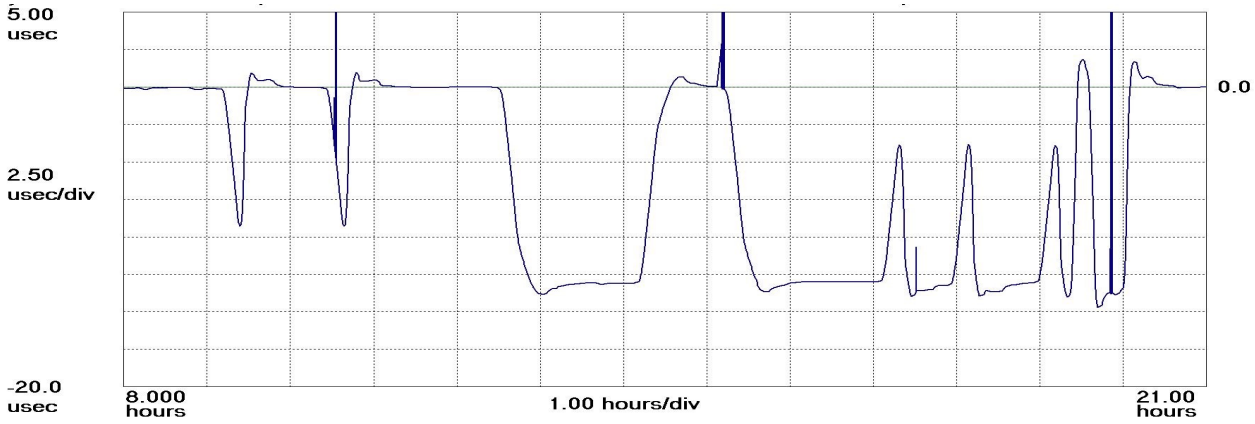
GPS Anomaly Event - 26 January 2016

GPS Satellite Vehicle Number (SVN) 23 launched in 1990 was retired from service in January 2016. It had occupied Pseudo-Random Noise (PRN) sequence 32 since 2008. According to NANU 2016008 it was marked unusable at 15:36 UTC on 25th January and decommissioned at 22:00 UTC later that same day. Unfortunately (for reasons not yet fully known) the UTC signal on some satellites was off by 13 microseconds. This Case Study charts the activity undertaken by the Chronos support team during and after this unprecedented GPS anomaly event. For some with long memories this is not the first time that SVN23 has caused a problem. The last time was 1st January 2004. The trace below shows how the anomaly event impacted one particular GPS timing receiver over an extended period during the day.



The official USAF press release stated:

"On 26 January [2016] at 12:49 a.m. MST, the 2nd Space Operations Squadron at the 50th Space Wing, Schriever Air Force Base, Colo., verified users were experiencing GPS timing issues. Further investigation revealed an issue in the Global Positioning System ground software which only affected the time on legacy L-band signals. This change occurred when the oldest vehicle, SVN 23, was removed from the constellation. While the core navigation systems were working normally, the coordinated universal time timing signal was off by 13 microseconds which exceeded the design specifications. The issue was resolved at 6:10 a.m. MST, however global users may have experienced GPS timing issues for several hours. U.S. Strategic Command's Commercial Integration Cell, operating out of the Joint Space Operations Center, effectively served as the portal to determine the scope of commercial user impacts. Additionally, the Joint Space Operations Center at Vandenberg AFB has not received any reports of issues with GPS-aided munitions, and has determined that the timing error is not attributable to any type of outside interference such as jamming or spoofing. Operator procedures were modified to preclude a repeat of this issue until the ground system software is corrected, and the 50th Space Wing will conduct an Operational Review Board to review procedures and impacts on users. Commercial and Civil users who experienced impacts can contact the U.S. Coast Guard Navigation Center at 001 703 313 5900."

