NANU Analysis from 2007 through 2015

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BIOGRAPHY

John W. Lavrakas is President of Advanced Research Corporation, where he provides consulting and research & development services on satellite navigation. He currently serves as a subject matter expert on GNSS for the U.S. Department of Transportation Volpe Center and Office of Assistant Secretary of Transportation for Research and Technology. He is active in the field of civil signal monitoring, coauthoring the "GPS Civil Monitoring Performance Specification", and serving on the U.S. delegation to the International Committee on GNSS. Prior work included technical support to various GPS initiatives, including Integrity Failure Modes and Effects Analysis, Civil Performance Monitoring, and the GPS Operations Center, plus membership on the National PNT Architecture study team. Mr. Lavrakas has spent over 35 years in GPS, supporting the development of the GPS Control Segment, GPS user equipment for military range applications, development of GPS performance analysis capabilities, and developing and marketing GPS-based commercial asset location systems. He is a graduate of Harvey Mudd College and the Claremont Graduate University with BS and MA degrees in mathematics.

ABSTRACT

This paper documents the behaviors of NANUs over a nine year time period, from 2007 through 2015 and the findings from this work, identifying issues in the way NANUs are implemented and highlighting progress made in minimizing errors.

The GPS program uses Notice: Advisory to Navstar User (NANU) as one means to notify GPS users of current, impending, and past outages in GPS service. It has provided NANUs for two and a half decades, and these are codified in memorandums of understanding between the US Department of Defense and Department of Transportation as a means to report to GPS users status information regarding satellites and overall GPS system operation. The most frequent use of NANUs is to report when satellites are removed from service, but NANUs are also used to report system tests, pending leap second adjustments, and PRN assignments. Today a robust standard for issuing NANUs is available in the form of ICD-GPS-240, which documents the format and protocols for issuing NANUs. By and large, NANUs are generated by the U.S. Air Force 2nd Space Operations Squadron (2 SOPS) any time day and night with dependability and accuracy. The statistics bear this out.

Although much automation has been inserted into the process over the years to reduce the likelihood of errors, the process of generating NANUs is largely operator-driven and mistakes are occasionally made. Civil users and their missions depend on NANUs and their quality. In 2009 John Wilde from DW International gave a presentation on "the Impact of NANUs on RAIM Prediction" at CGSIC [Ref 3], in which he identified problems with NANUs, the impact on their Receiver Autonomous Integrity Monitoring (RAIM) Prediction services, and recommended actions to take.

Over the past six years, about three percent of NANUs were issued in error. The types of errors made ranges widely from issuing the wrong NANU types and times to issuing NANUs when not expected.

INTRODUCTION

This report documents the behaviors of NANUs over a nine year time period, from 2007 through 2015 and the findings from this work, identifying issues in the way NANUs are implemented and highlighting progress made in minimizing errors.

The GPS program uses the Notice: Advisory to Navstar User (NANU) as a means to notify GPS users of current, impending, and past outages in GPS service. The United States Air Force has provided NANUs for two and a half decades, and these are codified in memorandums of understanding between the US Department of Defense and Department of Transportation as a means to report to GPS users status information regarding satellites and overall GPS system operation. The most frequent use of NANUs is to report when satellites are removed from service (about 86% of the time), but NANUs are also used to report other events, such as system tests, pending leap second adjustments, and PRN assignments. Today a robust standard for issuing NANUs is available in the form of ICD-GPS-240 [Ref 1], which documents the format and protocols for issuing NANUs. This can be obtained from the website gps.gov. There is also a description of NANUs provided on the U.S. Coast Guard Navigation Center website at navcen.uscg.gov. By and large, NANUs are generated by 2 SOPS any time day and night with dependability and accuracy. The statistics bear this out.

NANUs are used by military, civilian and commercial users for mission planning and post-mission assessment. For example, following 9/11, U.S. and coalition forces employed GPS-guided munitions for operations in Afghanistan, and the GPS Operations Center at Schriever Air Force Base used NANUs to support its dilution of precision (DOP) predictions sent to warfighters in the field. Aviation authorities and service providers use NANUs to support route planning to predict RAIM service availability. Likewise NANUs are used to do post-mission assessments such as battle damage reports using GPS-guided munitions and accident investigations when aircraft are using GPS for flight guidance. In many of these cases, agencies and companies have developed software tools to read in the data from NANUs to facilitate the assessments.

