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Wednesday, April 24, 2019

Data Logger Issue Report/Update

YSI's Solution to Interrupted Transmissions in October 2018

AN INFORMATIONAL PRESENTATION FOR THE GOES DSC TECHNICAL WORKING GROUP MEETING

Steve Parmley, Director, R&D - YSI

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GPS Clock Rollover

The Problem and the Solution

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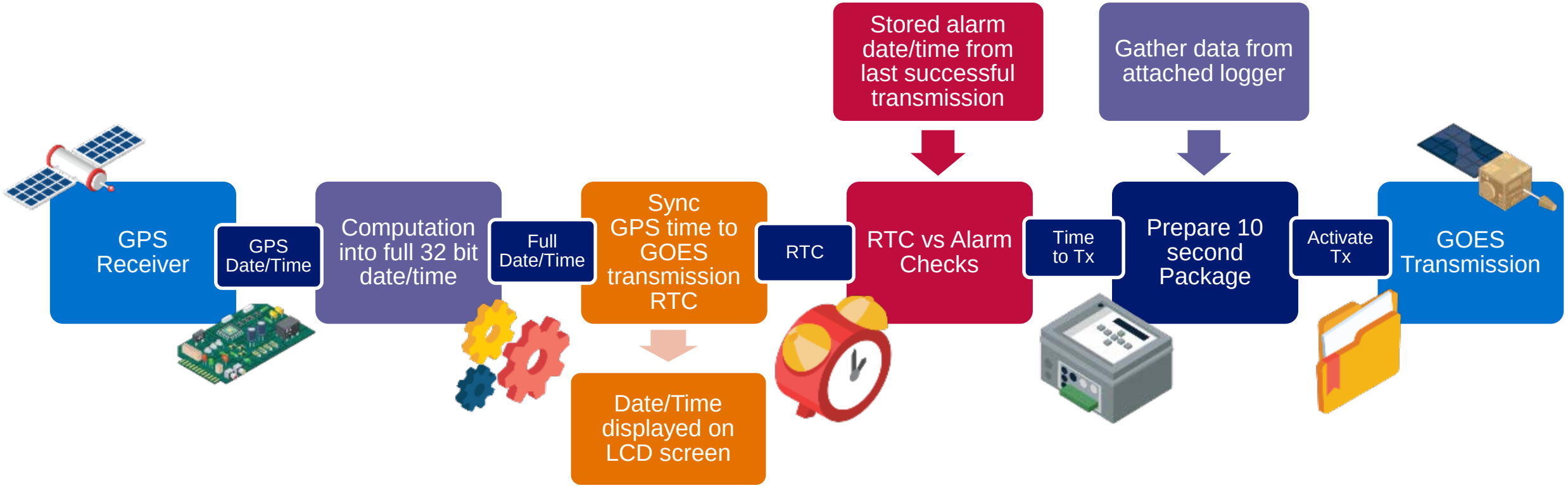
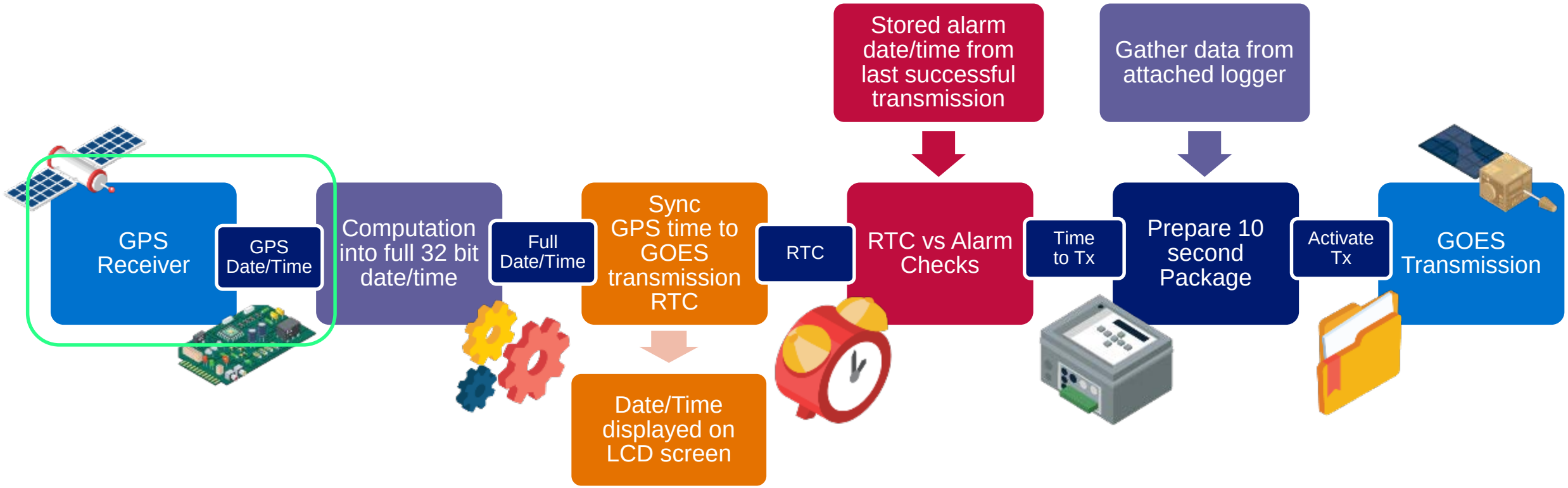
The Big Picture

