOP message logs as shown below. Since this evaluation measured actual ATM communications in New York OCA - West airspace, this data produced the highest fidelity for measurement purposes. Secondary data sources were collected from the list above in order to investigate specific latency profiles along the different communication segments.

Example of ATOP data elements to be collected:

SAT voice RB:

QU NYCAPXA .NYCXGXA 051143 [1]AGM FI XXX123/OS TE VE RDO CHECK DT NYC SP A 051141 04 - ZNY16 ATCC XXX123 ... 11:39:23 XXX123 RB

Initiating voice clearance:

QU NYCXGXA .NYCAPXA 051139 [1]AGM FI XXX123 MA 534O DT ZNY 051139 - ZNY16 ATCC ABW704 ROUTE HAS BEEN CHANGED, CLEARD DIRECT 43N050W 45N040W 47N030W 49N020W BEDRA NERTU 11:39:23

The ATOP system attaches a header to the ACARS message in the archived file - that contains the exact receipt time of the readback, in this case:

11:43:16:210AM. ACP calculation is 11:43:16 – 11:39:23 = 233 seconds

Figure 5-1 – Example of ATOP data elements to be collected

5.1.5. BENCH MARK TIME SOURCE FOR RCP CALCULATION

The primary method of ACP calculation was determined by figure 1, below, off of ATOP message logs.

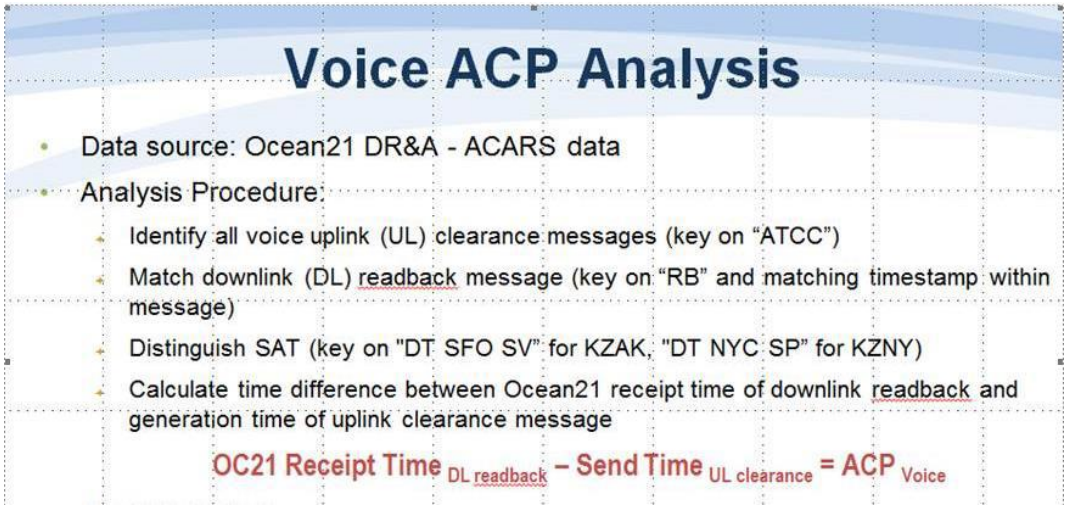

Figure 5-2– Voice ACP Analysis Method

5.1.6. FAA INFO 15015 FLIGHT PLAN COMPLIANCE

JetBlue Airways actively files the appropriate field 10a and field 18 codes commensurate with its SATVOICE system. See yellow highlight in actual flight plan example below.

```
QU HDQXSYF
.BWIASB6 291823
_FF KZMAZQZX MDCSZQZX MDCSZRZX
291823 KJFKJBUH
_(FPL-JBU237-IS
-A321/M-SDE3GHIM3RWZ/S
-KJFK1959
-N0450F330 DCT SHIPP DCT LINND DCT ROLLE/M078F330 DCT ATUGI
L454 LUCTI/M078F330 L454 MNDEZ M594 GTK A554 SEKAR/N0460F330
A554 PTA DCT SGO DCT
-MDST0311 MDSD
-PBN/A1B1C1D1O1S2T1 NAV/RNVD1E2A1 RNP10 REG/N974JT

EET/KZBW0005 KZNY0007 KZWY0036 KZMA0213 MDCS0257 SEL/HMAB
CODE/AD935B DOF/161229)
```