NANUs are both structured and unstructured. An example of a structured NANU is as follows:

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2016058
SUBJ: SVN51 (PRN20) FORECAST OUTAGE JDAY 252/2030 - JDAY 253/0830
1. NANU TYPE: FCSTDV
NANU NUMBER: 2016058
NANU DTG: 312053Z AUG 2016
REFERENCE NANU: N/A
REF NANU DTG: N/A
SVN: 51
PRN: 20
START JDAY: 252
START TIME ZULU: 2030
START CALENDAR DATE: 08 SEP 2016
STOP JDAY: 253
STOP TIME ZULU: 0830
STOP CALENDAR DATE: 09 SEP 2016

Structured NANUs have a common header and three separate sections. Section 1 contains all the pertinent information relating to the event, such as NANU type, NANU number, date/time group, reference NANU, space vehicle number, pseudorandom noise number, start day and time and stop day and time. Because of this dependable structure, many users have written programs to read NANU details for use in mission planning and assessment.

An example of an unstructured NANU is as follows:

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2014038 NANU TYPE: GENERAL
*** GENERAL MESSAGE TO ALL GPS USERS *** The purpose of this notification is to inform users of an upcoming event related to the GPS satellite constellation. Air Force Space Command will be implementing CNAV messages on the GPS L2C and L5 signals beginning J118/1430z with updates from the control segment approximately twice per week. The message populated signal content will include Broadcast Message Types (MT) 10, 11, 12, 30, and 33. There are no planned GPS satellite outages or degradations for this activity. L2C and L5 CNAV messages should be transparent to GPS receivers that do not process L2C or L5 CNAV messages. These populated signals are intended to facilitate user familiarization and development of compatible user equipment.

In this case, the NANU is written in free text. There is no time associated with it. The only information provided is the NANU number and NANU type. Because it is free flowing text without structure, it is not readable by programs for processing.

Although much automation has been inserted into the process over the years to reduce the likelihood of errors, the process of generating NANUs is largely operator-driven and mistakes are occasionally made. Civil users and their missions depend on NANUs and their accuracy and timeliness. In 2009 John Wilde from DW International made a presentation on "the Impact of NANUs on RAIM Prediction" at the Civil GPS Service Interface Committee (CGSIC) meeting [Ref 3], in which he identified problems with NANUs, the impact on their RAIM Prediction services, and recommended actions to take. Engineers at the U.S. Department of Transportation Volpe Center has taken steps to automate the incorporation of GPS satellite outage information into the predictive capabilities they provide. They sought to develop in house a capability to parse out the salient fields (typically around 25 bytes from the ~2K NANU) but encountered one thing after another that stopped their efforts in their tracks.

Over the time surveyed in this study, however, the satellite operators have done much to improve the production of NANUs. In 2007 through 2009 there were about 10 anomalous NANUs per year. Now the number is about 2 per year, or about 3% annually.

SUMMARY OF STUDY

A percentage breakdown of each of the NANU types for the period of assessment is as follows:

- 73% Forecast signal outages (satellite maintenance and delta-v)
- 13% Unscheduled signal outages
- 10% General
- 4% Other (leap second, set usable, decom, etc)

The quantity and quality of NANUs have changed over the period of the study. Here are some of the trends in NANUs over the period of the study:

Number of NANUs. The number of NANUs issued each year has decreased over the years. In 2007 through 2010, there were an average of 150 per year. By 2013 through 2015, the average was down to 92 per year.

- This reduction is largely due to a decrease in FCSTMX scheduled outages and a decreased use of GENERAL NANUs.
- The number of unscheduled outages has largely stayed the same at 5 to 6 per year. Note, however, that since the total number of NANUs has decreased, correspondingly the percentage rate of unscheduled outages has increased.

Use of GENERAL NANUs. GENERAL NANUs occur much less frequently now than they used to several years ago. In 2007 through 2009, there were an average of 15 each year. Between 2013 and 2015, the average was down to 7 per year. There are several reasons for this:

- Decommissioning of satellites were reported using General NANUs. Now they are reported using the DECOM NANU.
- FCSTUUFN was implemented in 2010 to replace use of GENERAL NANUs in report indefinite removal of a satellite from service.