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CASE STUDY

Chronos Support Desk –The Unfolding Story of the SVN 23 Event 2016

The Chronos Hot Spares Support Facility

Chronos operates a 24x7x365 support (Service Support Plan – SSP) desk for nearly 100 timing equipment users in over 50 countries around the globe. The first call into the Chronos support team came at 02:00 UTC from a panicked engineer from Customer A who had been called out of bed by their Network Operations Centre (NOC) reporting alarms at a handful of Microsemi (Symmetricom) SSU2000s. These were disqualifying GPS inputs due to the Maximum Time Interval Error (MTIE) metric being outside of set limits. The customer's engineer was concerned as three sites had gone into holdover since (at those sites) no backup inputs had been assigned. At this stage it appeared that the GPS error had cleared and the Chronos SSP Manager was able to force the units out of holdover. However the scale of the problem escalated as these sites went back into holdover along with dozens of other sites suffering GPS based timing issues. It was apparent at this point that there was something amiss with the GPS constellation itself and a fault report was logged at USCG NAVCEN website at the second attempt on the 26th at 12:00 UTC and phone contact was made with NAVCEN at 14:00 UTC.

Over the next 12 hours the GPS anomaly affected approximately two thirds of the Netsync 55300 GPS Timing Units and SSU2000 estate belonging to the customer. The impact was different on the two systems. The 55300 would squelch the GPS feed into the 55400 SSU and would not be available for approximately 100 minutes, whereas the SSU2000 would disqualify the GPS input due to the MTIE threshold being breached for more than 100 seconds. The MTIE values were showing an error of 13 microseconds across all the affected SSU2000s. Reports were coming in from industry sources that only some satellites were reporting the error. These were SVNs 6, 9, 23 and 26. This would explain why the problem appeared sporadic and in some instances was not equipment affecting, in others the problem re-occurred. Most of the errors were concentrated on systems from the UK Midlands down to the South East.

The Chronos SSP team worked with the customer to maintain a level of alarms low enough to avoid the situation escalating into a "Serious incident" before normal working hours. During the whole course of the event more than 2000 alarms and report messages were dealt with.

At 08:00 UTC the Chronos support team received a call from Customer B operating a London transportation network communications system, reporting two SSU2000s in holdover. This had escalated internally and was causing major concern. Hourly updates were requested until the issue was resolved.

A proactive period of customer network assessment and damage limitation then took place. By 09:30 UTC all customers with whom Chronos had support contracts with remote access had been checked and relevant customer teams alerted to the issue and the effect it was having on their network.
All customers were instructed how to clear down the MTIE alarms thereby re-qualifying the

GPS input once the events had stopped occurring.

During the proactive period a major global network belonging to Customer C was reporting 300 alarms at the time of logging in. The majority of their sites had been seriously impacted and were in holdover due to a lack of secondary backup synchronisation feeds. The Chronos support team started work to remotely recover the systems from holdover however most sites re-entered holdover due to the on-going nature of the problem and at this stage further remedial work was abandoned. Due to alarm escalation settings these alarms became Major / Critical after 24 hours. Rubidium backup ensured that there was little risk of traffic impairments assuming that the situation could be resolved.

At 15:00 UTC Customer D who had decided in the past not to renew their support contract, and therefore had not been proactively called, contacted the Chronos support desk to ask why their SSU was in holdover.

The Chronos SSP desk received notification from USCG NAVCEN at 16:00 UTC on 27th to confirm that the issue had been identified and resolved. However, it was clear that the issue was not yet fully resolved as although the frequency of events slowed down by 14:00 on the 27th there was some evidence of events up to the early hours of the 28th. Customer A's network was fairly alarm free by now due to the constant clearing down of events throughout the morning.

Work started getting Customer C's global network alarm free on the morning of the 28th which by then had generated nearly 2500 alarms and took about 4 hours to clear.

The Chronos SSP desk took a call on the 27th from Customer E who managed a major transportation telecom network to ask if there had been issues during the previous day. At this point we had not been aware of many Symmetricom (Microsemi) TimeSource systems being affected. Again the impact was not 100% with 30% of systems causing downstream switches to reject the timing inputs and enter free run. These units had no visible alarm warnings.