Figure 5-3– Actual Flight Plan Example

5.1.7. CREW ELIGIBILITY REQUIREMENTS

All AIRBUS Flight Deck Crewmembers are current and qualified to fly in WATRS+ airspace utilizing HF communications while conforming to the existing RCP 400 and RSP 400 standard in use today. Additionally, as of November 30th 2016 all Flight Deck Crewmembers have completed SATVOICE system training per JetBlue's FAA approved AQP training. In order to maintain objectivity, all JetBlue pilots operating in the WATRS+ airspace were included as potential evaluation participants.

To prepare for the evaluation, JetBlue disseminated materials to all AIRBUS crews outlining the evaluation and the conditions of the SATVOICE communications. In addition JetBlue leadership provided communications which reinforced the crewmember communications expectations.

5.2. Evaluation Results

This section will provide a discussion of the JetBlue Airways WATRS+ Operational Evaluation results.

5.2.1. SATVOICE Actual Communication Performance (ACP) Summary

In summary, the aggregate JetBlue Airways SATVOICE ACP performance exceeds RCP 400 Transaction Time (TT) criteria. Out of 239 qualified messages, 228 achieved RCP 400 Transaction Time (TT) criteria and 235 achieved the Expiration Time (ET) criteria.

RCP 400/V Criteria	Compliant Attempts	Success Rate
Transaction Time (TT) (95% < 320 sec)	**228**	**95.40%**
Expiration Time (ET) (99% < 370 sec)	**235**	**98.33%**

As shown, while the RCP 400 TT criteria was achieved, the evaluation fell slightly below the RCP ET criteria. However, RCP ET was eventually achieved by the end of the evaluation period as improvements were introduced. The aggregate ACP performance is depicted below in Figure 5-4.