From 2013 to 2015 more than half of the General NANUs issued were to report setting a reserve SV usable. This then appears to be the primary use of General NANUs today.

Anomalous NANUs. In general NANUs are issued without error. Success rates run about 97%. The number of erroneous NANUs has decreased somewhat, although since the total number of NANUs has decreased, the percentage of erroneous NANUs has remained largely unchanged. Between 2007 and 2009, there were an average of twelve erroneous NANUS per year. Between 2013 and 2015, the average was three.

In general, the errors found in NANUs have been decreasing year by year, demonstrating a pattern of continuous improvement. That said, there seems to be a floor of several anomalous NANUs each year indicating we have not reached a fault free operation.

DETAILED ANALYSIS

There are four major types of NANUs: Forecast NANUs predicting future outages, unscheduled NANUs used to report unplanned on outages, special purpose NANUs such as for reporting pending leap second or satellite launches, and GENERAL NANUs used to provide descriptive information.

Each of these types and their observed behaviors are described below.

Forecast (FCST) events

There are seven types of Forecast or scheduled NANUs:

FCSTDV, or Forecast Delta-V - gives scheduled outage times for Delta-V maneuvers. The satellite is moved during this maintenance and the user may be required to download a new almanac.

FCSTMX, or Forecast Maintenance - gives scheduled outage times for satellite maintenance such as Ion Pump Operations or software tests.

FCSTEXTD, or Forecast Extension – extends the scheduled outage time "Until Further Notice"; references the original NANU.

FCSTSUMM, or Forecast Summary - gives the exact outage times for the scheduled outage, including the FCSTEXTD; sent after the maintenance is complete and the satellite is set healthy to users; references the original NANU.

FCSTCANC, or Forecast Cancellation – cancels a scheduled outage; new maintenance time not yet determined; references the original NANU.

FCSTRESCD, or Forecast Rescheduled – reschedules a scheduled outage; references the original NANU.

FCSTUUFN, or Forecast Unusable Until Further Notice - Scheduled outage of indefinite duration not necessarily related to Delta-V or maintenance activities used to remove a satellite from service.

Statistics for the nine year period of the study for forecast NANUs are shown in Table 1. Over the referenced period, the number of scheduled NANUs decreased significantly from an average of 45 between 2007 and 2009 to an average of 29 between 2013 and 2015 (35% decrease). Scheduled durations are typically allocated for 12 hours, several as low as 6 hours and some as high as 24 hours.

Today FCSTDVs occur more frequently than FCTSMX events. The median number of Delta-V operations is 24 per year. The number of general maintenance activities has declined from around 25 per year to 8 per year.

Typically, there is a FCSTSUMM to close out every FCSTDV and FCSTMX that is performed. The number of FCSTSUMM do not always equal the sum of FCSTMX and FCSTDV, however, since some of the forecasted outages are canceled.

Summary of FCST outage durations

Forecast MX times range from 7 to 18 hours with typical outages projected at 12 hours.

Forecast DV times range from 12 to 24 hours with typical outages projected at 12 hours.

Over the nine years studied, there were 216 DV events and actual DV times ranged from 5 to 12 hours with typical outages taking about 6 hours. There were two DV periods in which the duration went an extremely long time. Once in 2010 (470 hours) and once in 2011 (215 hours), but these long periods are unusual and have not recurred in the past four years.

Also, over the nine years studied, there were 157 MX events and actual MX times ranged from 1 to 11 hours

with typical outages taking about 5 hours. There were two MX periods in which the duration went an extremely long time. Once in 2011 (147 hours) and once in 2012 (138 hours) but these long periods are unusual and have not recurred in the past three years.

Analysis of MX vs DV times
While the outages were similar for both MX and DV, the DV times were a bit more uniform than the MX times, presumably because a delta-v maneuver is generally predictable, while a general maintenance could depend greatly on the service being provided. This is borne out in the numbers. The median actual MX outage was 4.7 hours with a standard deviation of 3.6 hours and median actual DV outage was 6.2 hours with a standard deviation of 2.2 hours.

The median unused time for Forecast MX was 8.3 hours and for Forecast DV was 6.5 hours. No instances of the actual time taking longer than the forecast and/or extended outage time were recorded since 2007.

