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GLONASS and GSM based Vehicle Tracking System

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Abstract - *Since a long time India has pioneered in production, fabrication, supply and use of* ***radioactive sealed sources*** *with utmost safety and responsibility. Various types of* ***irradiator sources*** *for use in the country and abroad are fabricated as per the standards. Not only the irradiation facilities run by the Government but with several radiation processing plants commissioned in the private sector after signing up MoU, the requirement for industrial radioactive sources has rapidly increased. The irradiators and the related sources have diversified roles ranging from* ***food processing****,* ***medical sterilization*** *to research and medical uses. A major challenge with* ***radioactive sources*** *apart from safe handling and use is safe transportation across the country. It is not viable to send an escort person every time to accompany the vehicle and the freight. An equipment has to replace a man. So as a standard practice a* ***GPS/GLONASS*** *based* ***Vehicle Tracking System*** *has been designed in-house as per own requirements.*

1. INTRODUCTION

A GPS and GLONASS are satellite based navigation system and being a common term known by most of us, it has a immense use in tracking, locating, guidance and navigation of people and assets. Starting from vehicle and traffic navigation, military use in guided missiles and bombs, freight and asset tracking, marine and sea navigation, air transport, homing location beacon, use in smart-phones and handheld devices etc. its uses are immense and too many possibilities of further developments. In India we need this extensively for tracking and locating our Cobalt-60 based radiation source transported by heavy motor vehicle. Though GPS is US based technology yet there are many countries that have their own versions of GPS namely GLONASS of Russia, BeiDou of China, IRNSS of India, Galileo of European Union, QZSS of Japan. The GPS modules often use one or more technology like GLONASS or IRNSS etc. in a single chip to provide redundant coverage either of one or more systems. Here is an important point to note that IRNSS and QZSS are regional systems limited to the borders of the country itself. However GPS and GLONASS being available for long in the market, most of the off the shelf modules support them and are easily available in local market. Gradually Indian IRNSS modules are also becoming available as many of the device startups are taking up fabrication of receiver modules.

We are using a standard GLONASS/GPS module for redundancy of reception and which is readily available in local market. A GPS receiver module is always a listening device. It always receives data from GPS satellites in form of incident radio waves. GPS module never transmits data, they only receive.

1.1 Methodology

GLONASS/GPS positioning is based on trilateration, which is the method of calculating exact position by measuring distances to points at known coordinates. As a bare minimum, trilateration requires three ranges to 3 known locations. GPS/GLONASS positioning requires four pseudo-ranges to four satellites where fourth satellite is used for timing error mitigation if we dig deeper into its working. We will see basics of GPS in this article for broad understanding of GLONASS as well which works in different frequency band but overall concept is very similar. As GPS is generic term, it is very easy for beginners to understand this concept. [1]

A signal is transmitted from all satellites towards the Earth. This signal contains the C/A(Coarse Acquisition) signal, P code or Precise Code and Navigation Message, which is received by GLONASS/GPS receiver modules. The exact timestamp perfectly synced with atomic clock on-boards the satellite that the signal is transmitted from the satellite is encoded within the signal incoming to the receiver module. Time of signal reception is recorded by receiver using on-board clock of the receiver module. A receiver measures the error in form difference in these two time data.