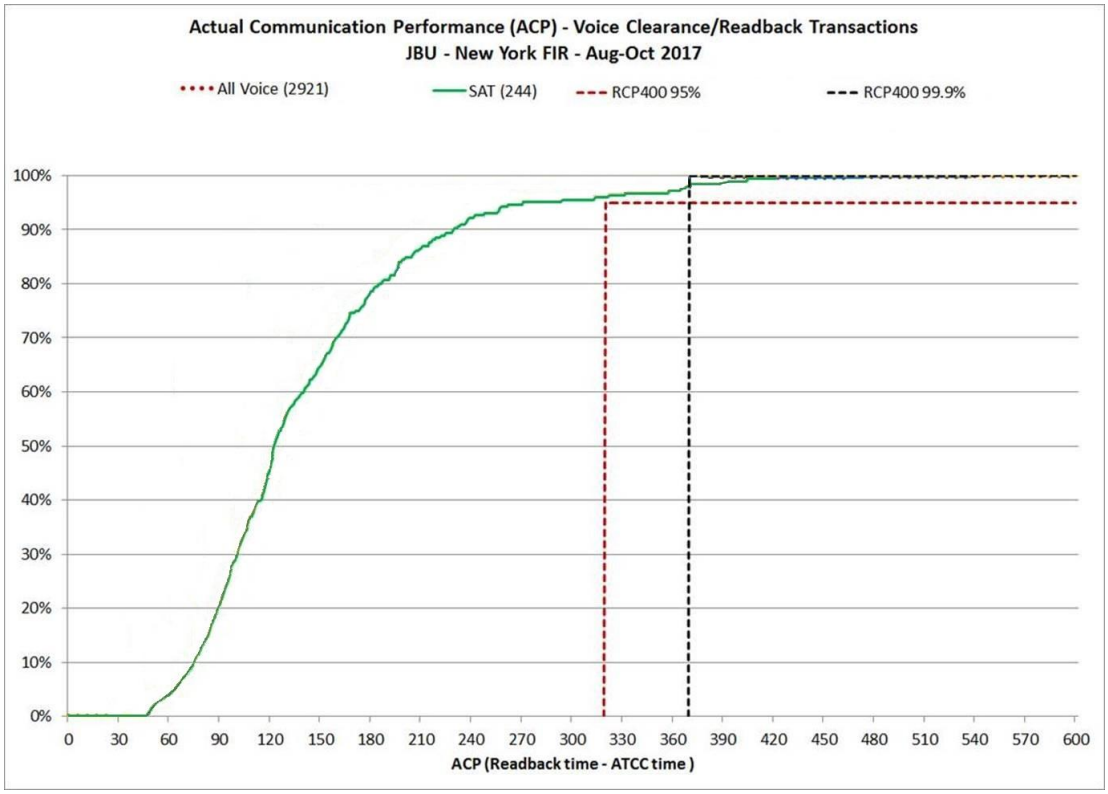

Figure 5-4 Aggregate SATVOICE RCP 400/VRO Total Transaction Performance Chart

In analyzing the call performance results, it was noted that performance varied throughout the evaluation as a result of two particular events:

- August 15th – 20th: Messages sent the first week of the evaluation did not meet the RCP 400 TT criteria due to confusion of evaluation test procedures. Performance notably improved with additional clarification for evaluation participants.
- October 13th – 20th: An Oceanic NOTAM was issued on October 13, prohibiting FANS operations over Iridium. Initially, some confusion ensued while JetBlue adjusted its ATC flight plan codes. After adjusting to the correct filing code, the remaining period of the data gathering indicated improvement once all participants understood impacts to test operation.

Figure 5-5 below compares the performance impact of each of these events. The "SAT w/o NOTAM period" (Violet) and the "SAT NOTAM period only" (yellow) represent the performance before and after the implementation of the October 13 NOTAM respectively. As can be seen, the ACP demonstrated while FANS was to be disabled exceeds both the 95% TT criteria and the 99% ET criteria.

For further analysis, the ACP for the August 15th – 20th period (first week) was excluded from the pre-NOTAM period and plotted as "SAT w/o first week" (orange). While the performance certainly shows improvement and exceeds the 95% criteria, it does not quite meet the 99% criteria. This analysis indicated that the operation of FANS had an apparent effect on the SATVOICE ACP. The root cause of this phenomenon was identified as the result of 1) a shared antenna resource and, 2) duplication and confusion of SATVOICE and CPDLC usage. Each of these issues are detailed in 5.4 Lessons Learned.