How could GPS cause a GOES transmitter to effectively go off-line?



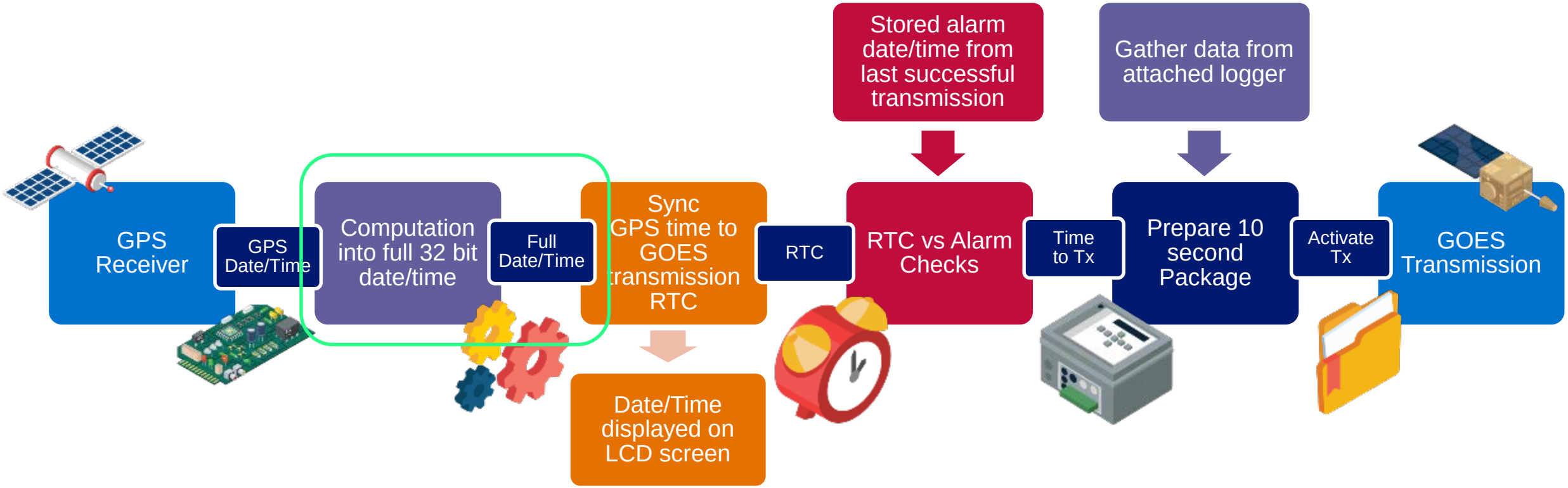
Interdependent systems – GPS, GOES, Real Time Clock (RTC), Firmware

A sequence of events that lead up to the overall system going off-line.



