NextGEN

International Civil Aviation Organization (ICAO) Operational Data Link Familiarization Seminar

Session 3 – Preparation for data link implementation – Post-implementation monitoring (compliance) (ANSP and Operator):

Nairobi, Kenya
2-6 November 2015

FAA

Presentation Overview

- Introduction → guidance material
- ANSP data collection
  - CPDLC transaction time/continuity
  - ADS-C report delivery time/continuity
  - SATVOICE transaction time/continuity
  - SATVOICE position report delivery time/continuity
  - Availability
- ANSP performance monitoring and analysis
  - Data filtering
  - Time/continuity
  - Availability
  - Monitoring reports for regional and global use
- Regional performance monitoring and analysis
- Regional problem reporting and resolution
- Benefits of PBCS

Introduction

- Guidance material for post-implementation monitoring and compliance contained in ICAO Doc **9869** – *Performance-Based Communication and Surveillance (PBCS) Manual*
  - Appendix D: CPDLC and ADS-C
  - Appendix E: SATVOICE
- Formerly contained in the Global Operational Data Link Document (GOLD) and the Satellite Voice Guidance Material (SVGM)

DATA COLLECTION

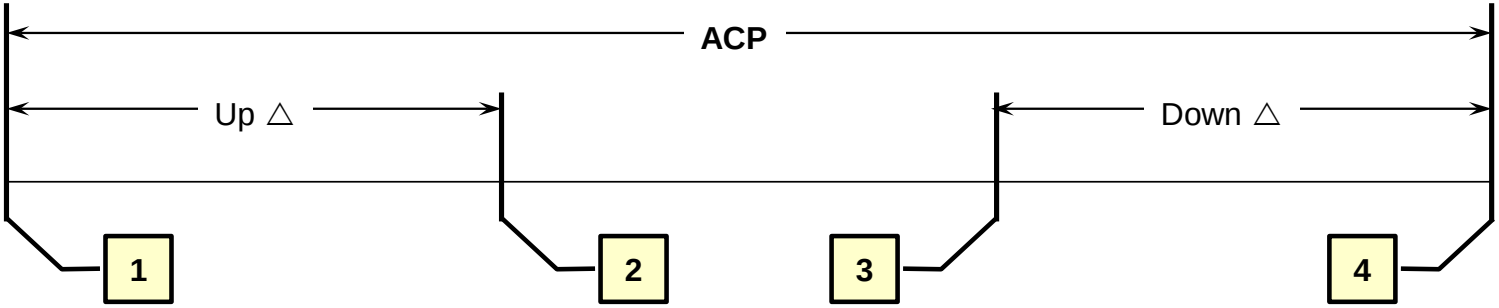
CPDLC Transaction Time/Continuity (1 of 3)

- CPDLC data set: controller-initiated transactions that receive a single DM 0 WILCO response
  - ❖ A DM 0 WILCO response following a DM 2 STANDBY is not measured
- **Table D-1** in PBCS Manual contains CPDLC data collection points
  - Most of required **19** data points can be extracted from either the ACARS or ATN B1 header or the CPDLC application message, or calculated based on the other data points
  - Aircraft type and operator will need to be matched from a separate database using the aircraft registration as the common point

CPDLC Transaction Time/Continuity (2 of 3)

- CPDLC analysis is based on measurement of:
  - Actual Communication Performance (ACP)
    - →Required Communication Monitored Performance (RCMP)
  - Actual Communication Technical Performance (ACTP)
    - →Required Communication Technical Performance (RCTP)
  - Pilot Operational Response Time (PORT)
    - →RCP PORT
- Suggested that ANSP also conduct regular analysis of the message use statistics for the current CPDLC message set for the purpose of assessing usage trends and future development of CPDLC applications

CPDLC Transaction Time/Continuity (3 of 3)



1	Uplink Sent	Date/time ATSU sent CPDLC clearance to the aircraft
2	MAS Received	Date/time ATSU receives the MAS for the CPDLC clearance
3	WILCO Sent	Date/time aircraft sends WILCO response for the CPDLC clearance
4	WILCO Received	Date/time ATSU receives WILCO response for the CPDLC clearance

The measurements (in seconds) are calculated as follows:

$$ACP = (\text{WILCO Received}) - (\text{Uplink Sent})$$ → **RCMP**

$$ACTP \cong \left(\left(\frac{\text{Up } \Delta}{2}\right) + (\text{Down } \Delta)\right)$$ → **RCTP**

$$PORT \cong ACP - ACTP$$ → **RCP PORT**

ADS-C Report Time/Continuity

- Actual Surveillance Performance (ASP)

  →Required Surveillance Performance (RSP)

  ASP = {time the ADS-C report is received at the ANSP} –
  {time at position extracted from the decoded ADS-C basic group}

- **Table D-3** in PBCS Manual contains ADS-C data collection points
  - Most of required **12** data points can be extracted from either the ACARS or ATN B1 header or the ADS-C application message, or calculated based on the other data points
  - Aircraft type and operator will need to be matched from a separate database using the aircraft registration as the common point

SATVOICE Transaction Time/Continuity

- SATVOICE communication performance analysis is based on the calculation of
  - Actual Communication Performance (ACP)

  → RCP time allocations for communication transaction (RCMP)
- The analysis uses the measurement of transit and response times related to clearances sent via SATVOICE that receive a single readback response
- **Table E-1** in PBCS Manual contains SATVOICE transaction data collection points
  - Most of required **9** data points can be extracted from either the ACARS or the ACARS application message, or calculated based on the other data points
  - Aircraft type and operator will need to be matched from a separate database using the aircraft registration as the common point

SATVOICE Position Report Delivery Time/Continuity

- Actual Surveillance Performance (ASP)

  → Required Surveillance Performance (RSP)

  ASP = {time the report is received at the ANSP} –
  {time-over-position extracted from the decoded ACARS message }

- Note: Because the accuracy of the time-over-position within the ACARS position report message is only to the minute (e.g. 15:11) while the accuracy of the timestamp of receipt at the ANSP is to the second (e.g. 15:11:11) the accuracy of the measurement of the surveillance performance will be limited to the minute

- **Table E-2** in PBCS Manual contains SATVOICE position report data collection points
  - Most of required **12** data points can be extracted from either the ACARS header or the ACARS application message, or calculated based on the other data points
  - Aircraft type and operator will need to be matched from a separate database using the aircraft registration as the common point

Availability (1 of 2)

- To calculate the actual availability of CPDLC and ADS-C ANSP and of SATVOICE service provision data should be collected for outages greater than 10 minutes
  - ✓ CSP notified system outages
  - ✓ Detected outages that are not observed by or notified by the CSP
- For each outage the following information should be collected:
  - **a) Time of CSP outage notification**: In YYYYMMDDHHMM format or “Not Notified” if no CSP notification received
  - **b) CSP Name**: Name of CSP providing outage notification if applicable
  - **c) Type of outage**: Report media affected SATCOM, VHF, HF, ALL
  - **d) Outage start time**: In YYYYMMDDHHMM format
  - **e) Outage end time**: In YYYYMMDDHHMM format
  - **f) Duration of Outage**: In minutes

Availability (2 of 2)

- Example of unreported outage
  - large ADS C downlink delays observed from 3 aircraft during the period from 11:20 to 12:13

Aircraft registration	Aircraft time	ANSP system time	Downlink time (Seconds)
ZKSUI	11:55:38	12:12:52	1,034
ZKSUI	11:44:42	12:12:19	1,657
ZKSUI	11:23:21	12:08:32	2,711
ZKSUJ	11:41:54	12:12:01	1,807
ZKSUJ	11:26:18	12:09:42	2,604
ZKSUJ	11:20:34	12:07:39	2,825
ZKOKG	11:53:52	12:12:51	1,139

Data Format

- Data may be stored in database or text format
- When sharing raw data (e.g. with the regional monitoring entity) it is suggested to be sent as a .csv file