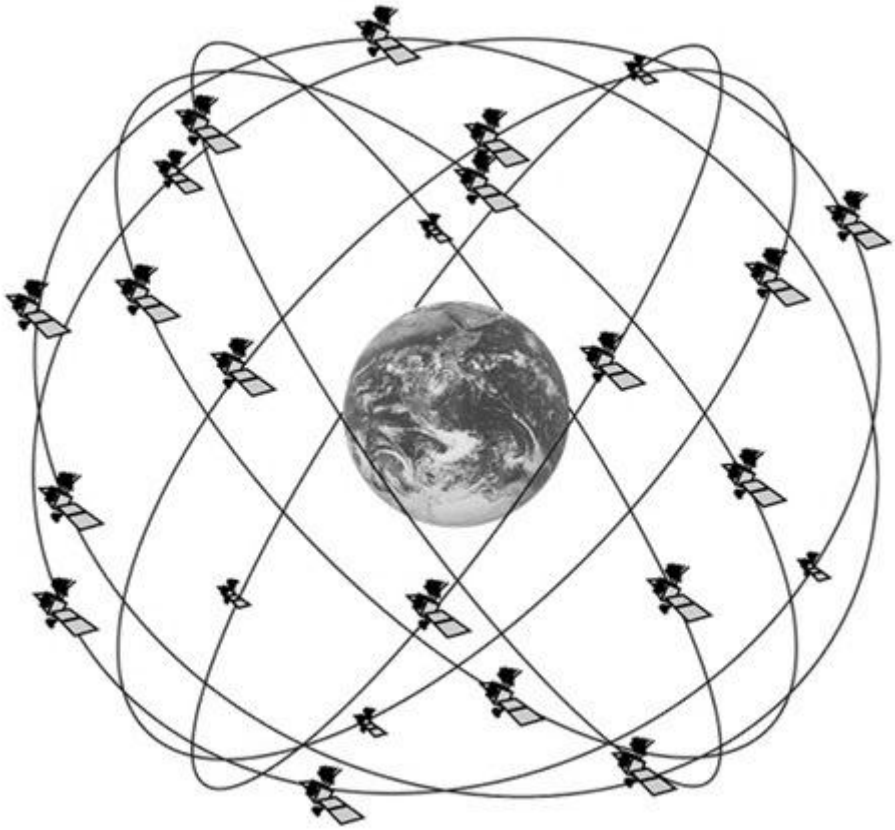

Fig.1 Arrangement of tracking satellites in orbit of earth

Nominal Constellation of a GPS or GLONASS

pseudorange = (time difference) x (speed of light)

Note that pseudorange is range containing clock errors because the receiver clocks are not perfect as atomic clock. The satellite clock error is encoded in Navigation Message, in the form of a digital polynomial stream generated by onboard logic. The receiver clock error can be calculated by the receiver along with unknown coordinates. There are 4 variables therefore we need a minimum of 4 pseudorange measurements to get the exact results. [3]

There are broadly four GPS/GLONASS segments to be known for beginners[2]:

- Space Segment, which includes the group of GPS/GLONASS satellites orbiting Earth, which transmit the signals to the receiver.
- Control Segment, which is responsible for the housekeeping of the Space Segment using satellite tracking and control.
- User Segment, which includes user hardware modules and processing firmwares and softwares for trilateration, positioning, navigation, and guidance applications.
- Ground Segment, which includes civilian/asset tracking systems that provide the User Segment with reference positions, precise ephemerides, and real time services.

The timing signals from a GPS satellite are generated by Cesium atomic clocks. The basel frequency is 10.23 Mhz. Two carrier signals generated from this signal by frequency multiplier of magnitude 154 for the L1 channel (frequency = 1575.42 Mhz; wavelength = 19.0 cm), and frequency multiplier of magnitude 120 for the L2 channel with frequency of 1227.6 Mhz which turns to be wavelength of 24.4 cm). The binary bit streams of 0s and 1s of have PSK modulation which leaves has phase intact for bit 0 or changes it by 180 degrees for bit 1.

There are three types of code on the carrier signals:

- The C/A code
- The P code
- Navigation Message

The C/A code can be found on the L1 channel. This is a code sequence regenerates every 1 ms. It is a pseudo-random code, which in fact is generated by a known complex algorithm. The carrier frequency is responsible for the transmission of the C/A code at bitrate of 1.023 Mbps. The information on C/A code is basically the time as per the satellite clock when the signal was transmitted. Each satellite has a different C/A code owing to unique set of generator logic, for individual identification by the receiver.

The P code is present and transmitted on both the L1 and L2 channel. Whereas C/A is a broader tolerance code sufficient for initially syncing onto the signal, the P code is for more precise positioning. P code can be protected and encrypted by a process known as anti-spoofing/anti-jamming and used by US military and allies and the access to the civilians are not provided.

The Navigation Message is on the L1 channel that is transmitted at a very slow bitrate of only 50 bps. It is a 1500 bit long sequence which takes 30 seconds to transmit. The Navigation Message includes information on the satellite orbit data also known as broadcast ephemeris , satellite clock corrections data, almanac data that is approximate position of all other satellites, ionosphere condition information, and satellite diagnostic status. All signals received by a GPS/GLONASS receiver module calculates the position in form of geographical latitude and longitude coordinates. For example like Latitude = 19.077142°N and Longitude = 73.013075°E. Apart from the geographical position data, GPS also measure altitude above mean sea level, speed of the vehicle, current date-time stamp, system health, battery charge status etc. On similar basis GLONASS also work but with different satellite configurations and different frequency bands of broadcast.