Forecast NANUs always request more time than is needed for the outage, typically on average 6.2 hours more for FCSTDV and 6.8 hours more for FCSTMX. In the past nine years, the actual duration has never exceeded the forecast duration.

Cancellations
There are an average of 2 cancellations per year. Nearly all of the notices are provided well in advance of the outage (10 hours or more).

Analysis of FCSTUUFN
In the January 2010 version of ICD-GPS-240 [Ref 1], the FCSTUUFN was implemented to allow operators to schedule taking a satellite out of service indefinitely. Since then, this NANU type has been used nine times.

Analysis of FCSTRESCD
Rescheduling of NANUs is quite infrequent, about once or twice a year and only once in the past three years. Advance notice to users falls in the range of one to two weeks in advance, and was never less than 140 hours in advance.

Analysis of FCSTEXTD
FCSTEXTD NANUs are used seldom if ever. They have not been used in the past four years.

Assessment of FCSTMX and FCSTDV against the 96-hour notification objective and 48-hour notification threshold

Issuance of NANUs failed to meet the 48 hour requirement 0.5% over the 9 year period, although in the past three years this was 2.2%. When this condition is not met, this is deemed a loss of continuity of service, as described in the GPS Standard Positioning Service Performance Standard, Section 3.6 [Ref 5].

For the past three years, following are the NANUs that exceeded the 96-hour objective (per ICD-GPS-240 Table 10-IV) [Ref 1] and 48 hour continuity threshold (per GPS Standard Positioning Service Performance Standard section 3.6). [Ref 5]

#2015020 = 72.83 hours
#2014043 = 16.53 hours (Violates 48 hour continuity rule)
#2013039 =71.57 hours
#2013012 =18.15 (Violates 48 hour continuity rule)

Unscheduled Outages
NANU types in the unscheduled outage group describe unplanned outages that are ongoing or have occurred in the recent past. There are three identified types in this group:

UNUSUFN – Unusable until further notice – notifies user that a satellite will be unusable to all users until further notice.

UNUSABLE – Unusable with reference NANU – closes out an UNUSUFN NANU and gives the exact outage start and stop times; references the UNUSUFN NANU.

UNUNOREF – Unusable with no reference NANU – gives start and stop times for an outage that was resolved before an UNUSUFN NANU could be sent.

Statistics for the nine year period of the study for unscheduled NANUs are shown in Table 2.

Analysis of UNUSUFN's
Over the period of analysis, the typical number of UNUSUFN's per year is 7, or about once every two months.

The Standard Positioning Service Performance Standard [Ref 5] states that "unscheduled interruptions resulting from system malfunctions or maintenance occurring outside the scheduled period will be announced to the Coast Guard and the FAA as soon as possible." The study shows that the median time to notify is 12 minutes, and the time to notify ranges from immediate to over an hour after the start time of the NANU. Note: "time to notify" is the latency from start time of outage to the time the NANU is issued.

Generally "unusable until further notice" or UNUSUFN outages are reported after an outage has begun, but several have been issued in advance of the start of the unscheduled outage. About 13% of these NANUs (9 out of 71) were reported more than 5 minutes in advance of the

start time of the outage over the 9 year period. This occurred for 17% of these NANUs (3 out of 18) over the past three years. This is not a diminishing trend, but continues through this year.

Following are examples of UNUSUFN NANU's reported in advance of the stop time of the outage.
#2015036 = 5 min before
#2014025 = 15 min before
#2013036 = 16 min before
#2012083 = 39 min before

Analysis of UNUSABLEs
There are typically about 5 UNUSABLE NANUs per year. The median time to notify is 5 minutes, and the time to notify ranges from immediate to about ten minutes after the end of the NANU outage.

About 13% of these NANUs (8 out of 63) over the 9 year period were reported more than 5 minutes in advance of the outage being completed. This was 25% of these NANUs (4 out of 16) over the past three years. For example, NANU 2014026 was issued, reporting its outage 37 minutes prior to the stop time of the outage. ICD-GPS-240 [Ref 1] states that UNUSABLE "closes out an UNUSUFN NANU and gives the exact outage times", so the expectation is that a NANU will be issued after the outage has ended.