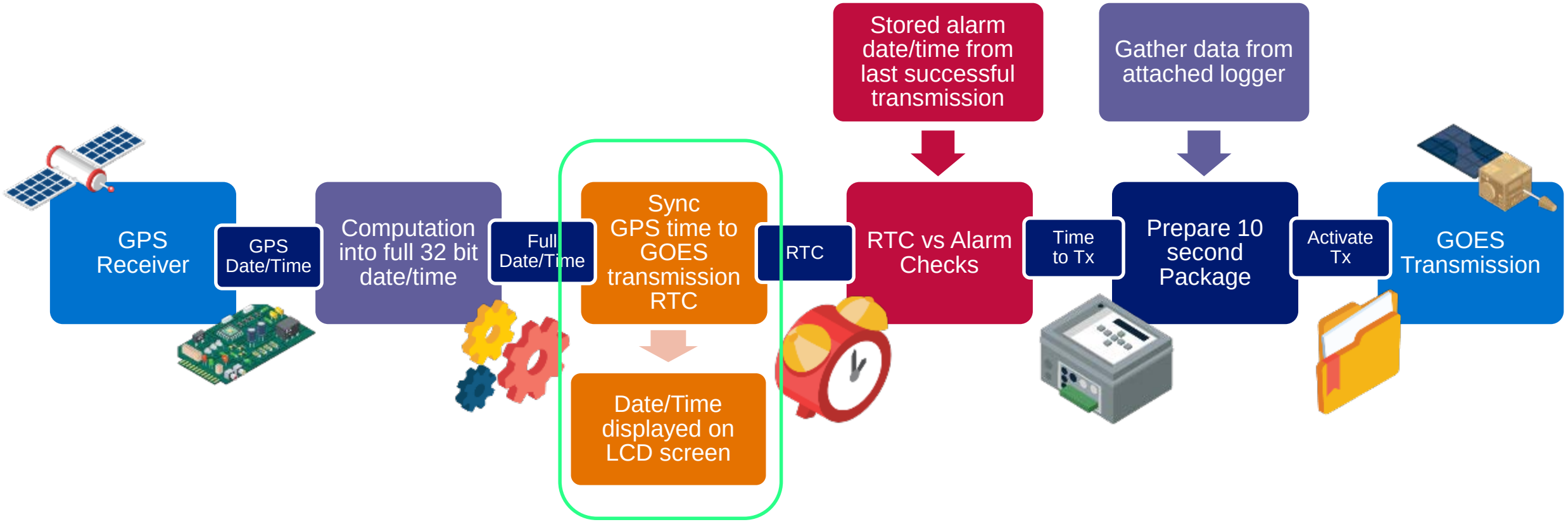
1st root cause to failure

- GPS rollover
  - 10-bit week counter
  - All GPS receiver affected by rollover, older units susceptible to math error, some newer units are capable of absorbing event, suppressing 19.7 year regression back to 1999
  - Older H-2221: Non-typical epoch rollover date (as compared to April 6 2019)
  - NMEA ascii data string