2. Working and Implementation

The system also uses GSM (Global System for Mobile communications) with a SIM card housed in the system. The device uses SMS (Short Messaging Service) to transmit the device's location to a receiving GSM modem attached to a Vehicle Tracking Server in user's premises. In the actual system GPS system and GSM system are housed in one single module that has been assembled on a single printed circuit board. The system is governed by a low power microcontroller that communicates with GPS/GSM module to fetch the location after a certain amount of time elapsed and send the location via SMS. The system includes on-board power regulator, on-board Li-Ion battery charger, battery protection system. LED indications have been provided for user convenience. The GSM uses a flexible patch antenna that has been pasted on the inside body of the enclosure and its has been connected to the system via a UFL connector (a type of miniature coaxial RF connector. The GPS uses a ceramic antenna with active biasing for higher sensitivity. It has been attached on top of the system board with UFL connection to the system. The battery cable via a key-switch and charging power cable has been connected though a DC barrel jack to the board. The SIM card is housed in a connector on bottom side of the board for concealment.

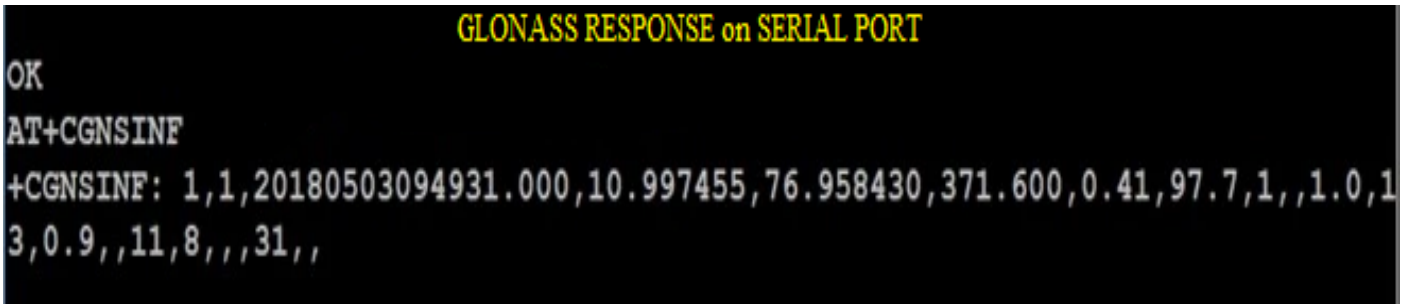

Fig.2 A Raw packet of response of GLONASS/GPS Module when queried by the on board microcontroller

As per Fig. 2 the raw packet of the GLONASS location data is shown where the Latitude/Longitude of the tracking system is shown alongside speed and altitude data.

