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THE ECONOMIC ANALYSIS OF SATELLITE GROUND SEGMENT GATEWAYS IN INFORMAL SECTORS OF INDIAN ECONOMY

Dr. C J Jagadeesha*

ABSTRACT

The socio-economic system is rapidly changing through digitalisation. Though the orchestration of digitalisation is having hundreds of architectures and methods, it is yet to take place in developing countries. The pace of digitalisation is low in India using even Low Code methods. . The Indian Business Schools at Hyderabad has already conveyed it to GOI and State Governments as to how to transform education, technology and policy that too when informal sector contribution to the economy is substantial. The younger generation should know how to make use of GOI / State Govt websites for effective contributions of informal sectors in natural resources utilization efficiently. Internet access via satellite networks has been a crucial solution for use cases such as emergency response, maritime, aviation, and broadband access in remote areas. Geostationary Orbit (GEO) satellite systems are the primary platform to provide broadband service, but only at a limited speed, between 5 Mbps to 100 Mbps, and with high latency, around 500 milliseconds, compared to other broadband platforms. The study and needs of the informal sector which contributes substantially to the Indian Economy needs to be taken up on priority and fixed appropriately, through startups , with LEO / GEO ground segment gateways assessment of economics.

***KEYWORDS**: Satellite Ground Segment Gateways, Automation, Economics of Informal Sectors.*

Introduction

A satellite earth station has the following major elements, the antenna subsystem,RF subsystem, the baseband subsystem, the control equipment, and the user interface.The most essential portion of the baseband equipment is the baseband processing or formatting, digital modulation and demodulation, and channel coding and decoding. On the receiving side , the demodulator detects the incoming carrier, synchronizes the data , performs error correction, and outputs a clean bit stream for the application. The transmit side works similarly in the opposite direction. The satellite operator (be it geosynchronous satellites or LEO,MEO satellites) sets up a satellite earth station gateway(s) and provides satellite capacity in 'Mhz'.The gateway includes an antenna and RF equipment.Conversion of Mhz to Mbps is done by the service provider using their own baseband equipment. New space policy enables the service provider to be from the private side. The satellite capacity is sold to service licensees in Mbps. [Ref.1]

These earth stations are also called Satellite Ground Segment Gateways (SGSG). The architecture of SGSG varies from technology developed in 2000 to 2022. The architecture depends on the level of use of the spectrum at terrestrial networks relying on SGSG. The mobile spectrum vendors, IoT spectrum users, Cloud system users, Earth Observation systems data downloaders, Navigation

* Adjunct Professor, KITS-Coimbatore, Former Scientist -ISRO, India.

satellite users, Crowd-sourcing users, all of these bank on service providers of SGSG. So the SLA-service level agreement needs to be there with each service provider in a geographical region of several square kilometers to several hundreds or thousands of square kilometers. The market need should emerge from local geographies.Government of India has already running a service of providing satellite spectrum to Lakshadweep islands communication needs at a 1:4 revenue loss and also signals are not available at the intended time(s) seasons because of rainfall occurring in SGSG at Bangalore.[Ref.2]

In comparison, the “ground” segment in the industry is beginning to ramp up, and needs to keep pace with discussions around industry developments such as NGSO HTS constellations, software defined radio, network function virtualization, and flat panel antennas, amongst others. It is only now that the wider Big Data industry recognizes a market gap in the satellite value chain, one that it is well positioned to address.

In recent times, The Government of India through the Department of Space has also come out with quite a few forward-looking policies like the Spacecom Policy, Space transportation policy, Remote sensing policy, Drone (UAV) policy etc. that create an enabling environment for the geospatial applications industry.