ANSP PERFORMANCE MONITORING AND ANALYSIS

Overview

- Collected data are used to monitor the time/continuity of CPDLC and SATVOICE transactions, and ADS-C and SATVOICE report delivery
- At a minimum, monitoring should be conducted for:
  - Aggregate system performance (all data combined)
  - All media types
  - All message type(s)
  - All operators
  - All aircraft types
  - All airframes

Data Filtering - CPDLC

- Aim is to include only those CPDLC transactions for which there is a critical communications requirement when applying reduced separation standards – i.e. intervention messages
- The following transactions are filtered out:
  - Uplink messages with any response other than DM 0 WILCO, including messages with DM 2 STANDBY responses followed by DM 0 WILCO
  - Non-intervention route messages (UM 79, UM 80, UM 81, UM 82, UM 83, UM 84, UM 91, and UM 92)
  - Contact instructions (UM 117 – UM 123)
  - RESUME NORMAL SPEED (UM 116)
- **Note**: the removal of all contact instructions (UM 117 – UM 123) may drastically reduce the monthly data set for some smaller ANSPs and make it difficult to assess ACTP. For this reason some ANSPs may retain these (UM 117 – UM 123) transactions when assessing ACTP only

Data Filtering – ADS-C

- Duplicate ADS-C reports should be removed from the data set prior to analysis
  - Occurs when ADS-C report is sent and the acknowledgement (ACK) from the GES is not received within a defined period of time causing the aircraft system to resend the report (typically during media transitions)
  - ❖ Only the ADS C report with the earliest receipt time should be kept in the data set
- ADS-C reports with delivery times of zero or less than zero should be filtered out
  - These times represent cases where the ADS-C basic group timestamp extracted as seconds since the most recent hour was incorrectly decoded into the HH:MM:SS format by the ATS unit's system

Data Filtering - SATVOICE

- When SATVOICE is used after failed attempts on HF, the observed performance may indicate excessive delays in the SATVOICE performance
- Analysis should include these data to reflect actual operational performance from the controller perspective and then determine whether procedures could potentially mitigate the effects of these delays
  - e.g. the radio operator may consider using the SATVOICE directly when it can be determined to provide a more reliable communication than HF

Data Filtering - Outage Periods

- The outage data collected to measure availability should also be used for filtering the ADS-C, CPDLC and SATVOICE data sets
- All ADS-C reports, CPDLC transactions, SATVOICE transactions, and SATVOICE position reports occurring during applicable outage periods reported by the CSP should be removed
- All ADS-C reports, CPDLC transactions, SATVOICE transactions, and SATVOICE position reports occurring during applicable unreported outages detected by the ANSP should also be removed

Cumulative Distributions to Measure Performance

- Filtering the data limits the size of the sample that will be used to create the cumulative distributions of data
- When providing cumulative distributions of the data, a sufficient sample size should be determined taking into account a number of factors, such as:
  - Type of data that will be considered in the sample
  - Cost, time and difficulty in collecting the data
  - Existing knowledge about the underlying technologies and implementation
  - Variability of the data collected
  - The specific criterion that the data sample will be measures against
  - Level of confidence desired in the estimated result
- Once a sufficient sample of filtered data has been collected, the next step is to calculate a cumulative distribution for each of the performance parameters to be measured:
  - ACP, ACTP, PORT for the CPDLC application
  - ASP for the ADS-C application
  - ACP only for SATVOICE intervention capability
  - ASP for the SATVOICE position reports

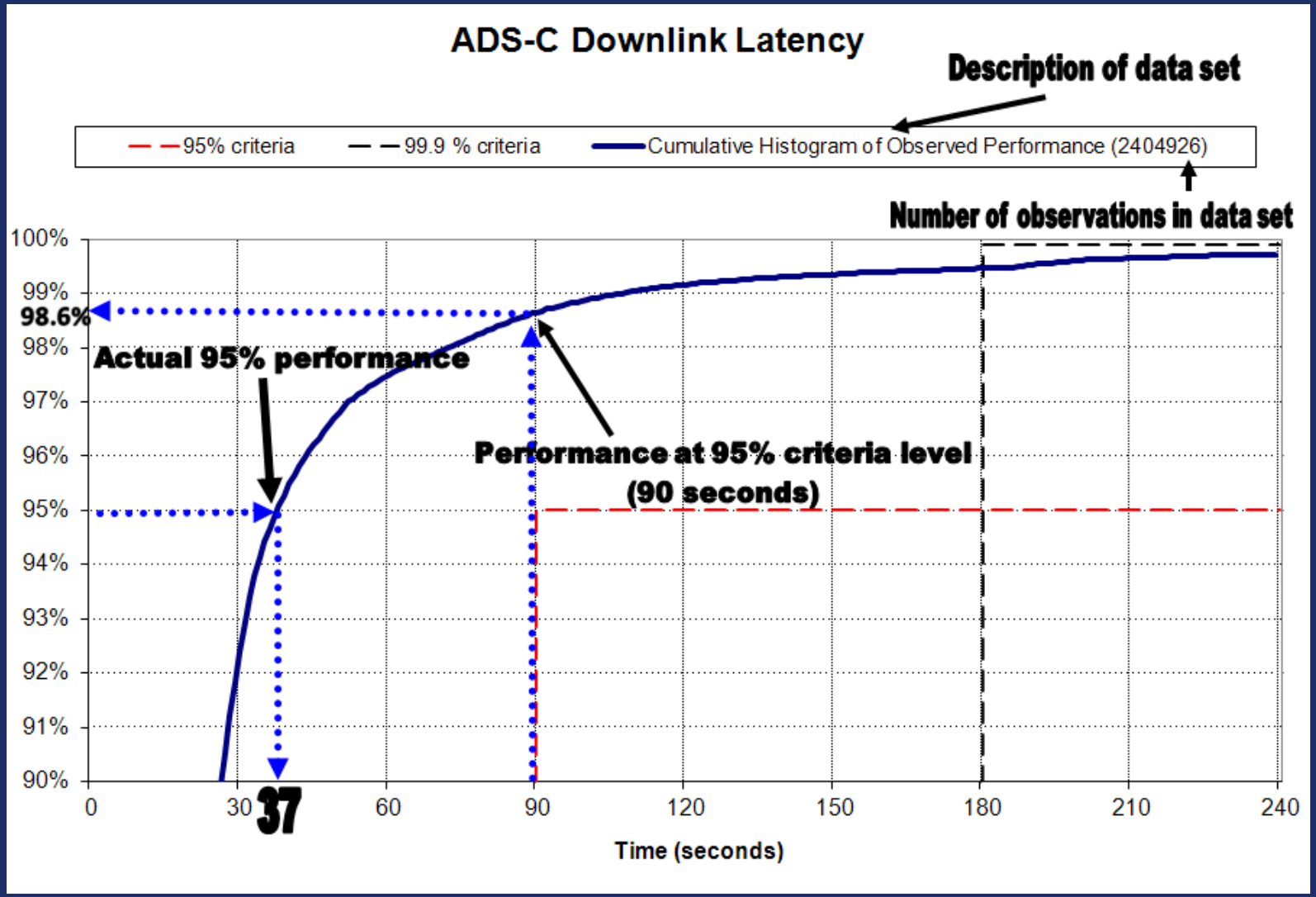
Graphical Analyses

- It is recommended to begin with graphical analysis of the data as this method is useful for clearly depicting the performance and facilitating the identification of performance problems
- The cumulative performance should be shown in comparison to the relevant parameter values for the transaction times and corresponding continuity requirements
  - For example - when measuring the cumulative ACP against RCP 240, the RCP 240 safety and efficiency requirements should be included:
    - 240 seconds at 99.9%
    - 210 seconds at 95.0%