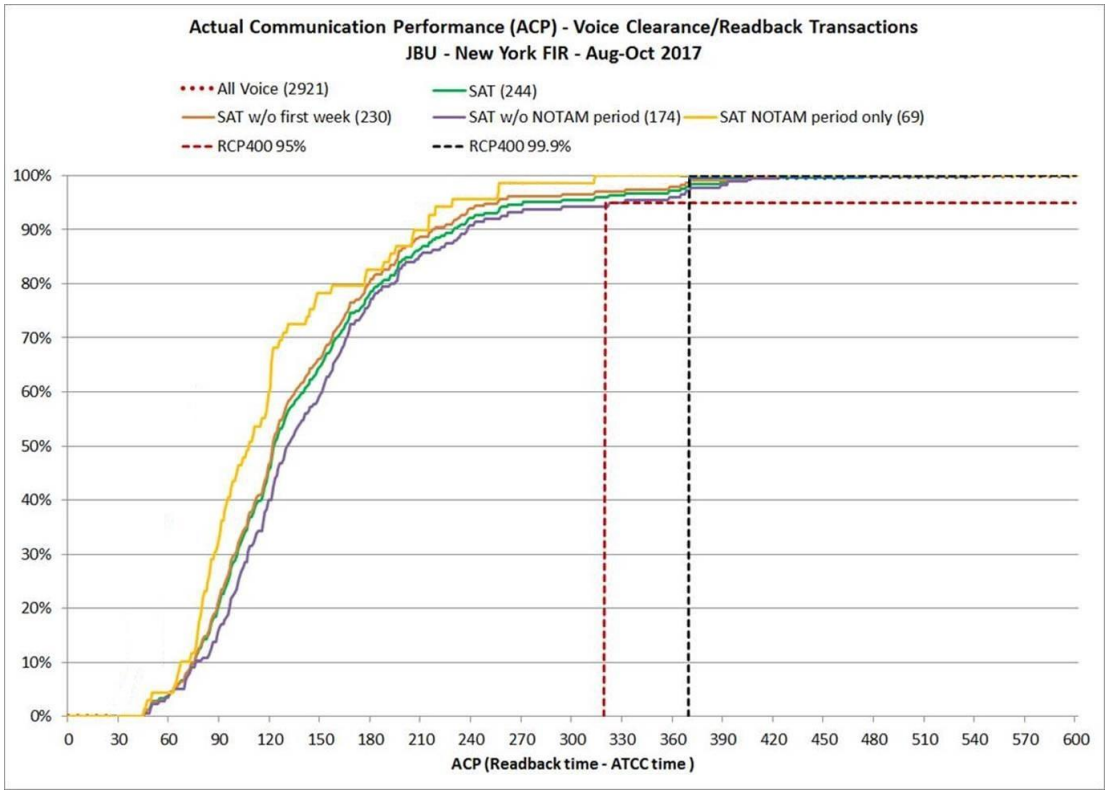

Figure 5-5 SATVOICE RCP 400/VRO SATVOICE Analysis Chart

Finally, the SATVOICE performance was compared with HF voice performance for reference. As depicted in Figure 5-6, HF performed better than SATVOICE. However, SATVOICE performance was reduced by the events noted above. The effects of these events were unique to SATVOICE and did not affect HF ACP. Notwithstanding the ACP compliant results of SATVOICE, it is understood that future ACP would be significantly improved with the lessons learned in this evaluation.

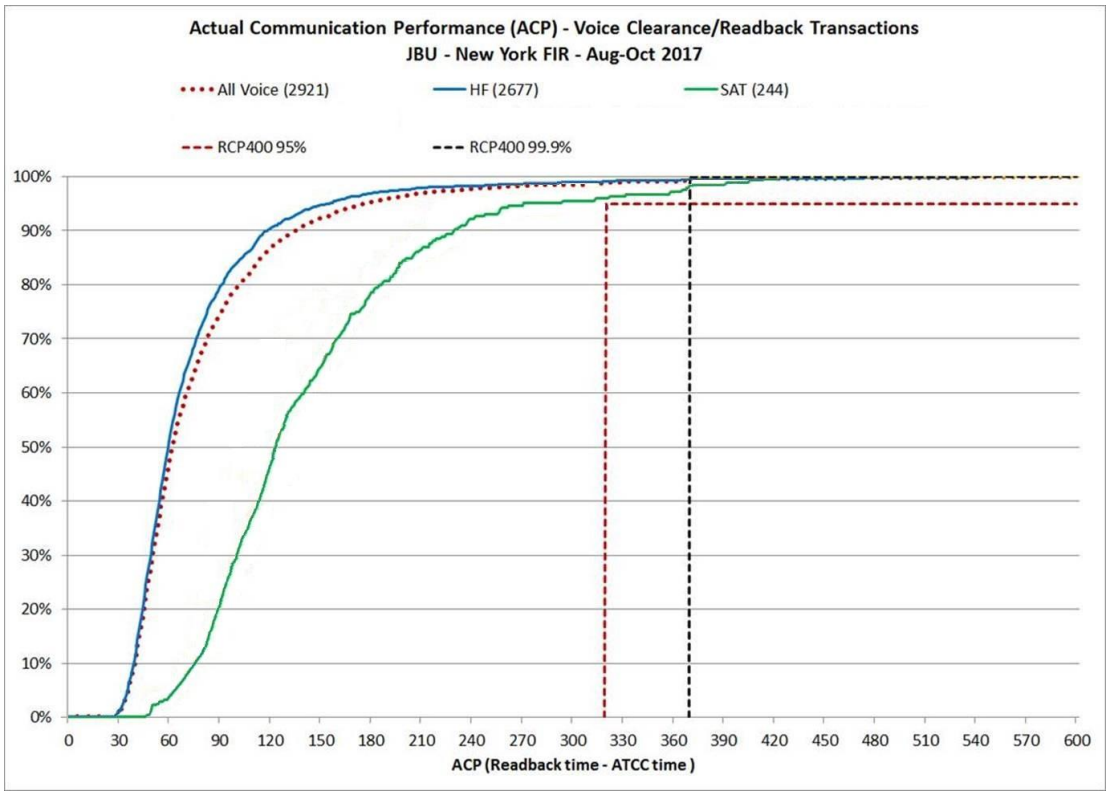

Figure 5-6–SATVOICE and HF Voice performance Chart

In addition to the RCP performance charts above, Table 3 below details the performance data as collected per week. The "ATC Clearances," column documents the performance of ATC clearance (intervention) messages which, by definition, are the only ones used to calculate "Actual Communication Performance (ACP)." For reference, the "All Timed Messages," lists the total messages sent and/or received,