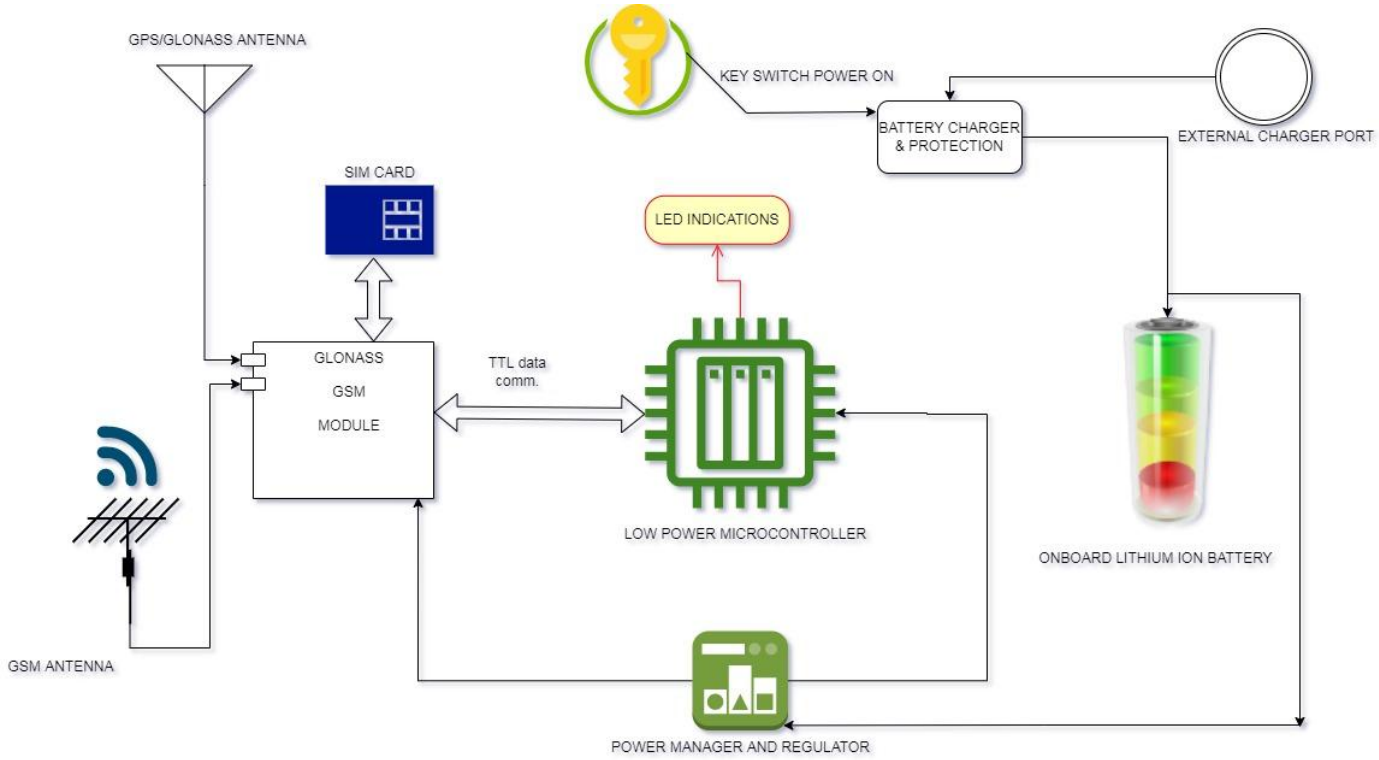

Fig 3. In-House developed Vehicle tracking unit Block Diagram

The unit measures only 12cm(L) x 7.5(B) cm x 5cm(H) that fits in the palm and weighs only 310 gms (including Li-Ion 5000mAh battery) that makes it highly portable kind of device as per Fig 4. image.

According to Fig. 3 and Fig. 4 the system has been fabricated on a custom designed single printed circuit board, which has been assembled on with electronic components in-house. It has been enclosed in a IP65 grade box to prevent dust and moisture ingress. The Lithium Ion battery of 3.7V, 5000mAh has been place just under the circuit board. The unit has been provided with a DC jack that is compatible with 9-12VDC, 1.5A DC adaptor for charging of the battery. The unit has also been provided with a key-switch instead of ordinary on/off switch so that unit shall not be maliciously turned off by unauthorized persons. Only station in-charge of the respective units from where the consignment has been dispatched from would be holding the identical keys for the system.