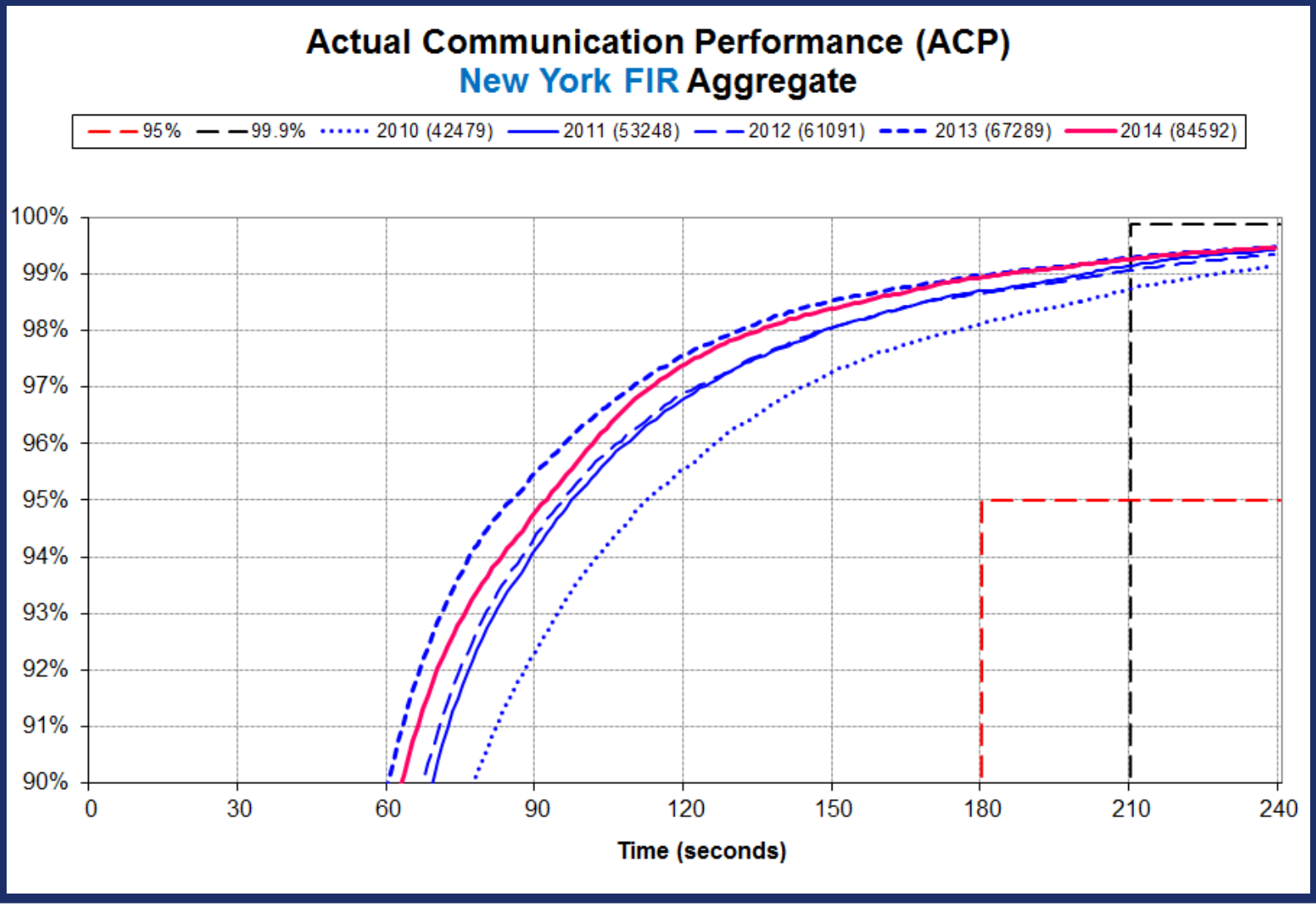
PBCS Time/Continuity Performance Criteria

Performance Measure	Percentage of Messages Required to Meet Criteria	RSP180 Criteria (sec)	RSP400 Criteria (sec)	RCP240 Criteria (sec)	RCP400 Criteria (sec)
ASP	95%	90	300		
	99.9%	180	400		
ACTP	95%			120	260
	99.9%			150	310
ACP	95%			180	320
	99.9%			210	370
PORT	95%			60	60

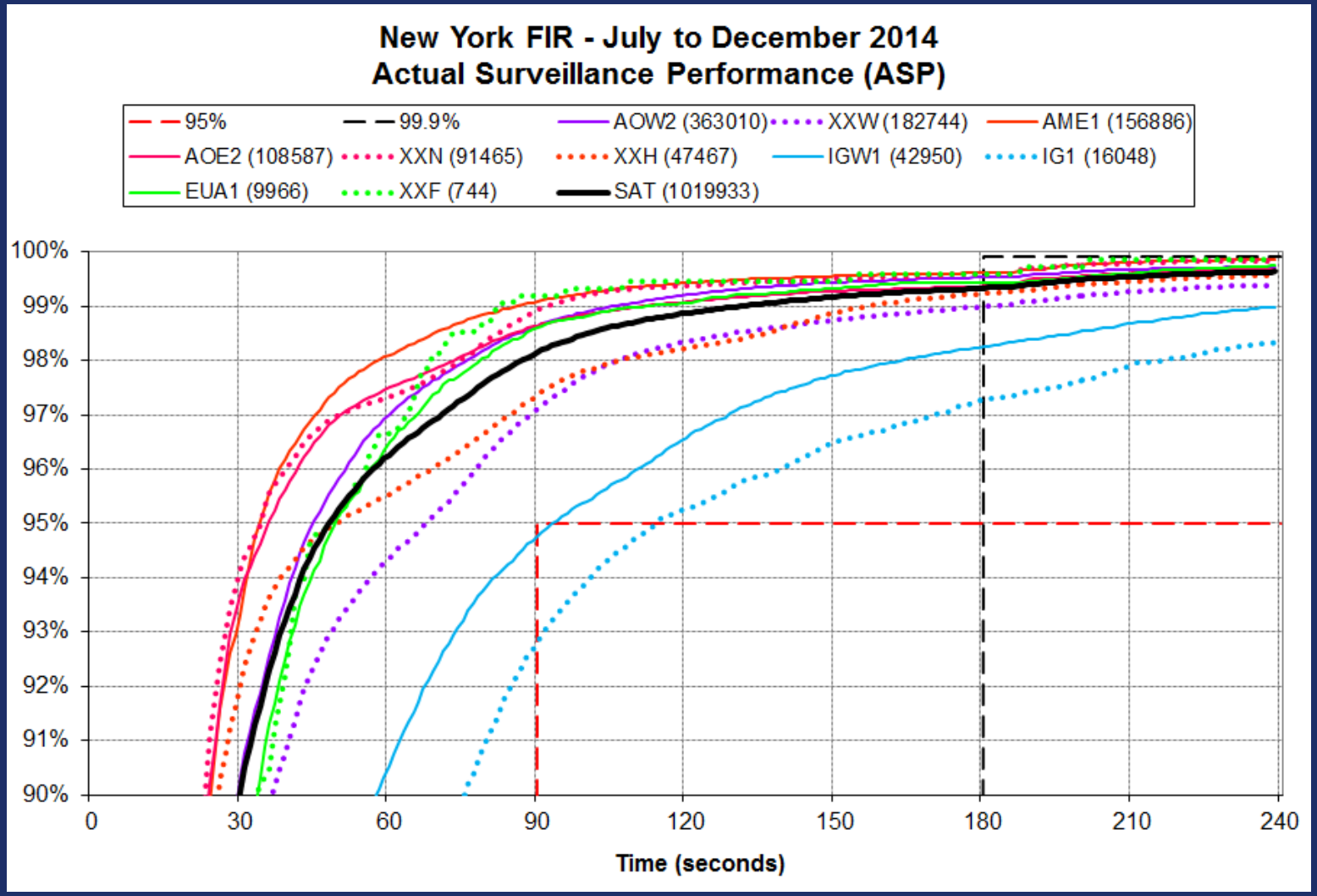
Sample Graphical Analysis Format



Example – Assessing Annual ACP



Example – Assessing ASP by Station ID



GES LOCATION(S)	SATELLITE/ REGION	SITA Identifier	ARINC Identifier
Burum, Netherlands	Inmarsat I-3 AOR-E	AOE2	XXN
	Inmarsat I-3 AOR-W	AOW2	XXW
Perth, Australia	Inmarsat I-3 IOR	IOR2	XXI
	Inmarsat I-3 POR	POR1	XXP
Fucino, Italy	Inmarsat I-4 EMEA	EUA1	XXF
	Inmarsat I-4 EMEA SBB	EME9	XXB
Paumalu, Hawaii, US	Inmarsat I-4 Americas	AME1	XXH
	Inmarsat I-4 Asia-Pac	APK1	XXA
	Inmarsat I-4 Americas SBB	AMR9	XXU
	Inmarsat I-4 Asia-Pacific SBB	PAC9	XXS
Kobe and Hitachiota, Japan	MTSAT Japan	MTS1	--
Phoenix, Arizona, US	Iridium Global	IGW1	IG1