Following are example UNUSABLE NANUs that were issued prior to the stop time of the outage:
#2015086 = 19 min
#2014059 = 17 min
#2014026 = 37 min
#2013069 = 6 min

Analysis of UNUNOREF
This NANU type is seldom used. In fact only five have been issued over the past nine years. Following is a list of all the UNOREFs used since 2007 and how long after the stop time they were issued.
#2015057 – 13 mins
#2015042 – 9 hours
#2012039 – 22 hours
#2010100 – 15 mins
#2010116 – one hour

General NANUs
There are currently about 8 General NANUs issued per year, which is down from about 17 per year between 2007 and 2011. The reduction was the result of more message types created in the 2010 edition of ICD-GPS-240 [Ref 1], including FCSTUUFN, LAUNCH, and DECOM. The most frequent use of General NANUs is to report an inactive satellite has resumed transmission. General NANUs are also used to report system testing and to report errors in other NANUs.

Statistics for the nine year period of the study for GENERAL NANUs are shown in Table 3.

GENERAL NANUs are used to report resumption of transmission of satellites that had been removed from service. Prior to the January 2010 edition of ICD-GPS-240 [Ref 1], GENERAL NANUs were used to report satellite decommissioning, and after that, GENERAL NANUs have only infrequently (and erroneously) been used to report decommissioning of satellites.

Other NANU Types
There are specific NANU types that report the launch, setting usable, and decommissioning of satellites, and notify impending leap seconds.

LAUNCH – Launch – notifies users after the launch of a satellite

USABINIT – Initially usable – notifies users that an SV is set healthy for the first time

DECOM – Decommission – notifies users that an SV has been removed from the current constellation identified within the broadcast almanac, but does not necessarily signify permanent disposal. DECOM first appeared in the January 2010 edition of ICD-GPS-240 [Ref 1].

LEAPSEC – Leap second - used to notify users of an impending leap second.

Table 4 lists the counts for each of the NANU types indicating satellite launch, set initially usable, decommissioning, and resumption of transmission.

Analysis of NANU Anomalies

From time to time, NANUs are issued with errors in them or not as expected. This does not happen often, but there are usual several per year. Following is a list of some of the more common types of anomalous NANUs that have been observed.

- Incorrect type
- Invalid time value -
- Incorrect reference NANU
- Duplicate NANU
- NANU issued unusually late
- False NANUs
- NANU number skipped

Statistics for the nine year period of the study for anomalous NANUs are shown in Table 5.

Examples of NANUs deemed invalid, based on expectations set by ICD-GPS-240 [Ref 1] are provided below. These examples do not comprise a complete list, but are

representative of the types of anomalous NANUs that occasionally occur.

NANU 2015021 – A General NANU was used to de-commission a satellite when a DECOM NANU should have been used.

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2015021 NANU TYPE: GENERAL
*** GENERAL MESSAGE TO ALL GPS USERS ***
SUBJ: SVN38 (PRN08) DECOMMISSIONING JDAY 085/2200
1. NANU TYPE: GENERAL
NANU NUMBER: 2015021
NANU DTG: 262242Z MAR 2015
REFERENCE NANU: 2015003
REF NANU DTG: 021712Z JAN 2015
SVN: 38
PRN: 08
UNUSABLE START JDAY: 303
UNUSABLE START TIME ZULU: 1500
UNUSABLE START CALENDAR DATE: 30 OCT 2014
DECOMMISSIONING JDAY: 085
DECOMMISSIONING TIME ZULU: 2200
DECOMMISSIONING CALENDAR DATE: 26 MAR 2015

NANU 2015022 – An invalid UNUSABLE NANU was issued. NANU 2015020 had already notified users of the pending outage, and NANU 2015023 closed it out with reference to 2015020. NANU 2015022 was unnecessary and should not have been issued. Furthermore UNUSABLE NANUs are reserved for cases in which a UNUSUFN has been previously issued, which was not the case in this instance.

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2015020
SUBJ: SVN23 (PRN32) FORECAST OUTAGE JDAY 088/2200 - JDAY 101/0000
1. NANU TYPE: FCSTMX
NANU NUMBER: 2015020
NANU DTG: 262110Z MAR 2015
REFERENCE NANU: N/A
REF NANU DTG: N/A
SVN: 23
PRN: 32

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2015022
SUBJ: SVN23 (PRN32) UNUSABLE JDAY 089/0005 - JDAY 101/0000
1. NANU TYPE: UNUSABLE
NANU NUMBER: 2015022
NANU DTG: 300007Z MAR 2015
REFERENCE NANU: 2015020
REF NANU DTG: 262110Z MAR 2015
SVN: 23
PRN: 32

NANU 2015082 – An UNUSUFN NANU was issued without a start date/time provided.