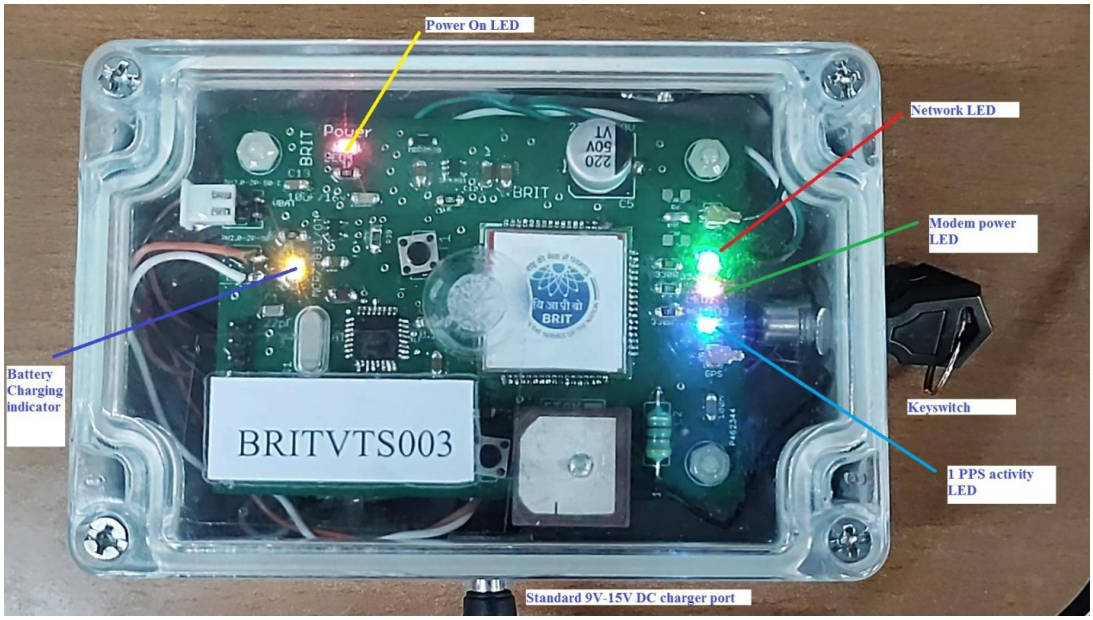

Fig 4. Actual Vehicle tracking unit with LED indications on a switch on mode.

According to Fig. 4 where the familiarity to the indication LEDs are provided, it can be seen that Red LED is for power on indication. The orange LED is the Battery charge indicator when the unit is being charged with DC adaptor. The battery charges at the rate of 500mA. Theoretically for a 5000mAh battery it would take minimum 10 hrs to charge. After charging is completed the Orange LED would shut off. Or whichever is earlier. The green network LED blinks continuously whenever the unit searches for GSM network in the vicinity. Once it fetches the network then it blinks once in every 3 seconds. The Yellow LED indicates the Glonass/GPS/GSM module power and the Blue LED that blinks every 1 second indicates modem activity.

Fig 5. Reference of the device with respect to palm to indicate the compact nature.

The receiving station consists of a GSM modem attached to a Linux based server system that reads a device ID, location message, status etc. and extracts the location and status data from the message and then stores the data in a database. Every GPS unit has been assigned with a specific ID e.g. BRITVTS00x and every ID has a SIM number associated with it. So the ID and SIM number of the unit is matched with the details stored in server database then only the location data is verified to be original. There is also scope of unique IMEI verification of a GSM unit module and may be implemented in future. Fig. 6 shows data storage.

A basic communication flow has been shown in Fig. 7. The GPS tracker mounted on vehicle travelling in remote area sends its location after a certain time that is communicated by GSM telephone network via local BTS to Exchange and then to home location BTS and finally delivered to Receiving station GSM modem in user's premises. As shown the server reads the data, stores the location data in local database and also fetches the location area name from pre saved pan-India location database to know the name of the places the vehicle has travelled through. Authorized users from user's premises have been provided access via existing web-server based portal to check the tracking updates whenever required.