Tabular Analysis

- It is sometimes helpful to view and report the results in tabular format
  - For reporting performance at a high level
    - Aggregate analysis and analysis by media type
  - When there is an impractical amount of series associated with a particular subset to be clearly displayed on a chart
    - Analysis by operator

Example - Performance by Media Type

53,570 flights

July – December 2014 | New York

Media Type	ADS-C			CPDLC					
	Count of ADS-C Downlink Messages	ADS-C 95%	ADS-C 99.9%	Count of CPDLC Transactions	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
Performance Criteria		RSP 180			RCP 240				
Aggregate	1,286,267	98.2%	99.3%	45,754	99.7%	99.8%	99.0%	99.3%	96.5%
SAT	1,019,933	98.1%	99.3%	41,822	99.7%	99.8%	99.1%	99.3%	96.5%
VHF	261,232	98.8%	99.5%	3,529	99.9%	99.9%	99.2%	99.4%	96.9%
HF	5,096	73.4%	86.1%	5	--	--	--	--	--

Example - Observed Performance by Operator

New York FIR

July – December 2014

Oper	ADS-C				CPDLC						
Code	Count of ADS-C	% of Total ADS-C	ADS-C 95%	ADS-C 99.9%	Count of CPDLC	% of Total CPDLC	ACTP 95%	ACTP 99.9%	ACP 95%	ACP 99.9%	PORT 95%
R	148,467	11.5%	97.7%	99.0%	3,003	6.6%	99.6%	99.7%	99.0%	99.3%	96.9%
AA	120,612	9.4%	99.2%	99.8%	5,557	12.1%	99.9%	100.0%	99.7%	99.8%	97.8%
L	108,020	8.4%	98.4%	99.5%	3,373	7.4%	99.5%	99.7%	98.8%	99.1%	96.5%
A	74,607	5.8%	96.1%	98.4%	1,942	4.2%	98.9%	99.3%	98.3%	98.7%	96.8%
BB	63,851	5.0%	99.2%	99.5%	3,424	7.5%	99.7%	99.7%	99.3%	99.5%	97.9%
II	62,662	4.9%	99.4%	99.8%	2,188	4.8%	99.9%	100.0%	99.3%	99.4%	97.1%
FF	60,264	4.7%	97.9%	99.4%	3,317	7.2%	99.6%	99.6%	99.1%	99.4%	97.4%
GG	48,648	3.8%	99.6%	99.8%	1,454	3.2%	99.9%	99.9%	99.2%	99.5%	96.9%
DD	42,901	3.3%	96.4%	99.0%	2,376	5.2%	99.7%	99.9%	98.7%	99.1%	94.7%
HH	38,428	3.0%	99.2%	99.5%	1,168	2.6%	99.8%	99.9%	99.6%	99.7%	96.0%
EE	36,659	2.9%	99.2%	99.6%	2,274	5.0%	99.9%	99.9%	99.3%	99.5%	96.1%
BH	35,812	2.8%	95.6%	98.4%	1,091	2.4%	99.1%	99.5%	97.9%	99.0%	95.4%
PP	28,575	2.2%	99.3%	99.8%	785	1.7%	99.8%	100.0%	98.9%	99.4%	96.3%
JJ	27,943	2.2%	97.6%	99.4%	401	0.9%	99.8%	99.8%	98.8%	99.0%	95.5%
SS	27,712	2.2%	98.4%	99.5%	771	1.7%	99.6%	99.6%	97.9%	98.4%	92.5%
CC	26,920	2.1%	98.0%	99.0%	732	1.6%	99.7%	99.7%	99.6%	99.6%	98.0%
AQ	24,905	1.9%	98.0%	99.1%	1,066	2.3%	99.9%	99.9%	99.4%	99.5%	97.8%
MM	24,742	1.9%	99.4%	99.7%	852	1.9%	99.9%	99.9%	98.9%	99.4%	95.2%
WW	22,122	1.7%	98.3%	99.6%	495	1.1%	99.6%	99.6%	99.0%	99.0%	96.6%
KKKK	20,933	1.6%	99.7%	99.8%	1,613	3.5%	99.8%	99.9%	99.8%	99.8%	98.0%
ZZZZ	15,758	1.2%	98.8%	99.5%	424	0.9%	100.0%	100.0%	98.1%	98.1%	91.3%
ZZ	14,738	1.1%	99.3%	99.6%	639	1.4%	99.8%	99.8%	99.7%	99.7%	97.5%

Example - Summary of Performance by Operator New York FIR

- There were 96 operators with at least 100 ADS-C messages during this 6-month period
- Summary of how many operators meet criteria for each performance measure:

Criteria	ASP	ACTP	ACP	PORT
Meets 95%	88	95	92	64
Meets 99.9%	11	68	42	
Below 99.9% but above 99.0%	67	22	33	
Below 99.0%	18	5	20	