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2015082
SUBJ: SVN41 (PRN14) UNUSABLE JDAY / - UNTIL FURTHER NOTICE
1. NANU TYPE: UNUSUFN
NANU NUMBER: 2015082
NANU DTG: 081510Z OCT 2015
REFERENCE NANU: N/A
REF NANU DTG: N/A
SVN: 41
PRN: 14
START JDAY:
START TIME ZULU:
START CALENDAR DATE:
STOP JDAY: UFN
STOP TIME ZULU: N/A
STOP CALENDAR DATE: N/A

NANU 2015087 – An UNUSUFN NANU was issued in error. The error was reported in 2015088 and a correct NANU was issued in 2015089.

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2015087
SUBJ: SVN34 (PRN04) UNUSABLE JDAY 306/2100 - UNTIL FURTHER NOTICE
1. NANU TYPE: UNUSUFN
NANU NUMBER: 2015087
NANU DTG: 281930Z OCT 2015
REFERENCE NANU: N/A
REF NANU DTG: N/A
SVN: 34
PRN: 04

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2015088 NANU TYPE: GENERAL
*** GENERAL MESSAGE TO ALL GPS USERS *** DISREGARD NANU REFERENCE #2015087.
*** GENERAL MESSAGE TO ALL GPS USERS ***

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2015089
SUBJ: SVN34 (PRN04) FORECAST OUTAGE JDAY 306/2100 - UNTIL FURTHER NOTICE
1. NANU TYPE: FCSTUUFN
NANU NUMBER: 2015089
NANU DTG: 282019Z OCT 2015
REFERENCE NANU: N/A
REF NANU DTG: N/A
SVN: 34
PRN: 04

NANU 2012039 – The UNUNOREF NANU reported SVN59/PRN19 as out for 28 minutes, but the satellite was set healthy throughout this period, per the report "An Analysis of Global Positioning System (GPS) Standard Positioning Service (SPS) Performance for 2012", Report #TR-SGL-13-03, Space and Geophysics Laboratory, Applied Research Laboratories, University of Texas. [Ref 2]

NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2012039
SUBJ: SVN59 (PRN19) UNUSABLE JDAY 169/0009 - JDAY 169/0037
1. NANU TYPE: UNUNOREF
NANU NUMBER: 2012039
NANU DTG: 182251Z JUN 2012
REFERENCE NANU: N/A
REF NANU DTG: N/A
SVN: 59
PRN: 19
START JDAY: 169
START TIME ZULU: 0009
START CALENDAR DATE: 17 JUN 2012
STOP JDAY: 169
STOP TIME ZULU: 0037
STOP CALENDAR DATE: 17 JUN 2012

GETTING PAST THE FAULTS

One major step taken by the USAF to streamline the transfer of NANU outage information is the implementation of the satellite outage file (SOF). This is a machine readable file that captures the salient elements of all outage NANUs generated by the 2 SOPS. In an InsideGNSS article "GPS Help Line" [Ref 4], the USAF reported, "To reduce human error, we have implemented the use of a satellite outage file (SOF), a standard XML-formatted file containing an accurate history of GPS satellite outages. When a new NANU is generated, the SOF file updates automatically and is checked for accuracy by an analyst.

GPSOC staff can then include this file type in analysis scenarios, allowing us to focus on problems, not on data collection." The process of creating the SOF involves reading the NANU into a tool that checks the NANU for errors and allows the analyst to resolve any discrepancies prior to publishing the SOF. The end result is a satellite outage file that eliminates errors that had been in the NANU.

FINAL THOUGHTS

Today's NANUs support today's signals. In the future, however, as modernized signals become operational, there may be cases in which signals on a given satellite are separately set healthy or unhealthy. For example, it is possible that an anomaly that affects the L5 signal but not the L1 or L2 signals may be necessitate setting L5 unhealthy alone. If this operational process is instituted, then the NANUs would need to be changed to accommodate this.