Satellite based Services

Satellite based services have started emerging in India. The ubiquitous coverage across the country can be made available for (a) remote sensing and imaging (earth observation systems) ,(b) mobile communications with 4 and 5Gs, (c) broadband connectivity , (d) GPS and navigation, (e) disaster management ,(f) satellite TV and radio broadcast,(g) IoT and M2M , (h) telemedicine and health systems .There are LEO (low earth orbits 160km-2000km), MEO (medium earth orbits from 2000km-20000km) and GEO (geostationary earth orbits at 36000 km) orbits for both remotes sensing and telecommunications. As per the current licensing regime in India, establishing earth station (ES) is linked with the service license, and there is no specific license for establishing ES by satellite operators to provide satellite based resources to the service licensee. The needs of geographies in India are not uniform as we have several agro-climatic zones. The agro-climatic zones are getting redrawn as per climate change principal happenings which are observed as multi-disasters.The flexibility in needs of the **geographies** are explained a little in section 3.

The emerging Geospatial Knowledge Infrastructure is summarized in Fig.1

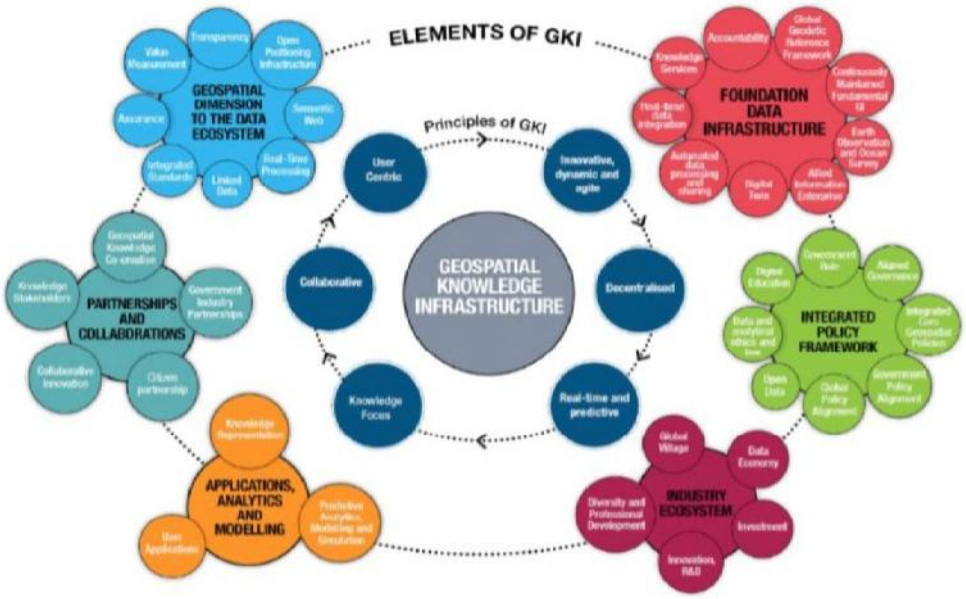

Fig.1 Elements and Components of Emerging Geospatial Knowledge Infrastructure in the World

Geospatial Knowledge Infrastructure provides frameworks for integration not only to the data ecosystem, but also to partnerships and collaborations, application analytics and modeling, industry ecosystem, and integrated policy framework. We need to develop political economy models for infrastructure development in command areas, rainfed areas, energy integration with rural business processes and analytical models. **(Ref.3)**

Coming back to satellite and terrestrial communications alone, the closing of the digital divide in terms of tele-density remains a daunting task. So we have to move towards wired and wireless tools. In the first place, it is noteworthy that there are countries with per capita income less than that of Indiabut with higher tele-density. Bolivia, having almost the same per capita income as that of India had a tele-density of 6.05 in the year 2000 against 3.20 for India. Tele-density is the number of telephone lines per 100 inhabitants. Moldova and Ecuador had a tele-density of 13.33 and 10.00 though it had per capita income of 150 dollars less than and 150 dollars more than that of India. It was also noted that these countries had either more equitable income distribution than India measured in terms of percentage of population living on less than two dollar a day or had a higher weightage of value added by the service sector in the GDP or both.Part of today's IT is 'telecom writ large', it flourishes on the telecommunication network and in turn permits modern day telecommunications to use sophisticated IT -software. Hardware is a common platform both for IT and telecom.