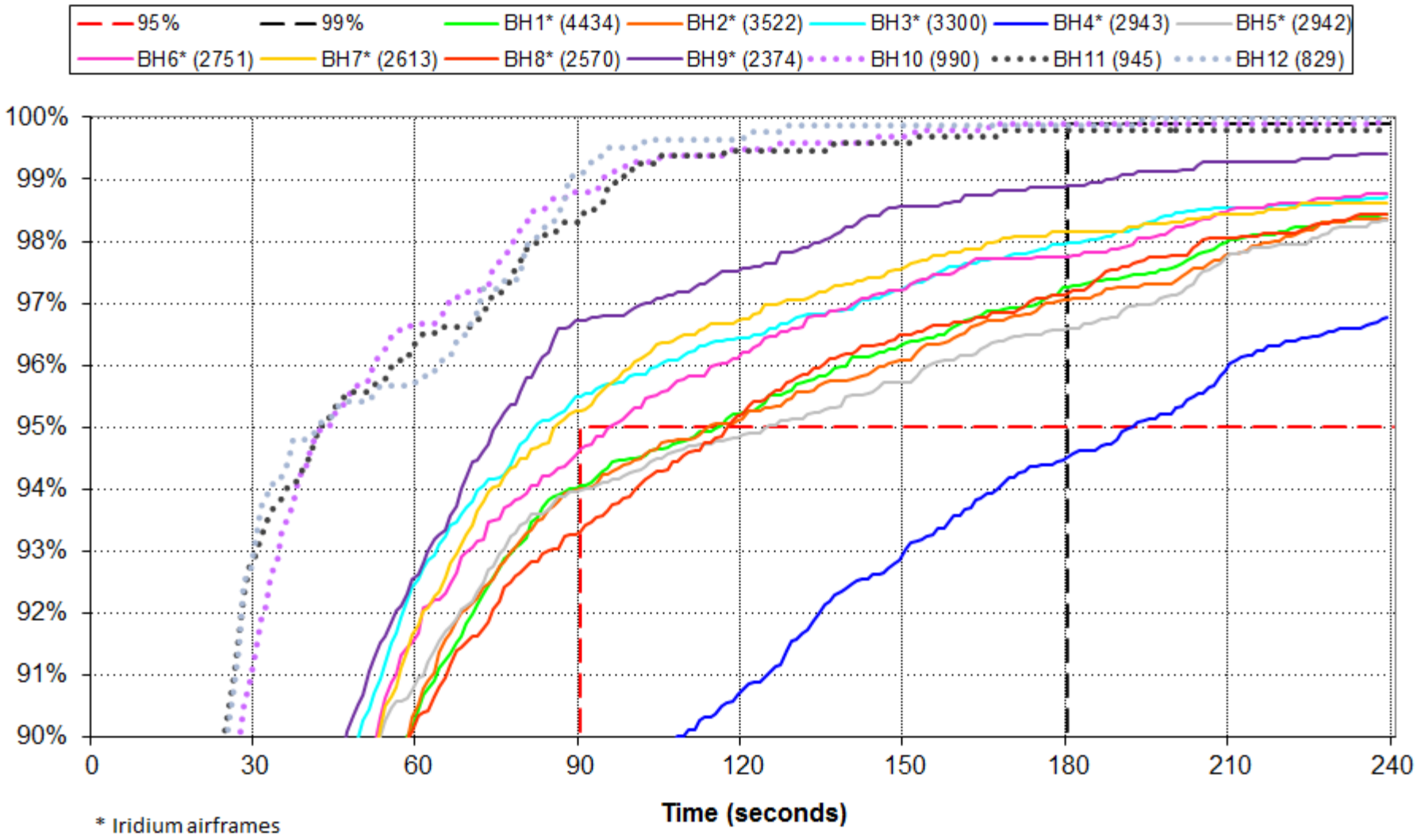
Identifying Poor Performers

- There are many potential causes of degraded performance
- Experience has shown that poor performance may be attributed to a specific aircraft in a fleet
  - Can be identified by graphing the monthly data for a fleet by aircraft registration
- Techniques such as graphing the positions of all delayed messages on a geographical display have identified areas for further investigation

Example – Poor Performer

- De-sensitized operator code: BH
- Fleet of 12 – B763 aircraft
  - 9 using Iridium → 3/9 meet 95% RSP180
  - 3 using I-3 → all meet 95% and 99.9% RSP180
- DSP: SITA
- Issue identified with 1 airframe (BH4) performing well below 95% and rest of fleet

New York FIR - BH B763 - Jan to Jun 2014
Actual Surveillance Performance (ASP)



Example – Graphing Positions

- Each ADS-C position annotated with station ID and associated delay, e.g. “XXU-136” = XXU station ID and 136 sec delay
- Clear pattern of higher delays at transition area between VHF and SAT

Example - Monitoring Availability of CPDLC and ADS-C

Jun 2014 to May 2015

PBCS criteria - max values			
Safety - 99.9%	48	520	99.90%
Reliability - 99.99%	4	52	99.99%

Station ID	# unplanned outages > 10 min	Sum of unplanned outages > 10 min (min)	Estimated availability
AME1	1	35	99.99%
AOE2	3	111	99.98%
AOW2	2	76	99.99%
APK1	1	35	99.99%
EUA1	1	35	99.99%
IOR2	3	124	99.98%
IG1	8	473	99.91%
IGW1	15	1,463	99.72%
POR1	4	465	99.91%
XXA	1	35	99.99%
XXF	7	151	99.97%
XXH	1	35	99.99%
XXI	3	340	99.94%
XXN	2	76	99.99%
XXP	3	376	99.93%
XXW	2	76	99.99%

	Meets safety and reliability criteria
	Meets safety criteria only
	Does not meet safety or reliability criteria

Monitoring Reports for Regional and Global Use

- Each ANSP within a region should compile monitoring reports at the interval agreed by the regional forum
- A tabular format can be used to report on the observed system performance in terms of the availability and time/continuity parameters specified in the applicable RCP and RSP specifications
- Appendix D of PBCS Manual contains sample reports for:
  - Service availability
  - RCP and RSP
  - Operator with different aircraft types/systems in its fleet

REGIONAL PERFORMANCE MONITORING AND ANALYSIS

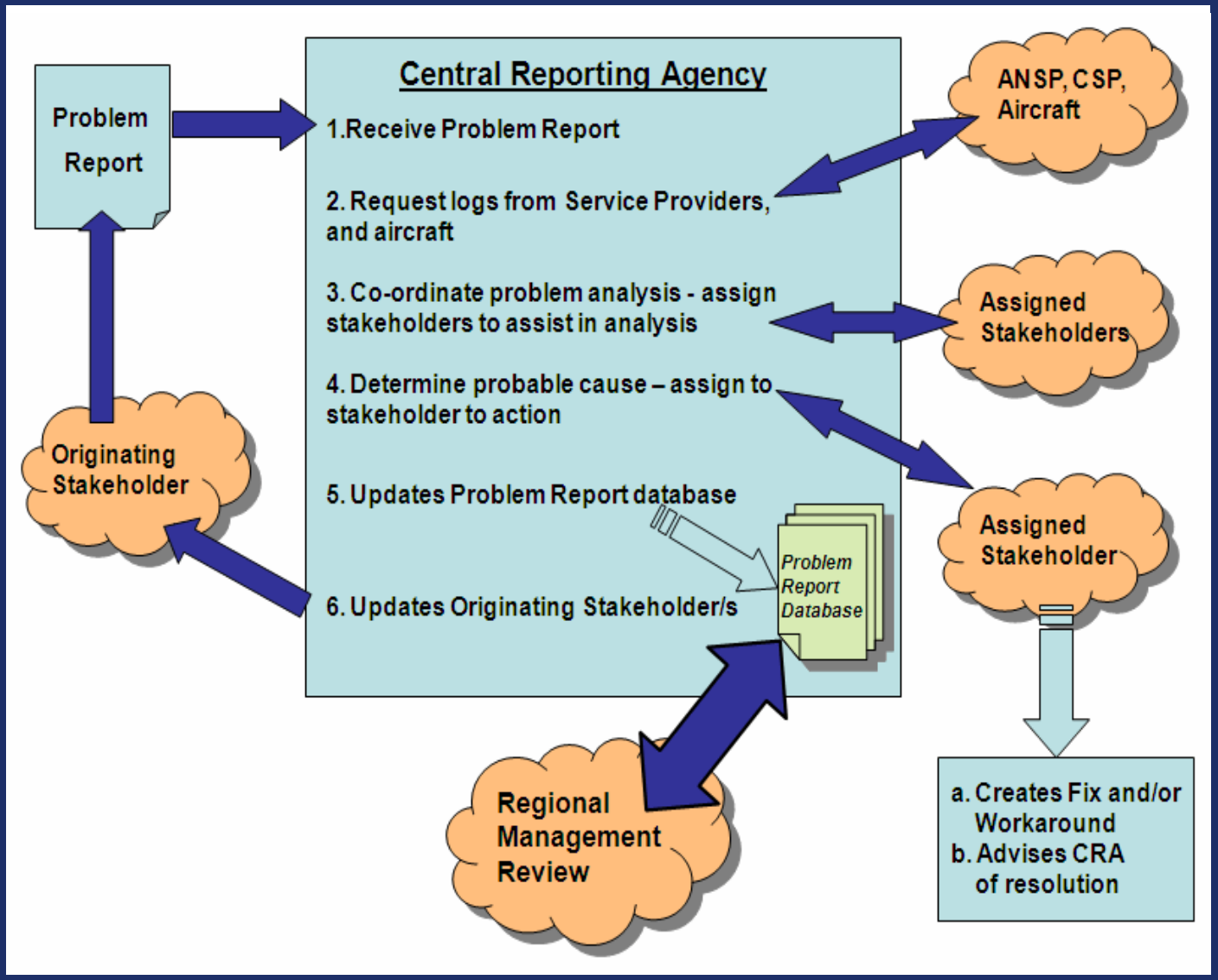
Overview

- Consistent data provided by each of the ANSPs within a region can be aggregated to create a regional PBCS monitoring report in graphical or tabular form
- Options for data sharing from individual ANSPs
  - Raw .csv files with data in formats described in Appendices D and E of the PBCS Manual
  - Data containing the cumulative distributions calculated by the ANSP
    - The regional PBCS monitoring program would specify the time period of interest, the subset(s) of interest, the required filtering and the required format to ensure consistency between the data sets)
- These regional performance metrics should be made available to all interested stakeholders
  - Regional website should be considered to enhance the distribution of metrics
- It is recommended that regions implement monthly performance reporting to obtain system performance metrics