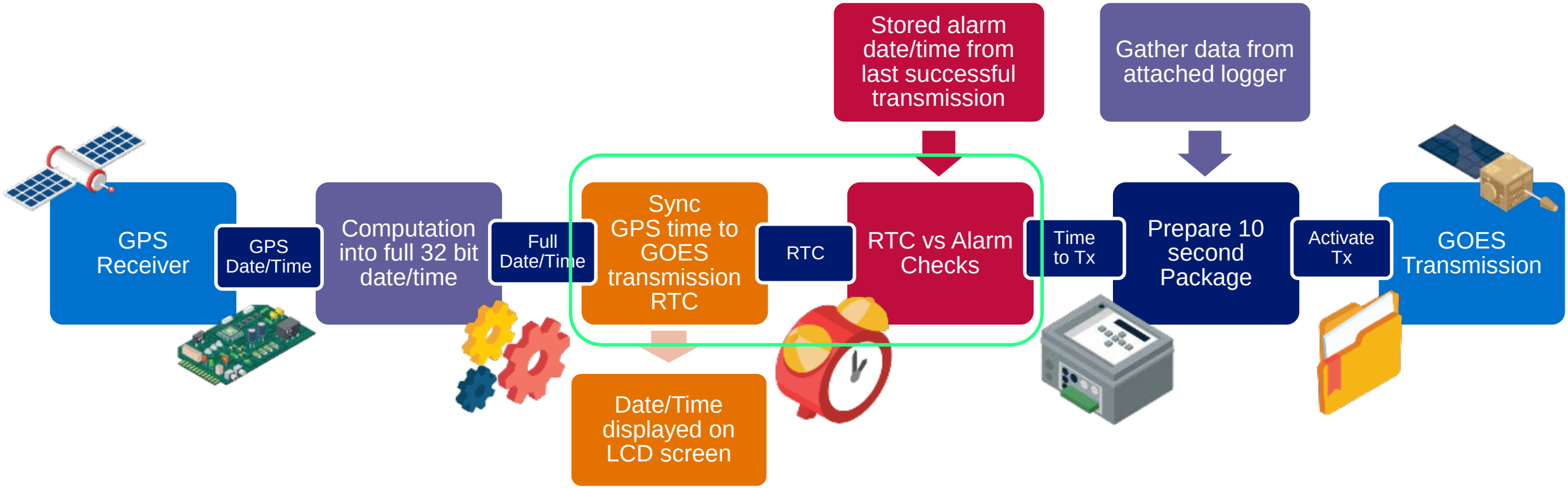


2nd root cause to failure

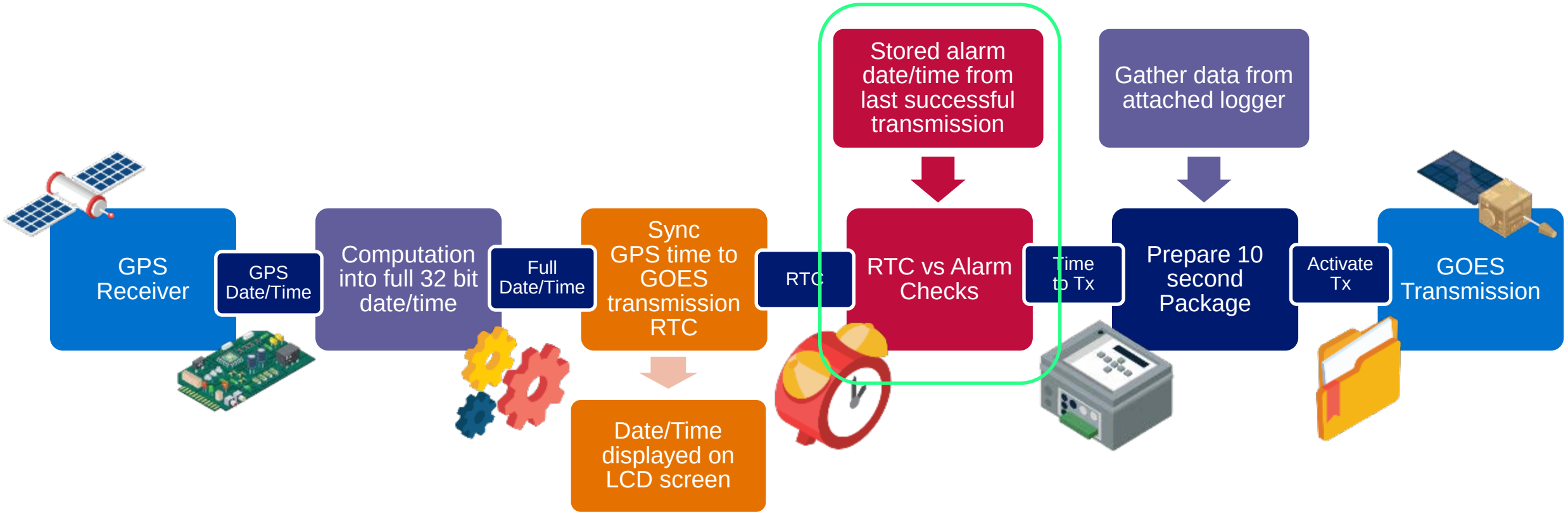
- Firmware interpretation of GPS rollover
  - '99' in ascii string perceived by firmware as 2099
  - Computational standard for representing time/date as 32-bit **signed** integer
  - Minimum = December 13, **1901**, 8:45:52pm, Maximum = January 19, **2038**, 3:14:08am
  - Time/Date rollover: 2099 = ~61 years past 2038, actually yields a date/time in **1963**



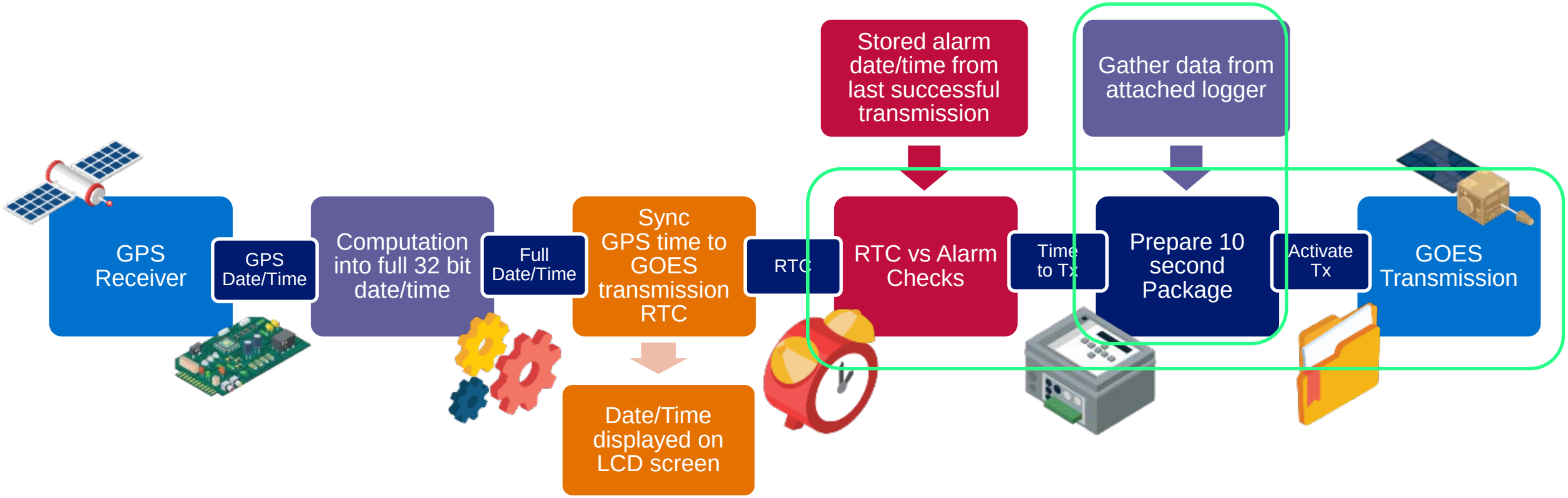
- LCD of Datalogger such as H-552+ show January 29, 1963
  - Time then proceeds to pass second for second.
  - Initial reports indicated January 29th, whereas later reports placed the units in early February 1963 since a few days had passed.