jetBlue SatVoice trial with NYCXA and New York Center											
Week	ATC Clearances					All Timed Messages					
	# of ATC Clearances	Transaction Time < 320 sec (RCP-400 target > 95%)		Transaction Time < 370 sec (RCP-400 target > 99.9%)		Total SatVoice Messages	All Time Measured Messages	Transaction Time < 320 sec (RCP-400 target >95%)		Transaction Time < 370 sec (RCP-400 target >99.9%)	
15-20 Aug	14	11	78.57%	12	85.71%	412	36	30	83.33%	32	88.89%
21-27 Aug	52	49	94.23%	51	98.08%	1051	97	92	94.85%	94	96.91%
28 Aug-3 Sep	28	28	100.00%	28	100.00%	795	42	41	97.62%	41	97.62%
4-10 Sep	24	23	95.83%	23	95.83%	617	42	40	95.24%	40	95.24%
11-17 Sep	20	20	100.00%	20	100.00%	479	35	32	91.43%	32	91.43%
18-24 Sep	4	4	100.00%	4	100.00%	140	7	7	100.00%	7	100.00%
25 Sep-1 Oct	8	7	87.50%	8	100.00%	269	14	12	85.71%	14	100.00%
2-8 Oct	14	13	92.86%	14	100.00%	551	30	29	96.67%	30	100.00%
9-15 Oct	26	24	92.31%	26	100.00%	486	53	48	90.57%	51	96.23%
16-20 Oct	49	49	100.00%	49	100.00%	451	81	78	96.30%	79	97.53%
Cumulative	239	228	95.40%	235	98.33%	5251	437	409	93.59%	420	96.11%

Table 3 SATVOICE Evaluation Performance Log

Notably, from 11 September to the end of the data gathering period, 100% of the messages achieved the RCP 400 target rate of 370 seconds. Also, the 18 Sept. to 8 Oct. timeframe experienced a large drop of flight activity due to a very active hurricane season in the New York West OCA.

5.3. Non-Conforming Call Analysis

As previously noted, 228 out of 239 clearance attempts achieved RCP 400 Transaction Time (TT) criteria while a total of 235 out of 239 clearance attempts achieved the Expiration Time (ET) criteria. In analyzing the 11 messages which did not meet the RCP 400 TT criteria, it was determined that each matched one of three causes:

1) Duplicate CPDLC and SATVOICE clearance attempts – 2 events
2) Multiple SATVOICE calls for one clearance attempt – 8 events
3) Extended SATVOICE call lasting over 4 minutes – 1 event

The first cause occurred during the August 15th – 20th week where there was still some confusion in the evaluation test procedures. As noted previously, performance improved with additional clarification for evaluation participants.

The second cause is affected by flight crew availability which resulted in some calls not being answered on the first attempt. This cause is common to the NO_ANS events identified in the original operational evaluations previously performed with Hawaiian and UPS aircrafts and flight crews.

The third cause only had one occurrence over the 239 total clearance attempts. In this case, the clearance message was delivered and acknowledged within RCP 400 TT criteria. However, the SATVOICE call remained active (off hook) after delivering the clearance message.

5.4. Lessons Learned

Throughout the evaluation, the JetBlue team identified several points for consideration.