REGIONAL PROBLEM REPORTING AND RESOLUTION

Overview

- All stakeholders should be actively involved in the problem reporting and resolution process
  - All aircraft operators in a region must have the opportunity to become involved in the process
  - CRAs should be pro-active in getting all aircraft operators and other stakeholders to register and participate in the process
- The problem identification and resolution process for each individual problem consists of:
  - Data collection phase
  - Problem analysis and coordination with affected parties to secure a resolution
  - Recommendation of interim procedures to mitigate the problem (as necessary)


Problem Report
Central Reporting Agency
1.Receive Problem Report
2. Request logs from Service Providers, and aircraft
3. Co-ordinate problem analysis - assign stakeholders to assist in analysis
4. Determine probable cause – assign to stakeholder to action
5. Updates Problem Report database
6. Updates Originating Stakeholder/s
Problem Report Database
ANSP, CSP, Aircraft
Assigned Stakeholders
Assigned Stakeholder
Originating Stakeholder
Regional Management Review
a. Creates Fix and/or Workaround
b. Advises CRA of resolution

ISPACG-CRA / NAT DLMA

- PRs filed via ISPACG-CRA, NAT DLMA Problem Reporting website: http://www.ispacg-cra.com/
  - Website hosted by Airways Corporation of New Zealand Limited
- Now used for:
  - CRA for South Pacific (ISPACG FIT)
  - CRA for North, Central, East Pacific (IPACG FIT)
  - DLMA for North Atlantic (NAT CNSG)
  - FIT-Asia for South China Sea, Bay of Bengal, Indian Ocean
- Continue to get new entities registered with website

PR Status Definitions

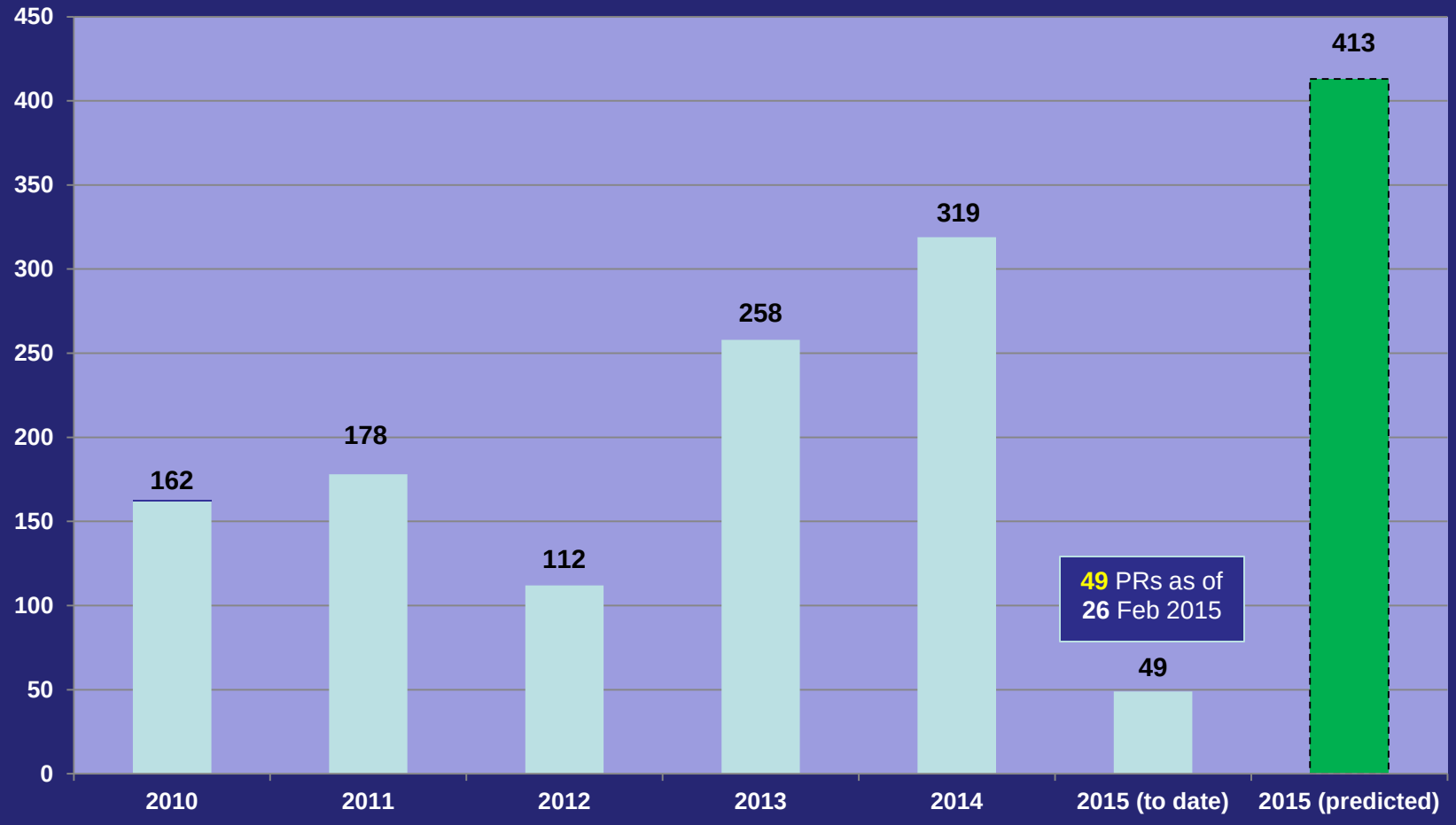
- **RAISED** - the PR has been filed by the originator but has not yet been processed by the CRA
- **ACTIVE** - CRA has processed the PR and allocated a CRA # and someone to investigate it. During this phase the PR is under investigation
- **OPEN** - The investigation is complete however some form of correction is required before it can be closed
- **CLOSED AS DUPLICATE** - Closed because problem is already covered under another PR
- **CLOSED** - Corrective action has been implemented or PR is a non-problem

PR Type Definitions

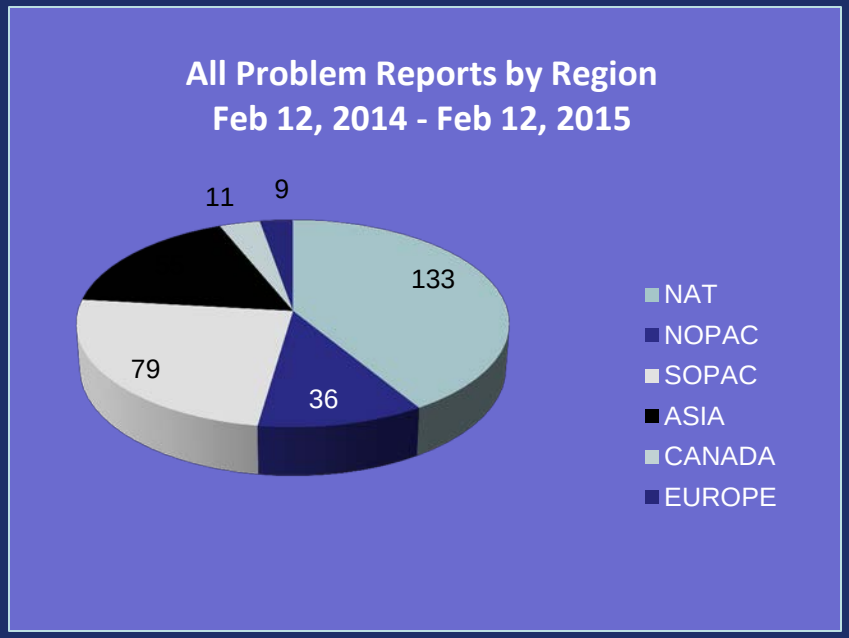
- Website choices: **AIR, GROUND, NETWORK, TBA**