Timeline of Events:

25 January 2016	15:36	SVN23 Marked unusable according to NANU
25 January 2016	22:00	SVN23 Decommissioned according to NANU
26 January 2016	00:21	First UK based alarm message logged by Chronos
26 January 2016	02:00	First call from Customer A
26 January 2016	07:49	NAVCEN acknowledge that there is a problem on press release
26 January 2016	09:00	Proactive call up of SSP customers
26 January 2016	12:00	Reported event at second attempt onto NAVCEN website
26 January 2016	13:10	NAVCEN "resolve" the problem (according to press release)
26 January 2016	14:00	Phone contact made with NAVCEN
27 January 2016	09:00	Support calls still coming in
27 January 2016	14:00	Events slowing down
27 January 2016	16:00	NAVCEN call Chronos to confirm issue identified and resolved
28 January 2016	02:00	Last events logged in the early hours of 28th
28 January 2016	09:00	4 hours to clear remaining alarms from Customer C's network

Holdover is a standard operational condition of the local oscillator in the SSU when no synchronising input is available. Normally a telecom network quality SSU will choose one of three or more inputs in a priority established by the network architect, e.g. three inputs might be 1-GPS, 2 – Network West, 3 – Network East and these network feeds will eventually lead to a Caesium based Primary Reference Clock. In some of the units impacted by the GPS failure, backup inputs 2 and 3 were not set. This meant that the SSU was in holdover. This is a dangerous condition – although normal for simple GPS timing receivers with no resilience and backup synchronisation feeds. The next thing to consider is the type of local oscillator. Would it be a Rubidium atomic oscillator or an oven controlled crystal oscillator? This will define how long the SSU can stay in holdover before there are network impacting frequency errors. This issue is discussed extensively in the Chronos White Paper **Dependency of Communications Systems on PNT Technology** . Long holdover with low grade oscillators could well lead to service impact in telecom networks, particularly 3G mobile. New Single Frequency Networks (SFN) in Broadcasting and future 4G services are much more sensitive to time errors and almost certainly an outage of this impact and duration will in the future cause major problems to critical infrastructure unless technically dissimilar backup time transfer technology is implemented.

Event Summary Table

	Network Type	Region	Qty GPS Elements	Notes
Customer A	**Fixed Line**	**UK**	**Large**	Generated nearly 2000 alarms and standing condition events throughout duration
Customer B	**Transport Comms**	**UK**	**Small**	Customer in panic mode as systems in holdover
Customer C	**Fixed Line**	**Global**	**Large**	Nearly 2500 alarms generated during event. Roughly 40 elements entered holdover due to lack of backup inputs.
Customer D	**Fixed Line**	**UK**	**Small**	Element in holdover
Customer E	**Transport Comms**	**UK**	**Small**	TimeSource only systems. Caused local switches to go into free run.
Customer F	**Mobile**	**UK**	**Medium**	No adverse impact. All systems have backup network feeds and Rb clocks
Customer G	**Private Network**	**UK**	**Small**	System backed up by Caesium
Customer H	**Mobile**	**UK**	**Medium**	Difficult to determine number of affected elements but majority of elements have backup sync feeds taken from another Telecom operator.
Customer I	**Fixed Line**	**Sweden**	**Medium**	Affected all SSU 2000 units
Customer J	**Mobile**	**UK**	**Medium**	Some TimeSource inputs reporting high MTIE and MTIE alarms on SSU2000
Customer K	**Mobile**	**UK**	**Medium**	All SSU2000 disqualified GPS inputs. Systems reverted to line timing traceable to another carrier

This event linked to SVN23 has been one of the most significant service affecting issues for GPS timing users and sits alongside the April 1st 2014 Glonass outage in scale - however its impact on global timing services is much more extreme. The customers listed in the Table above have support contracts with Chronos with help desk SLAs ranging from 24x7x365 to next working day and man-on-site options. Due to the severity of the event the Chronos SSP team took an executive decision to suspend the next-working-day option and deal with problems outside of normal working hours and in a proactive manner. Their expert knowledge and ability to remotely reconfigure equipment and its inherent resiliency ensured that the problem did not escalate to a traffic impacting situation.

Chronos is aware of other more catastrophic impacts to networks and non-telecom applications which were not under supply and support contracts.

CASE STUDY