- Real Time Clock Set with incorrect time



- Stored alarm time/date is provided by the GOES ‘radio alarm clock’ for comparison
- If RTC time has passed the stored alarm, time to transmit.
  - The alarm clock, was set to go off an hour after the last successful GOES transmission, you remember - on October 21, 2018.
  - But the current date is in 1963!
  - The alarm clock will not ‘ring’ for another 55 years!
  - The GOES radio patiently sleeps, waiting to be told to transmit.



- Normal expected behavior is transmission upon alarm activation from comparison between RTC vs stored alarm date/time.

The GOES transmitter Firmware: v2.2.6

The firmware is changed to detect a GPS NMEA data string with a year of 99 or 00-to-17 and process those ‘impossible’ past-history dates.

- Those dates imply a GPS 10-bit 1024 week rollover event has occurred.
- Firmware will first convert a 99 into **1999**, or 00-to-17 into **2000-to-2017**.
- Then add 1024 weeks to **undo the rollover**.
- A GPS date of 99 becomes 1999, becomes 2018.
- As the GPS date increments to 00 and up through 17, the firmware reports out 2019 through 2037.

The 2nd issue of the date rolling past 2038 is avoided altogether, eliminating the 32-bit signed integer math issue.

- No 1963 date is miscomputed.

RTC sync time is accurate, LCD is accurate and the GOES radio alarm clock wakes up the transmitter as expected.