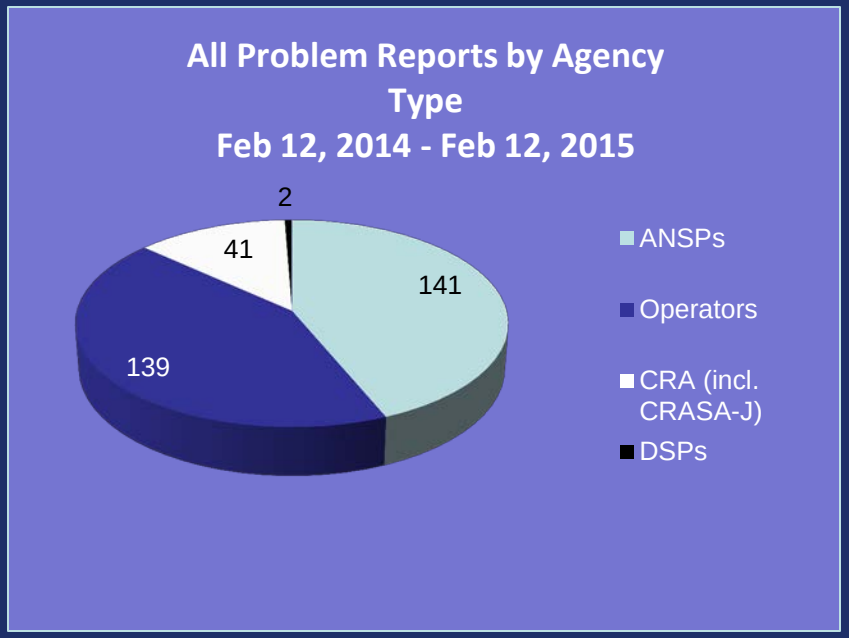
- CRA tracking breaks out as:
  - **AIR – procedural** – Problem due to flight crew action
  - **AIR – technical** – Problem due to avionics fault
  - **GROUND** – Problem due to issue at ATSU
  - **NETWORK** – Problem at GES or in network
  - **Mult** - Problems occurred in more than one area
  - **None** - Problem was a non-problem
  - **TBA** – To Be Assigned – problem type not yet determined

Problem Report Metrics
Growth in Number of PRs per Year



Problem Report Metrics



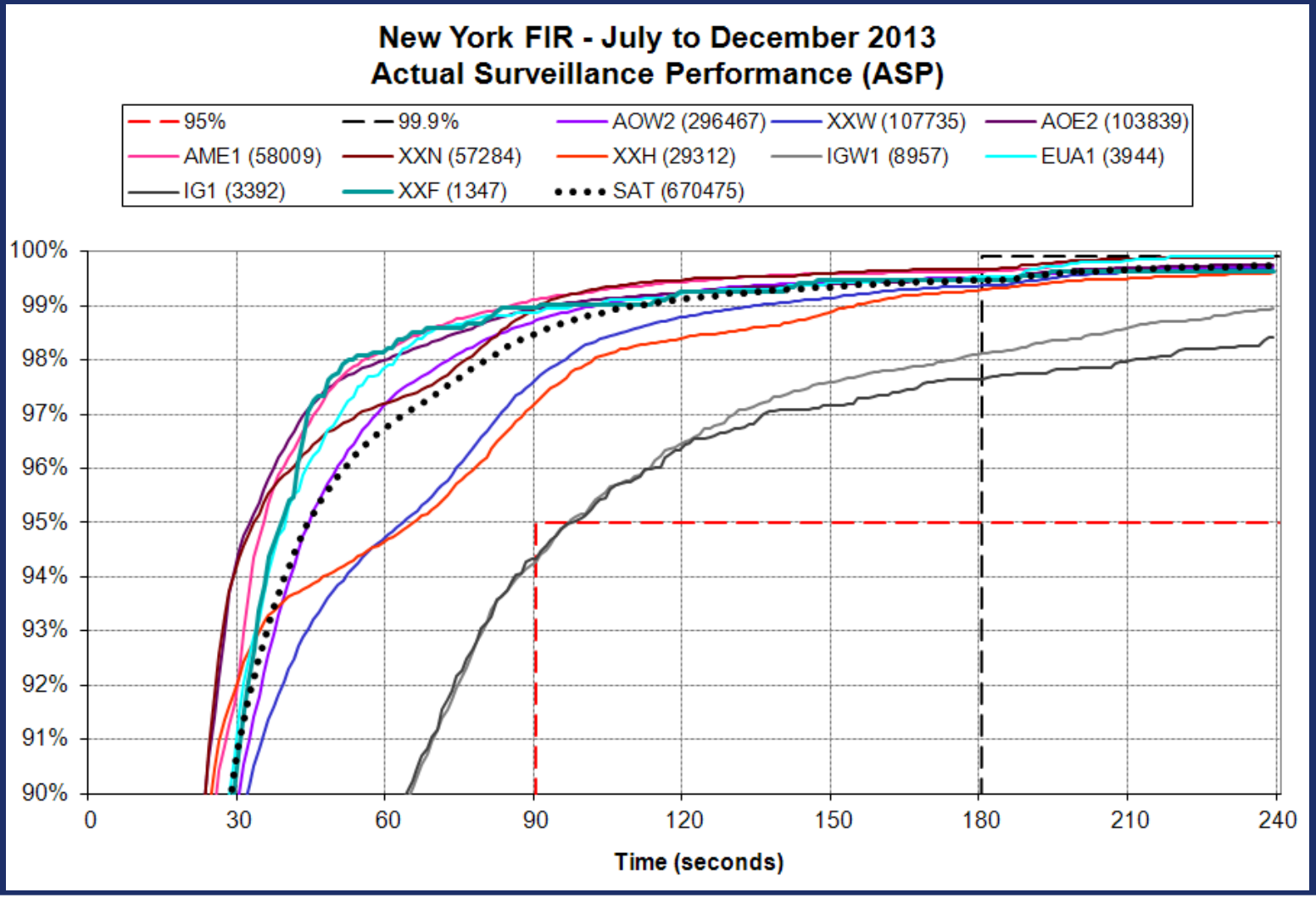


Example: PR 1508-MM

- PBCS analysis, ASP by station ID, in New York FIR highlighted several paths with notably lower performance, including XXH, data link service provided by ARINC using the Inmarsat I-4 Americas satellite via the ground station in Paumalu, Hawaii, US
- Upon further investigation, notable variation between operator/aircraft type combinations, with the top user of XXH barely meeting the 95% criteria for RSP180
- PR submitted 5 Feb 2014
- The issue has been worked between the operator, Honeywell, and Boeing since then
- Initial solution was to change ORT settings – however this did not resolve the issue
- Honeywell has indicated that a specific incompatibility between certain Honeywell SATCOM avionics and the Inmarsat Classic Aero network is the likely cause of this problem and are continuing to work on a solution