britvts.locationData: 13,049 rows total, limited to 1,000

Next | Show all | Sorting (1) | Columns (15/15) | Filter

id	trackingUnit	latitude	longitude	speed	altitude	course	location	battLevel	battVolt	isBattCharge	eventDateTime	infoFlag	freeze	recordDateTime
13,463	BRITVTS004	9.023082	77.787328	51.17	91.900	11.0	30 Km West of Kovilpatti/Chidambaranar/Tamil Nadu	37	3703	0	12-04-2022 00:56:31	0	0	2022-04-12 01:06:01
13,462	BRITVTS004	8.985315	77.775990	9.41	83.000	12.7	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	38	3708	0	12-04-2022 00:41:06	0	0	2022-04-12 00:48:01
13,461	BRITVTS005	8.984785	77.776058	0.24	89.000	91.0	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	13	3505	0	12-04-2022 00:31:10	0	0	2022-04-12 00:36:01
13,460	BRITVTS005	8.985208	77.776058	2.74	83.600	151.8	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	13	3505	0	12-04-2022 00:15:42	0	0	2022-04-12 00:24:01
13,459	BRITVTS005	8.985312	77.776175	0.17	84.400	88.5	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	13	3511	0	11-04-2022 23:44:15	0	0	2022-04-11 23:48:01
13,458	BRITVTS004	8.985173	77.775832	0.00	77.800	55.4	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	39	3719	0	11-04-2022 23:21:44	0	0	2022-04-11 23:30:01
13,457	BRITVTS005	8.985292	77.776077	0.80	83.800	60.2	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	14	3516	0	11-04-2022 23:12:51	0	0	2022-04-11 23:18:01
13,456	BRITVTS004	8.985180	77.775828	0.00	77.300	55.4	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	39	3719	0	11-04-2022 23:06:19	0	0	2022-04-11 23:12:01
13,455	BRITVTS005	8.985318	77.776120	0.35	82.900	88.0	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	14	3516	0	11-04-2022 22:57:25	0	0	2022-04-11 23:06:01
13,454	BRITVTS005	8.985325	77.776037	0.72	73.000	303.3	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	15	3522	0	11-04-2022 22:42:00	0	0	2022-04-11 22:48:01
13,453	BRITVTS004	8.985280	77.775825	0.02	82.700	213.6	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	40	3725	0	11-04-2022 22:34:54	0	0	2022-04-11 22:42:01
13,452	BRITVTS005	8.985297	77.776047	0.67	71.000	273.5	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	15	3527	0	11-04-2022 22:26:34	0	0	2022-04-11 22:36:01
13,451	BRITVTS004	8.985467	77.776022	0.02	85.300	194.2	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	41	3730	0	11-04-2022 22:19:28	0	0	2022-04-11 22:24:01
13,450	BRITVTS004	8.985462	77.776017	0.02	85.900	194.2	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	41	3730	0	11-04-2022 22:04:02	0	0	2022-04-11 22:06:01
13,449	BRITVTS004	8.985458	77.776017	0.02	86.700	194.2	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	41	3736	0	11-04-2022 21:48:37	0	0	2022-04-11 21:54:02
13,448	BRITVTS005	8.985292	77.776022	0.63	94.000	94.5	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	16	3533	0	11-04-2022 21:39:08	0	0	2022-04-11 21:42:01
13,447	BRITVTS004	8.985478	77.776017	0.02	85.500	208.3	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	41	3736	0	11-04-2022 21:33:11	0	0	2022-04-11 21:36:01
13,446	BRITVTS005	8.985543	77.776050	0.54	87.600	116.9	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	17	3538	0	11-04-2022 21:23:40	0	0	2022-04-11 21:30:01
13,445	BRITVTS004	8.985238	77.775832	0.04	79.900	274.2	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	42	3741	0	11-04-2022 21:17:46	0	0	2022-04-11 21:24:01