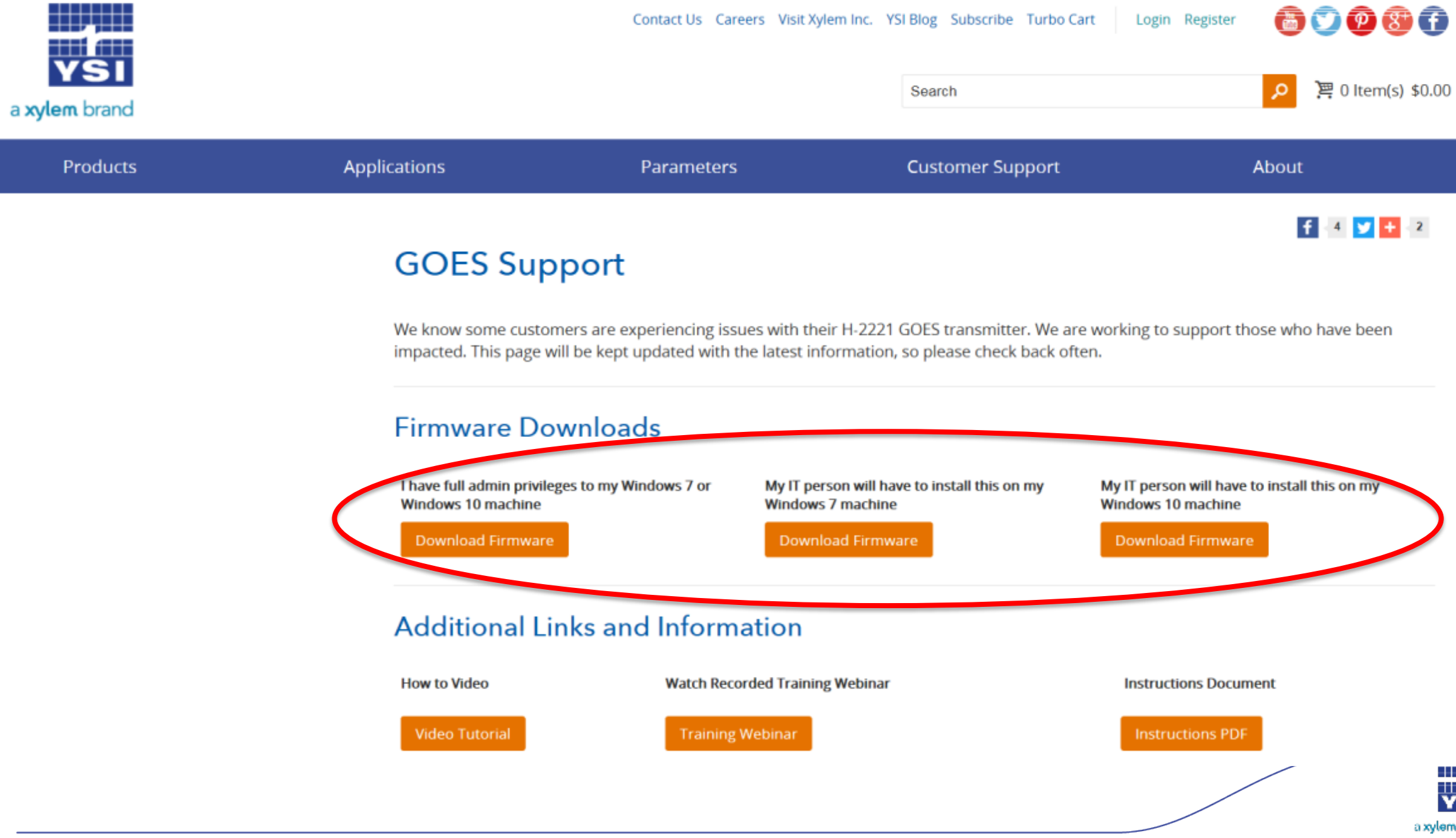
The Updater Software

To facilitate simple firmware upgrade of a deployed H2221 GOES radio, a software ‘updater’ was created.

The software ‘updater’ takes the firmware and uploads it to the H2221 over USB cable.

Three version created:

- Windows users with full Admin rights
- Windows 10 users without full Admin rights*
- Windows 7 users without full Admin rights*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2
GOES Support
We know some customers are experiencing issues with their H-2221 GOES transmitter. We are working to support those who have been impacted. This page will be kept updated with the latest information, so please check back often.
Firmware Downloads
I have full admin privileges to my Windows 7 or Windows 10 machine
Download Firmware
My IT person will have to install this on my Windows 7 machine
Download Firmware
My IT person will have to install this on my Windows 10 machine
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Training Webinar
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YSI Repair Facility or Site Visits to Upgrade Firmware






Install base activity since deployment of Firmware and Software updates

- During the months of November and December, YSI processed updates to numerous units
- Field service, Technical service and Sales personnel were trained and deployed cross country to support on-site updates to affected units.
- Web site downloads of software/firmware update continued as users were also able to perform the update themselves.
- Since December, the downloads and requests for YSI or onsite support has effectively stopped.
- We believe all active GOES transmitters are now updated. Any remaining units that still exhibit the issue would be offline anyways.

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Questions?

Contact us:

info@ysi.com

+1 (937) 767-2762

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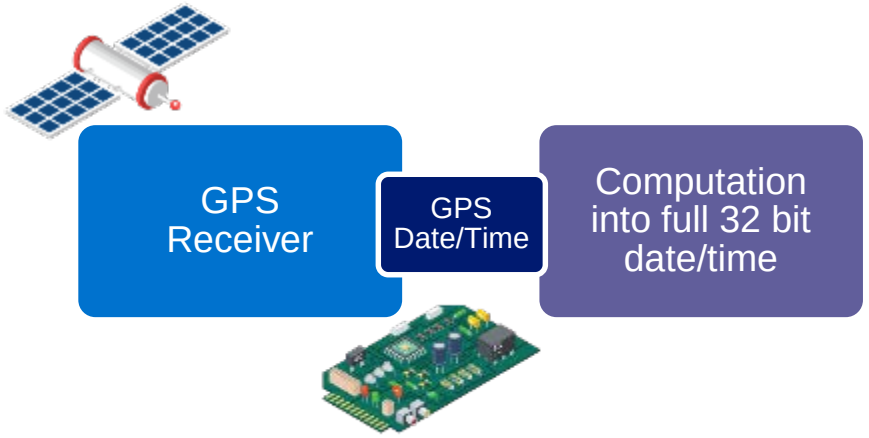
Supporting slides