Internet kiosks, telkiosks, telecottages, and cyber cafeterias have emerged in important roles in expanding community access to ICT and domestic markets. Their expansion crucially hinges on the growth of telecommunications infrastructure for which many players are there and ASTROME is one for space communications.In India, a spectrum of technologies has been unleashed to connect remote villages. They include WLL (wireless in local loop) , wireless cum wired technology developed by C-DOT (GOI-center for development of telematics – www.tenet.res.in) , radio systems, switching systems of different capacities, integrated with underground cables, CorDect and medium capacity satellite systems. This enables information society to emerge.

Broadly speaking, mobile telecommunications and internet technologies are going to set the contours of further technological progress in the current decade. The most recent initiative aims at convergence of voice streams, in mobile handheld devices, global satellite systems, mobile handsets ,and calling cards have made virtual presence possible almost everywhere and anywhere overcoming the barriers of distance, topography, and remoteness.

Political Economy Models

The main concern of political economy is to determine the relationship between governments and individuals, and how public policy affects society. This is done through the study of sociology,politics, and economics.Some of the characteristics or themes of a political economy include the distribution of wealth, how goods and services are produced, who owns property and other resources, who profits from production, supply and demand, and how public policy and government interaction impact society. The types of a political economy include socialism (which states that any production and wealth should be regulated and distributed by society), capitalism (where private owners control a nation's industry and trade for profit), and communism (the theory where all property is publicly-owned and everyone works based on their own needs and strengths).Why was agriculture subsidies in rich countries and taxed in poor countries? (Ref. 4)

The economics literature is dominated by two–partly complementary-views on government intervention in agriculture.On the one hand, there is the farm problem view which focuses on the singularities of the agricultural sector and the specific characteristics of agricultural markets in particular. According to this view, the government should alleviate, and, if possible, solve market and income problems associated with this'farm problem'. On the other hand, there is the market failure view. Market failure arguments not only refer to public goods such as food security, (guarantee of) food quality, agricultural R&D Or 'state insurance' against production failures and natural disasters, but also to external effects of agricultural production, such as erosion and pollution of air, soil and water.Both the farm problem and the market failure view implicitly regard the government as an omniscient benevolent dictator who has the capacity to take corrective action in an adequate and timely manner wherever necessary, with the overall objective of maximizing social welfare.

The political economy of the water sector involves "Financialization" of water infrastructure concerning the processes and infrastructure through which water is produced and distributed. Although these arrangements have varied around the world, a common trend has been to move from small,

isolated private networks to publicly owned networks. These are often pursued initially by local governments, followed by national governments. The reasoning behind such a shift concerns the strategic importance of water for local and national development, as well as the assumption that only the public sector possesses the resources necessary for reliable, large-scale public utilities.

Similarly the world trends of political economy needs to be observed in agriculture, environment and energy sectors also.

The amount of India's cropland increased by 8.5 percent, whereas its population grew by 20 percent. This USGS study showed that, out of the 10 leading cropland countries, four countries (Ukraine, Nigeria, Russia, and Indonesia) showed an 18 to 31 percent increase in cropland areas, on the basis of GCEP-30 by the year 2015, compared to 2000. Nigeria's cropland area increased by 25 percent, and its population increased by 31 percent in the same period. In these countries, food security is maintained by cropland expansion, productivity increases, and virtual food trade. Nevertheless, this trend of increasing net-cropland area and productivity will likely become difficult to maintain, owing to diminishing arable lands and plateauing of 50 years of continual yield increases, requiring policymakers to explore novel and data-supported approaches to solving future food security issues. (Ref.5)

Research is underway to extend the performance-based approach to water resources engineering (including hazards such as flooding, drought, sea level rise and tsunami), and to develop planning, design and operations procedures in which the consequences of competing hazards are properly balanced and investments in damage reduction and recovery can be made appropriately. Systems science/ engineering for disasters for sustainable engineering economics in the water sector has already emerged which will give timely and resilient infrastructures.