1) Radio operators need to adjust sensitivity of SATVOICE microphones, or ensure radio operators speak closer to the microphones. Volume level of ground station was sometimes poor in the cockpit.
2) Radio Operator DTMF dialing volume. Initially, the volume level of the NY Radio dialing switch was set too low. This caused the Iridium voice switch to fail to recognize some of the DTMF tones generated from the ARINC switch. Iridium identified this issue in the testing. NY Radio raised the DTMF audio level by 5dB, which is considerable. For future reference, DTMF tones will need to meet minimum volumes.
3) Use ICAO SATVOICE short codes in lieu of actual telephone numbers (area code plus 7-digit phone number) in aircraft dialing directory. This allows the ground system to adjust Public Switched Telephone Number (PSTNs) corresponding to the short codes, which New York Radio had done to facilitate line roll over functionality, reducing the likelihood of busy signals for incoming calls. New PSTNs for New York are no longer published, which is an added security feature.
4) Response in kind issue. Aircraft were FANS-equipped and included the applicable codes in the ATC flight plan, for safety reasons. However, this resulted in events where crews made requests through voice but received CPDLC communication in response. Two such events resulted in ACP exceeding the RCP targets, and could arguably have been removed from the data pool. This is primarily an issue relating to design of data collection. In a real-world use of SATVOICE for safety services, the most likely scenario would be that data communications are not available, so this response-in-kind issue would not be a factor. During the last week of the data-gathering effort, in fact, data communications were indeed not available, and SATVOICE performance was noticeably better then.

5) Shared Antenna Resource Affected Performance. The SATCOM system utilized by JetBlue prioritizes data communications over voice, and uses a single antenna for both communication types. When voice reports were being made via SATVOICE while ADS-C (SATCOM data) was active and transmitting, SATVOICE performance suffered. Degradation was minimal, but noticeable. Installing a second, dedicated antenna would likely resolve this issue, but there could be other, less costly solutions. Until such time that a mitigation is implemented, crews should be made aware of this possibility via a remark in the Airplane Flight Manual.
6) Pilots, in several instances did not answer an incoming call from ATC. It is not specifically known why, and it should be noted that there are many valid reasons pilots might choose not to answer an incoming call. These failed calls area valid part of the RCP400 discussions as they did contribute to some of the non-conforming ATC clearances

6. Recommendations

As indicated in the evaluations performed and results detailed herein, SATVOICE is viable for RCP 400 operations. Therefore, the following recommendations are suggested.

6.1. Recommendation 1

The PARC CWG recommends that the FAA remove the restrictions in the United States Aeronautical Information Publication (AIP) on SATVOICE communications in order to enable it as an approved long range communications system (LRCS) for communicating with air traffic control (ATC) via New York and San Francisco RADIO.

6.2. Recommendation 2

The PARC CWG recommends that the FAA advocate that all ICAO signatories, where infrastructure so permits, remove restrictions on SATVOICE communications to harmonize this new operational philosophy globally.

7. Stakeholders

The Satellite Voice Project team is comprised of 36 members representing 14 stakeholders as follows:

a) FAA

b) Seven (7) Airlines:

1) Hawaiian Airlines

2) Sun Country Airlines

3) United Airlines

4) Southwest Airlines

5) UPS Airlines

6) Delta Air Lines

7) JetBlue Airways

c) Two (2) SSPs:

1) Inmarsat

2) Iridium

d) Two (2) CSPs:

1) Rockwell Collins

2) SITA

e) Boeing

f) Two (2) LRU OEMs:

1) ICG (Rockwell Collins)

2) Avionica

8. Post Implementation Monitoring

The ICAO Global Plan calls for the implementation of a performance based system and ICAO Annex 11 requires that communication system performance is monitored to verify that an acceptable level of safety continues to be met. Annex 11 at paragraph 2.2.7.5 states:

> "Any significant safety-related change to the ATC system, including the implementation of a reduced separation minimum or a new procedure, shall only be effected after a safety assessment has demonstrated that an acceptable level of safety will be met and users have been consulted. When appropriate, the responsible authority shall ensure that adequate provision is made for post-implementation monitoring to verify that the defined level of safety continues to be met."

Oversight of the compliance to the Annex 11 requirements is a matter for the States. However, States participate in planning and implementation regional groups (PIRGs), and most use a regional monitoring agency to facilitate monitoring activities within their respective region. The individual states/ANSPs will need to provide the data and information and analysis that will portray regional performance measures.

Monitoring of SATVOICE communications in terms of RCP is an important part of the performance based system described in the ICAO Global Plan.

9. References

The following table lists references used throughout this document with corresponding document numbers and titles.