Details: 1st root cause: GPS receiver

GPS inherent 10-bit rollover

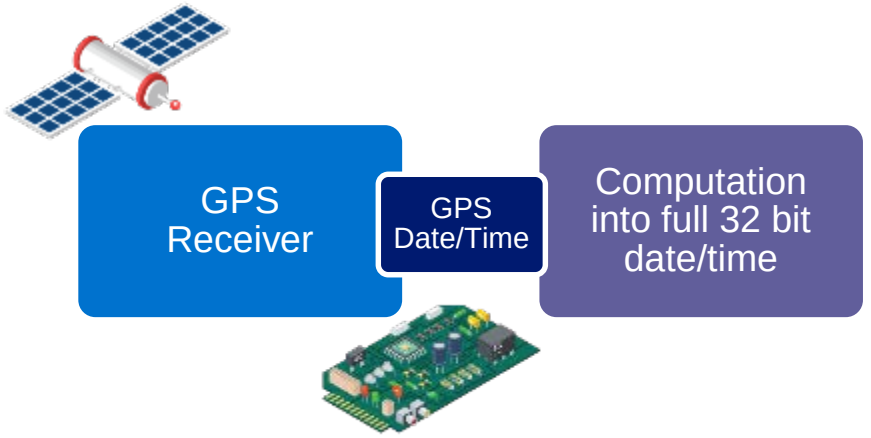
- Data that is sent from the Satellites to the GPS receivers is limited in time/date information. Time is conveyed by a counter that increments once per week, and has a maximum of 1024 (10-bits) unique weeks before it reverts to the 1st week and starts counting again.
- Additionally, the number of seconds passed within that week is conveyed.
- The missing information is the epoch or start date/time of the 1st week at 0 seconds. Each GPS chip manufacturer can choose their own epoch time.
- The epoch + week counter + seconds into that week allow the GPS receiver to compute the time/date, and it does so accurately… for 1024 weeks (19.7 years).



Details: 1st root cause: GPS receiver

GPS inherent 10-bit rollover (cont.)

- Upon the final week, when the seconds in that week complete and the week counter increments one last time, it rolls over. Effectively the time/date regresses backwards 19.7 years.
- On October 21, 2018, the GPS receiver experienced a rollover event.
- From that moment on, the packet is encoded into a NMEA data string where again the YEAR is simply represented as 2 digits. A portion of the data string is shown below:
  - $GPRMC,120100,A,3948.38,N,8353.22,W,000.0,000.0,0603**99**,020.3,E*68
- Notice the **99** in bold. The rollover event has induced the GPS receiver to report 1999.



Actual date	10/21/2018
What the GPS chip will compute after rollover	3/7/1999
just the year	1999
just the last 2 digits as encoded in the NMEA string	**99**

1999 by itself is enough to cause GOES transmission issues

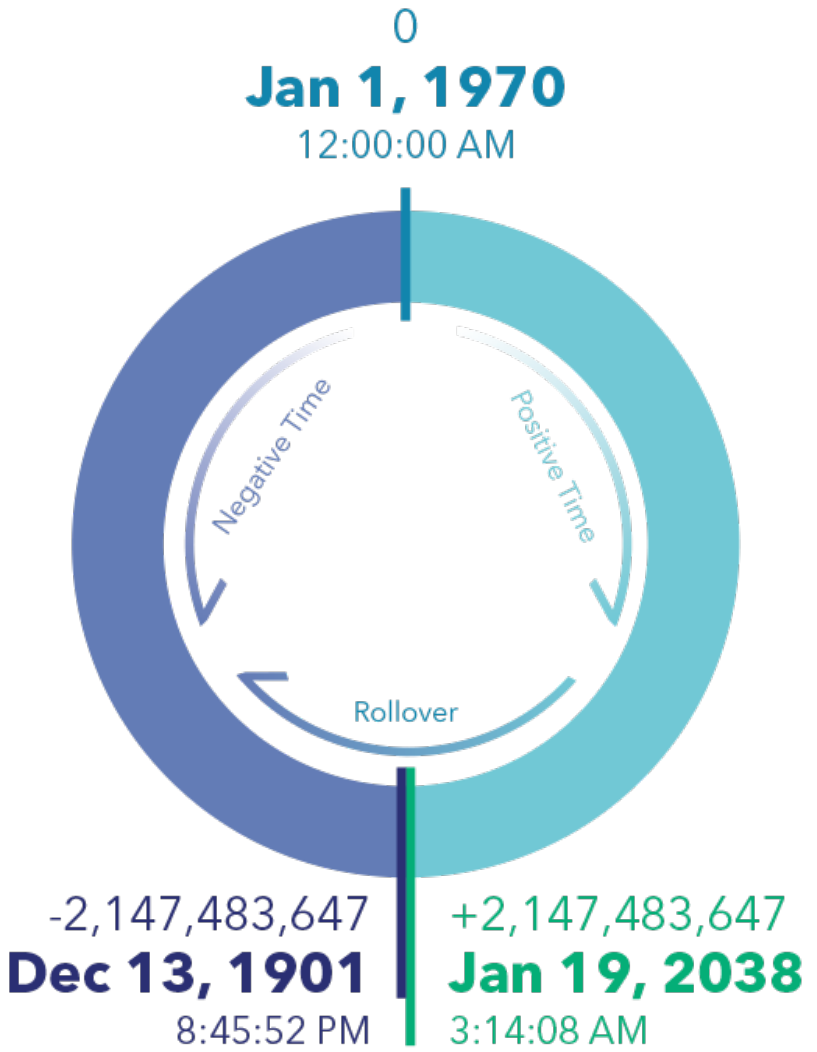
Details: 2nd root cause: Firmware Interpretation of GPS Rollover