13,444	BRITVTS005	8.985457	77.776072	0.44	82.800	17.4	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	17	3538	0	11-04-2022 21:08:14	0	0	2022-04-11 21:12:01
13,443	BRITVTS004	8.985233	77.775822	0.02	78.700	274.2	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	42	3741	0	11-04-2022 21:02:20	0	0	2022-04-11 21:06:01
13,442	BRITVTS005	8.985372	77.776097	0.87	78.200	96.4	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	17	3538	0	11-04-2022 20:52:48	0	0	2022-04-11 21:00:04
13,441	BRITVTS004	8.985230	77.775822	0.02	77.100	274.2	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	43	3747	0	11-04-2022 20:46:54	0	0	2022-04-11 20:54:03
13,440	BRITVTS005	8.985332	77.775965	0.50	73.400	27.9	29 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	17	3538	0	11-04-2022 20:37:22	0	0	2022-04-11 20:42:01
13,439	BRITVTS004	8.975855	77.774547	8.57	70.700	6.0	28 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	43	3747	0	11-04-2022 20:31:29	0	0	2022-04-11 20:36:01
13,438	BRITVTS005	8.976990	77.750712	26.82	83.900	127.3	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	17	3544	0	11-04-2022 20:21:56	0	0	2022-04-11 20:30:01
13,437	BRITVTS004	8.977273	77.744787	0.02	93.100	18.4	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	44	3752	0	11-04-2022 20:16:03	0	0	2022-04-11 20:24:01
13,436	BRITVTS005	8.977252	77.744732	0.02	88.300	275.6	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	17	3544	0	11-04-2022 20:06:31	0	0	2022-04-11 20:12:01
13,435	BRITVTS004	8.977275	77.744787	0.04	92.900	18.4	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	44	3758	0	11-04-2022 20:00:36	0	0	2022-04-11 20:06:01
13,434	BRITVTS005	8.977250	77.744737	0.02	89.100	204.3	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	18	3549	0	11-04-2022 19:51:03	0	0	2022-04-11 20:00:05
13,433	BRITVTS004	8.977275	77.744787	0.02	93.100	18.4	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	44	3758	0	11-04-2022 19:45:10	0	0	2022-04-11 19:54:02
13,432	BRITVTS005	8.977213	77.744743	0.02	92.400	14.4	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	17	3544	0	11-04-2022 19:01:56	0	0	2022-04-11 19:06:01
13,431	BRITVTS004	8.977177	77.745013	0.00	94.500	222.6	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	46	3774	0	11-04-2022 18:56:36	0	0	2022-04-11 19:06:01
13,430	BRITVTS004	8.977168	77.745013	0.02	94.300	222.6	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	48	3785	0	11-04-2022 18:41:10	0	0	2022-04-11 18:48:01
13,429	BRITVTS004	8.977160	77.745017	0.04	94.300	222.6	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	47	3780	0	11-04-2022 18:24:59	0	0	2022-04-11 18:36:01
13,428	BRITVTS005	8.977187	77.744702	0.04	97.800	29.9	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	19	3555	0	11-04-2022 18:14:32	0	0	2022-04-11 18:18:01
13,427	BRITVTS004	8.977158	77.745015	0.00	94.500	222.6	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	47	3780	0	11-04-2022 18:09:04	0	0	2022-04-11 18:12:01
13,426	BRITVTS005	8.977210	77.744732	0.50	99.000	102.4	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	19	3555	0	11-04-2022 17:59:05	0	0	2022-04-11 18:06:02
13,425	BRITVTS005	8.977225	77.744755	0.20	97.400	270.4	27 Km North of Tirunelveli/Tirunelveli Kattabomman/Tamil...	19	3555	0	11-04-2022 17:43:38	0	0	2022-04-11 17:48:01