Informal Sectors of Economy

The informal sector represents a significant part of the economies of most countries in the world,especially developing nations.According to the OECD, people who work in the informal sector typically operate at a low level of organization, with little or no division between labor and capital as factors of production and on a small scale. Labour relations – where they exist – are based mostly on casual employment, kinship or personal and social relations rather than contractual arrangements with formal guarantees."Unlike the formal economy, economists do not include the informal sector's components in GDPcomputations. This means that countries are probably richer than official statistics suggest.

In the advanced economies, between 10% and 20% of income comes from the shadow economy. In some emerging countries, it can represent more than fifty percent. The informal sector, also known as the underground economy, black economy, shadow economy,or gray economy, is part of a country's economy that is not recognized as normal income sources.People who work in the informal sector do not declare their income and pay no taxes on them. The term includes illegal activities, such as drug pushing and smuggling. It also includes cleaning car windshields at traffic lights or doing construction work, i.e., legal work.

This sector includes situations where people must work without receiving any pay. It also includes sectors in which individuals work and in exchange receive something other than money.Even though the informal sector represents a major part of most developing nations' economies, it is typically stigmatized. Critics say it is unmanageable and also extremely troublesome.

It provides vital economic opportunities for those at the bottom of the socioeconomic ladder. It has been growing considerably since the 1960s.

Most emerging economy governments are currently trying to integrate the shadow economy into the formal sector. In India also there is an estimate that agriculture contributes to 60 percent of GDP.

The New types of Services Needed by Indian Rural Economy from Satellites

The agricultural water/inputs management to sustain Farmer producer organizations FPOs. This includes (i) economics of resources at watersheds of hectares scale at farmers level to squares of kilometers at village clusters level; (ii) economics of sub catchments- sub basins resources (water, energy, agri-industry, etc); (iii) economics of industrial clusters for sustainability; (iv) economics of disasters like floods, droughts, earthquakes, cyclones, cloud bursts, landslides all needing IoT,CC, and Internetworking technologies.

The satellite broadband, narrow band and terrestrial networks need to be integrated in an economical way to sustain the economies. The political economy models need to be analyzed using SEM (structural equation modeling) and data mining tools and discussed in a vibrant democracy.

The following types of activities which need continuous real time monitoring also needs to be considered as an essential economic services

- Rural drinking water supply networks (both surface and ground water integrated)
- Rural irrigated agri-water supply networks (both rainfed and irrigated)
- Sustainable water supply networks considering water quality and aquifer health and human health.
- Monitoring house building operations for rural populations using 3D printing building technologies
- Monitoring river flow water networks using Synthetic Aperture Radar (satellite) technologies
- Monitoring transportation networks of rural produce

The business processes involved in providing sustainable Farmer Produce Organizations are : Considering farm as a firm (a) agricultural and allied activities as profitable activities,(b) unique risks and uncertainties (risks associated with rainfall, soil moisture availabilities at farm cluster levels; risks of obtaining available seeds / fertilizers/pesticides at farm cluster cooperative levels etc) (c) economies of scale and scope (which needs to be assessed and published online for each season part of the year),(d) sub optimal to optimal equilibrium using game theoretic approaches solved by AI/ML based big data processing analytics,(e) disruptive innovations will happen for village clusters based FPOs using the satellite earth station gateways by aggregators at different levels.

Each sub catchment / sub-basin level FPOs needs to be continuously monitored / tracked for their performance through ICT technologies.

- Monitoring ports and harbors for their maritime surveillance and port construction activities using satellite based AR/VR enabling.
- Monitoring accidents on roads,highways, railways using ICT methods
- Monitoring and managing navigable waterways

India Governemnt Websites which will help Startups in Economic (Natural Resources Economics) Sectors

The following websites help researchers / start-ups alike for carrying out GeoBigData Analytics. This data can be used by management, business, commerce, economics,computer science, geographers, engineers alike for modeling and analysis of socio-economic development scenarios.