Table 9-1 – References

Ref No.	Document Number	Title
1	14CFR	Code of Federal Regulations, Title 14 – Aeronautics and Space
2	GANP (Doc 9750-AN/963)	ICAO Global Air Navigation Plan
3	ICAO Annex 11	ICAO Annex 11 to the Convention on International Civil Aviation
4	ICAO SVGM	ICAO Satellite Voice Guidance Material (SVGM)
5	N 8900.277[4]	FAA OpSpec B045, Extended Overwater Operations Using a Single Long-Range Communication System
6	PANS-ABC (Doc 8400)	Procedures for Air Navigation Services, ICAO Abbreviations and Codes
7	PBCS Manual (Doc 9869, second edition)	Performance Based Communications and Surveillance

[4] https://www.faa.gov/documentLibrary/media/Notice/N_8900.277.pdf.
The notice has expired because the guidance has been incorporated into FAAO 8900.1, V3, Ch 18, Sec 4. http://fsims.faa.gov/PICDetail.aspx?docId=8900.1,Vol.3,Ch18,Sec4 . The OpSpec templates published in the N8900.277 are still current.

Appendix A. RCP 400/VRO Specification

This section includes the RCP 400/VRO allocations referenced throughout this document.

The aforementioned RCP 400/VRO allocations and general terms and definitions applicable to RCP 400/VRO specifications are provided by the PBCS Manual (Doc 9869, second edition).

RCP 400 specification (communication transaction times and RCP continuity)												
RCP	**400**											**RCP**
95%	350											95%
	RCP 400/V_{RO} allocations – Radio operator using SATVOICE example											
ATM	**Controller issues ATC instruction**	**Monitored operational performance**									**Controller receives response**	**ATM**
99.9%	$P_{C/ATSU}$(30)	370									$P_{C/ATSU}$ (30)	ET
95%	$P_{C/ATSU}$ (30)	320									$P_{C/ATSU}$ (30)	TT
RCMP		RCTP (ground-to-ground)		Queue/ connect performance	RCTP (ground-to-air)	Answer/call performance	RCTP (ground-to-ground)					**RCMP**
99.9%		P_{RCTP}(18)		147	30	175	P_{RCTP} (18)					ET
95%		P_{RCTP} (10)		132	25	163	P_{RCTP} (10)					TT
	A	C	S1	S2	S3	S4	S5	S6	S7	S8	X	Z
RCTP		ATSU system	Network	Aero station system		Aircraft / Aero station system		Aero station system	Network	ATSU system		**RCTP**
99.9%		P_{ATSU} (4)	P_{NET} (10)	P_{AS} (4)		30		P_{AS} (4)	P_{NET} (10)	P_{ATSU} (4)		ET
95%		P_{ATSU} (2)	P_{NET} (6)	P_{AS} (2)		25		P_{AS} (2)	P_{NET} (6)	P_{ATSU} (2)		TT

Note.— $P_{[SUBSCRIPT]}$([value]) means part of the specified [value], and that the combination of all the allocations in the row, denoted by, $P_{[SUBSCRIPT]}$, equals the [value] specified.

Figure A-1 – Typical Voice Communication Transaction Allocation

Appendix B. Radio Operator (RO) Message Table

Table B-1 – RO Message Table

Success of Call	Attempts	Quality	Number of Drops	Explanation of Coding
OK	1 - 3*	5x5**	0 - 3***	Call answered normally, first attempt, voice quality level good, no dropped calls
NE (Not Equipped)				Aircraft not equipped with SATVOICE equipment
NA (No Answer)	3*	No other data required.	No other data required.	Crew did not answer phone after 3 attempts
UN (Unavailable)	3*	No other data required.	No other data required.	SATCOM not logged on to Satellite system. A message that states, "Caller not available on system" after 3 attempts
BS (Busy Signal)	3*	No other data required.	No other data required.	Busy signal received by RO for 3 attempts
QD (Queue Delay)	1 - 3*	5x5**	0 - 3***	RO delayed in making call due to a large number of clearances or requests in queue
CF (Call Fail)	3*	No other data required.	3***	Call connected but fails or drops 3 times

*If more than 3 attempts are required for contact discontinue calling.

**Voice quality measurement scale 1 to 5 where the first 5 measures loudness and second 5 measures clarity.

*** If a call drops 3 times please use code “Call Fail”.