Computational standard for representing time/date

- In order to facilitate the use of a standardized Time/Date format for use by subsequent sub-systems, the information contained in the NMEA string is extracted, part by part and assembled into a single number
- This number represents the number of seconds elapsed since January 1, 1970.
  - December 19, 2018, 11am = 1,545,217,200 seconds
  - January 19, 2038, 3:14:08am* = 2,147,483,647 seconds

32-bit signed integer

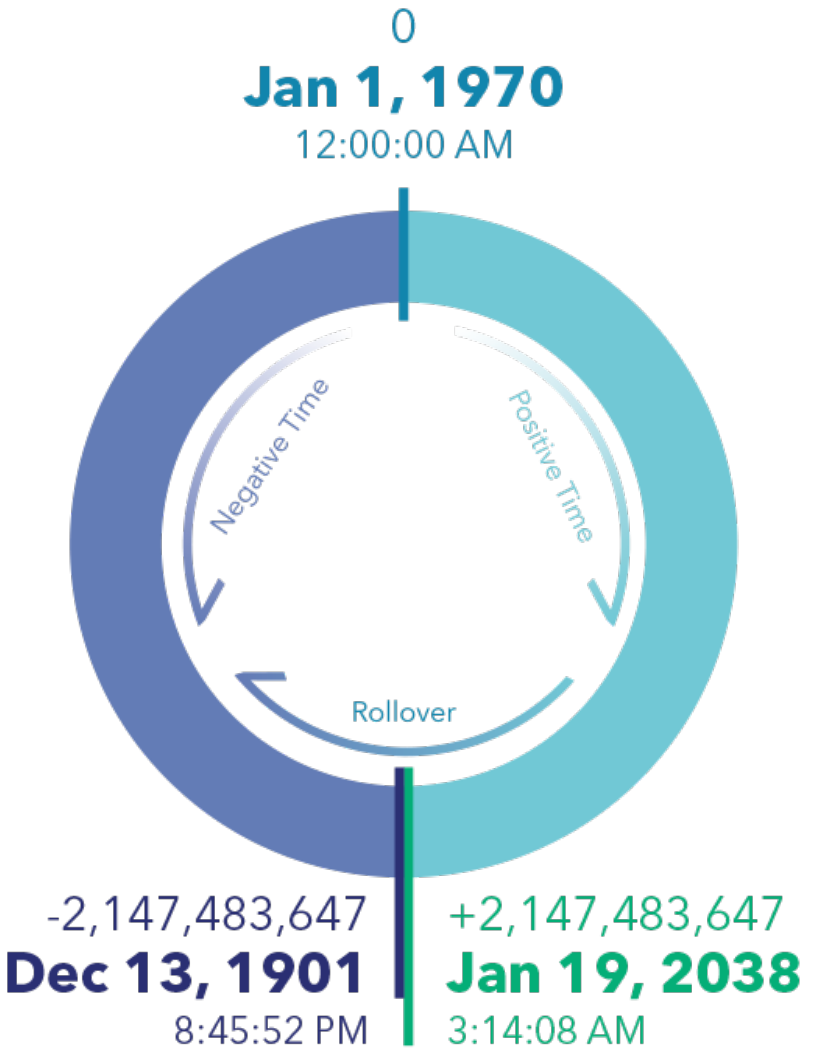
- A number, between **-**2147483648 and **+**2147483647, and when representing time where the most negative number represents **-**68 years from 1970 (December 13, 1901), and the most positive number represents **+**68 years from 1970 (January 19, 2038*)



Details: 2nd root cause: Firmware Interpretation of GPS Rollover

“Negative” time

- Any computational math with a 32-bit signed integer that results in exceeding the maximum **+**2147483647 will rollover to **-**2147483648, reverting the number to the most negative and count up from there.
- So when the number represents time, one second past January 19, 2038, 3:14:08am will revert time to December 13, 1901, 8:45:52pm.
- 2099 will rollover and then some.



Details: 2nd root cause: Firmware Interpretation of GPS Rollover

2099 exceeds 2038 ➔ 1963

- Maximum signed integer can represent time/date of January 19, 2038
- 2099 – 2038 = 61 years overshoot
  - Or ~ 1.923 Billion seconds past 2038
  - Creating a number (~ -223 Million seconds) that represents January 29, 1963