Fig. 6 MYSQL based backend of web-server for storage and processing of location data

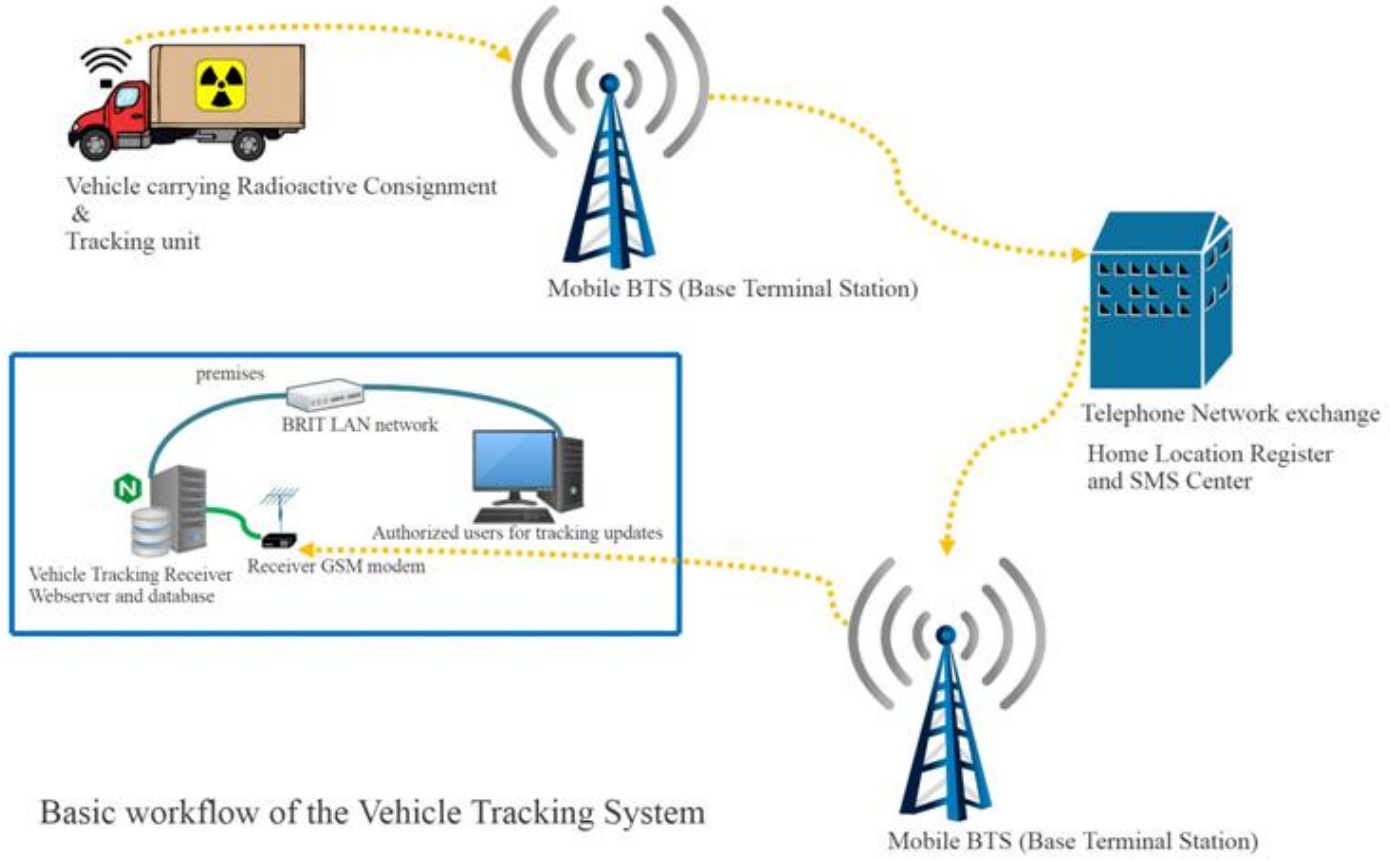

Fig 7. Communication Flow of Vehicle Tracking System.

A tracking page is shown in Fig. 8 where the latest location is at the top. The columns of the page table are self explanatory.

BRIT Vehicle Tracking System

Tracking Data for Unit: **BRITVTS003**

Consignment transit period from 16-01-2021 to 16-01-2021

Sr no.	Location	Date & Time	Latitude	Longitude	Speed	Battery Level (%)	Status
1	2 Km South West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 13:08:34	12.954535	77.571128	0.06	96	RUNNING OK
2	2 Km South West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 12:53:11	12.954480	77.571203	0.11	96	RUNNING OK
3	2 Km South West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 12:37:47	12.954462	77.571210	0.04	97	RUNNING OK
4	2 Km South West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 12:22:23	12.954425	77.571270	0.04	100	RUNNING OK
5	2 Km South West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 12:07:00	12.957565	77.572108	0.00	100	RUNNING OK
6	Bangalore/Bangalore Urban/Karnataka	16-01-2021 11:51:37	12.967640	77.588292	17.17	100	RUNNING OK
7	1 Km North of Bangalore/Bangalore Urban/Karnataka	16-01-2021 11:36:14	12.977012	77.585825	9.00	100	RUNNING OK
8	3 Km North West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 11:20:50	12.982457	77.568002	11.74	100	RUNNING OK
9	5 Km North West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 11:05:27	13.000945	77.552983	11.45	100	RUNNING OK
10	9 Km North West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 10:50:03	13.030055	77.538068	14.65	100	RUNNING OK
11	18 Km North West of Bangalore/Bangalore Urban/Karnataka	16-01-2021 10:34:39	13.064427	77.455735	51.67	100	RUNNING OK
12	28 Km South West of Dod Ballapur/Bangalore Rural/Karnataka	16-01-2021 10:19:13	13.116893	77.372558	18.71	100	RUNNING OK
13	33 Km West of Dod Ballapur/Bangalore Rural/Karnataka	16-01-2021 10:03:48	13.200875	77.268918	63.95	100	RUNNING OK

Fig. 8 Tracking page as shown to authorized users

3. CONCLUSIONS

It is beyond doubt that GLONASS/GPS and similar technology based vehicle tracking have become a very important part for freight and asset tracking[4]. As the demand of Radioactive materials for medical, industrial and research uses will increase, so will the number of transportation events would increase as well. Having these GPS trackers handy would be beneficial. In-house development of such devices gives quick troubleshooting, replacement, up-gradation benefits. For a critical tasks use of in-house devices reduces dependability of India on others. The **future scope** of this work can be extended with

- Inclusion of Map features in server for visual atlas with location.
- Inclusion of Radiation monitor along with the upgraded unit to check for radiation leakage along the way.
- Upgrading of diagnostic features as per requirement.
- Implementation of Indian IRNSS when receiver modules are available in domestic market.

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