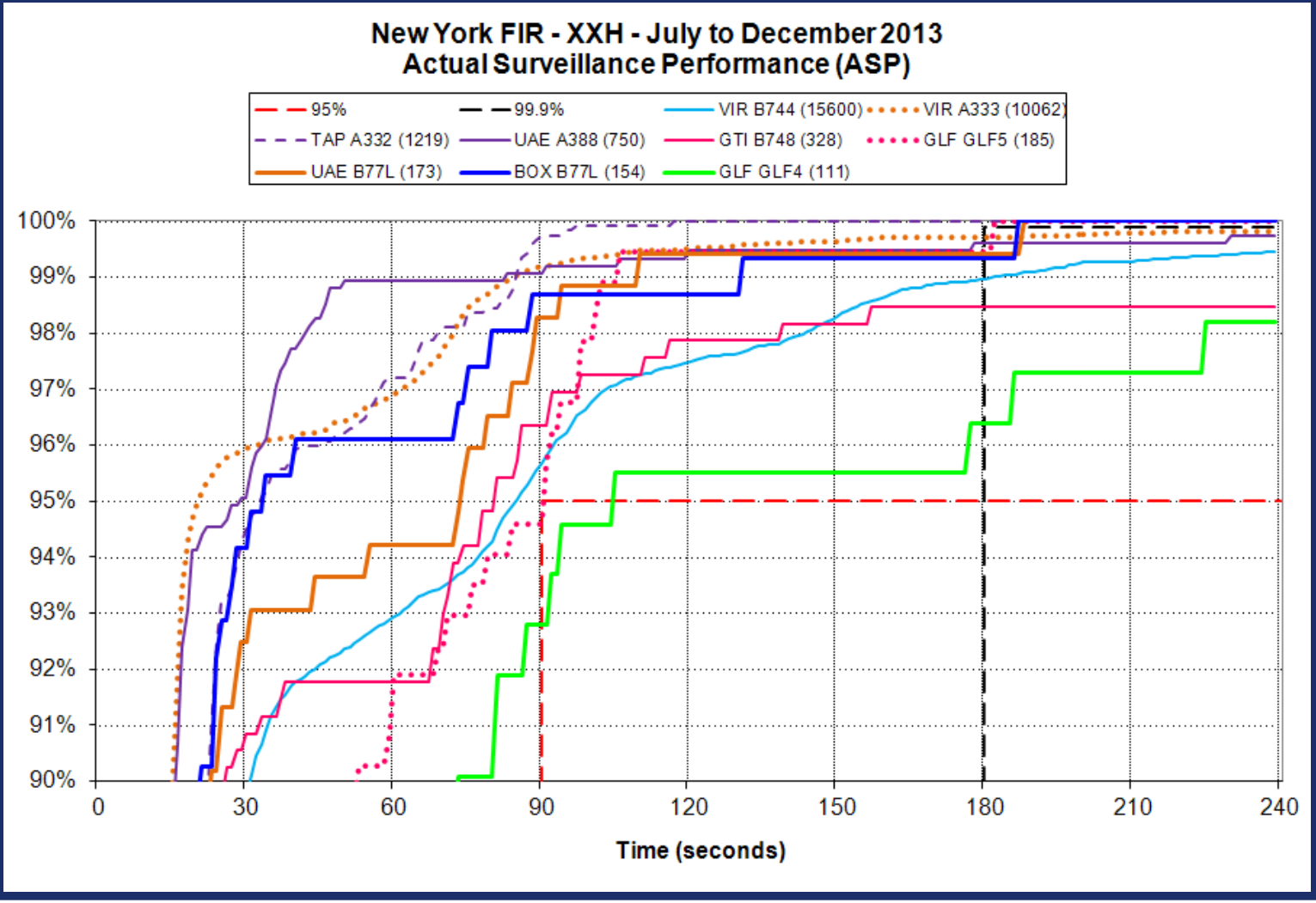
Example: PR 1508-MM

ASP by Station ID for New York FIR



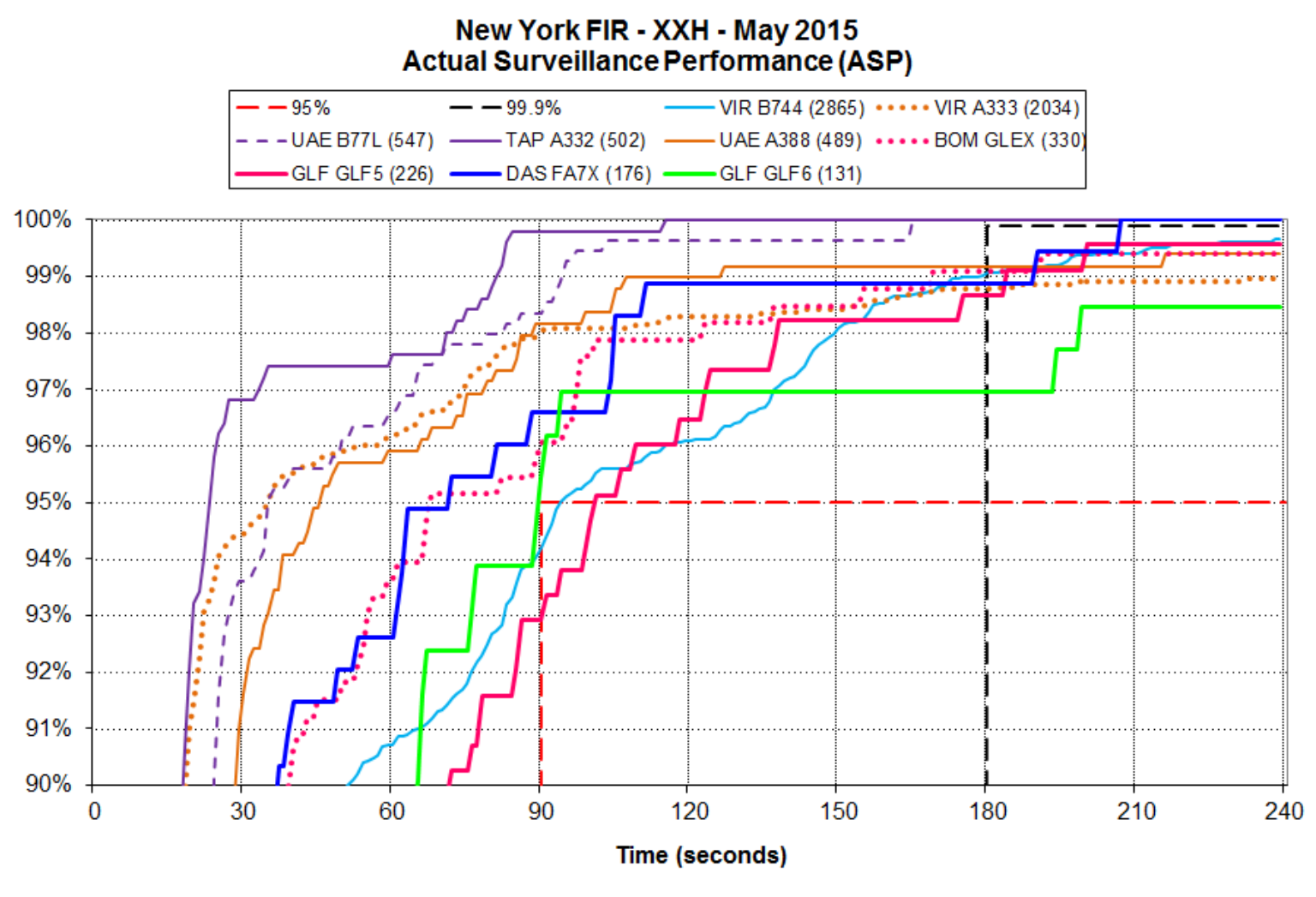
Example: PR 1508-MM

ASP by Operator/Aircraft Type for New York FIR – Jul to Dec 2013



Example: PR 1508-MM

ASP by Operator/Aircraft Type for New York FIR – May 2015



Benefits of PBCS

- Ensures actual system performance is maintained in accordance with RCP-RSP specifications
  - Actual communication performance is measured against appropriate RCP specifications
  - Actual surveillance performance is measured against RSP appropriate specifications
- Provides effective way to improve system performance
  - Analysis tools can be and are shared (e.g. G-PAT)
  - Local results can be exchanged regionally and globally