Implementation of the Satellite Outage File presents the possibility of a zero-defect outage reporting, that is, for near 86% of NANUs that apply to signal outages. Although the satellite outage file is not yet available to the public, this is expected to happen soon. The USAF is implementing a change in ICD-GPS-240 [Ref 1] that permits the public to have access to this file. Once this takes place, mission planners and analysts will have access to a rapid and accurate report to GPS satellite outages.

The author is extremely grateful to the men and women of the 2 SOPS and the GPS Operations Center for their service in providing dependable and accurate satellite status information, and for their willingness to continuously improve the processing of this information to meet GPS user needs. The net effect is improved safety for GPS users, and greater efficiencies for those involved in GPS planning and assessment.

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ACKNOWLEDGEMENTS

The author thanks Brent Renfro of the University of Texas Applied Research Laboratories for his longstanding support of the work in understanding GPS data behaviors. He also thanks Jon Parmet of Volpe Center and John Wilde of DW International/NAVBLUE for their insights into the operational uses of NANUs. The author deeply appreciates the service of the U.S. Coast Guard Navigation Center in responding to requests for information on NANUs, and for the help provided by Rick Hamilton.

Table 1. Counts for FCST NANU types

	Total Count	*Past 9 years*	*Past 3 years*	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**
FCSTSUMM	339	34.9%	31.4%	31	30	26	28	33	55	40	53	43
FCSTDV	216	22.3%	24.5%	22	29	17	20	23	27	27	27	24
FCSTMX	157	16.2%	9.0%	11	3	11	11	11	32	19	33	26
FCSTCANC	42	4.3%	2.2%	1	3	2	3	3	6	9	5	10
FCSTRESCD	12	1.2%	0.4%	0	1	0	1	2	2	2	2	2
FCSTEXTD	5	1%		0	0	0	0	2	2	0	0	1
FCSTUUFN	9	1%		3	5	0	1	0	0	0	0	0

Table 2. Counts for Unscheduled NANU Types

Unscheduled NANUs	*Past 9 years*	*Past 3 years*	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**
UNUSABLE	63	16	6	4	6	4	5	5	5	7	21
UNUSUFN	71	18	7	4	7	4	7	7	10	7	18
UNUNOREF	5	2	2	0	0	1	0	2	0	0	0

Table 3. Counts for General NANU Types

General NANUs	*Past 9 years*	*Past 3 years*	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**
Totals			**8**	**5**	**8**	**9**	**17**	**17**	**16**	**10**	**18**
Decommission satellite	12	1	1	0	0	0	4	0	3	1	3
FCST Outage for Decommissioning	4	0	0	0	0	0	1	0	3	0	0
Set usable	9	0	0	0	0	0	2	0	2	4	1
Resume transmission	25	14	5	3	6	5	2	1	0	2	1
Discontinue transmission	5	0	0	0	0	0	1	1	2	1	0
Install software	13	0	0	0	0	3	3	5	0	0	2
Testing & Assessments	11	2	0	0	2	1	2	3	3	0	0
Correct NANU	12	2	2	0	0	0	0	2	0	0	8
Other SV related notifications	17	2	0	2	0	0	2	5	3	2	3

Table 4. Counts for special purpose NANU Types

	2015	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**
LAUNCH	3	4	1	1	1	1	2	1	2
USABINIT	3	4	1	1	2	1	1	2	1
DECOM	3	4	1	1	0	0	0	0	0
LEAPSEC	1	0	0	1	0	0	0	1	0

Table 5. Counts for types of Anomalous NANUs

Anomalous NANUs	Total	2015	2014	2013	2012	2011	2010	2009	2008	2007
Incorrect type	13	3	0	0	0	5	2	1	1	1
Invalid time value	13	1	2	0	0	0	2	0	4	4
Incorrect ref NANU	5	0	0	0	0	0	3	1	1	0
Duplicate	14	0	0	0	0	0	1	8	0	5
Other	1	0	0	0	0	0	0	0	0	1
Issued late	3	0	1	1	1	0	0	0	0	0
False NANUs	4	0	0	0	1	0	0	0	0	3
Number skipped	5	0	0	0	0	0	0	0	0	5
Total Anomalous NANUs	59	4	3	1	2	5	8	10	7	19
% Anomalous		4.0%	3.1%	1.3%	2.3%	4.7%	5.1%	7.6%	4.7%	11.4%