- **BHUVAN:** Geospatial hydro products and services of BHUVAN are available at https://bhuvan.nrsc.gov.in/nhp/

Bhuvan is a geoportal / geo-infrastructure which helps natural resource managers with spatial data of Indian Remote Sensing Satellites and thematic maps prepared over decades with the help of user agencies belonging to both central and state governments. Bhuvan is a software application which allows users to explore a 2D/3D representation of the surface of the Earth. The browser is specifically tailored to view India, offering the highest resolution in this region and providing content in four local languages. On the main page we can see that following portals are present-see Table 1.

Table 1: Some Bhuvan Portals in Bhuvan Website

Visualisation and free download	Maps and OGC Services	Governance/Central Ministries
Bhuvan 2D	Thematic services	Application sectors
Bhuvan 3D	Disaster services	Special applications
Open Data Archive	Ocean services	BhuvanPanchayat Portal
Climate and Environment	Create map/ GIS	

Latest Bhuvan portals contain the soil moisture maps geospatially made available watershed wise (cluster of villages wise) in daily time steps.(see Fig.2)

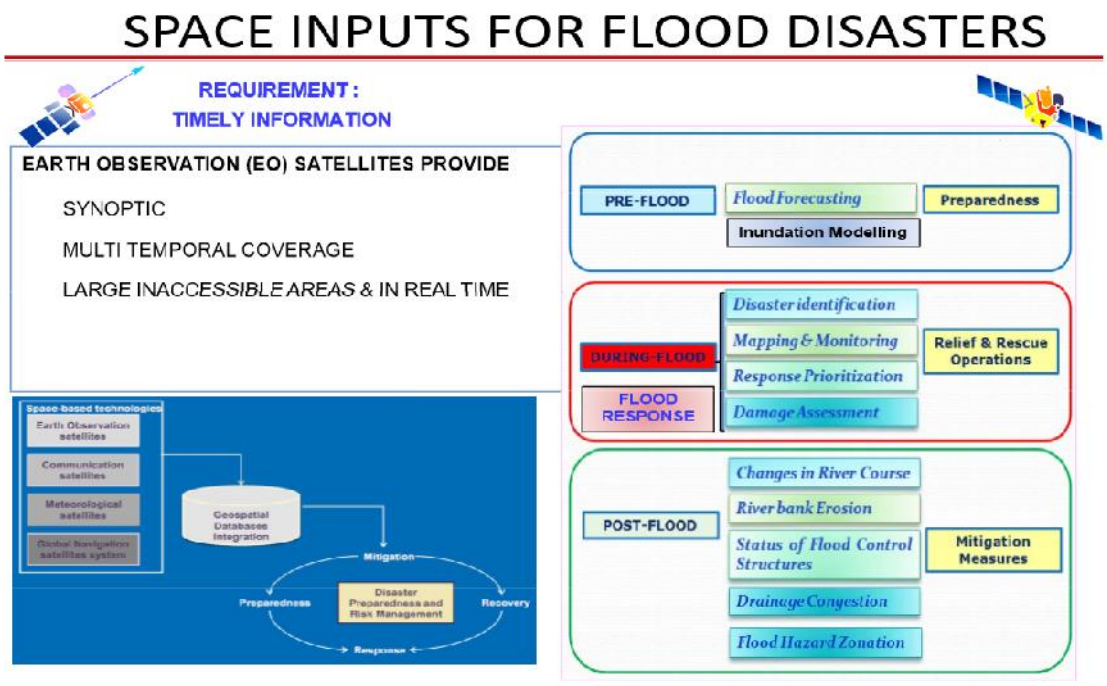

Fig.2: Depiction in Process Flow which enables users to prepare their own flood maps

The soil moisture maps available for watersheds (cluster of villages) prepared by modelling using satellite data is displayed in Fig.3

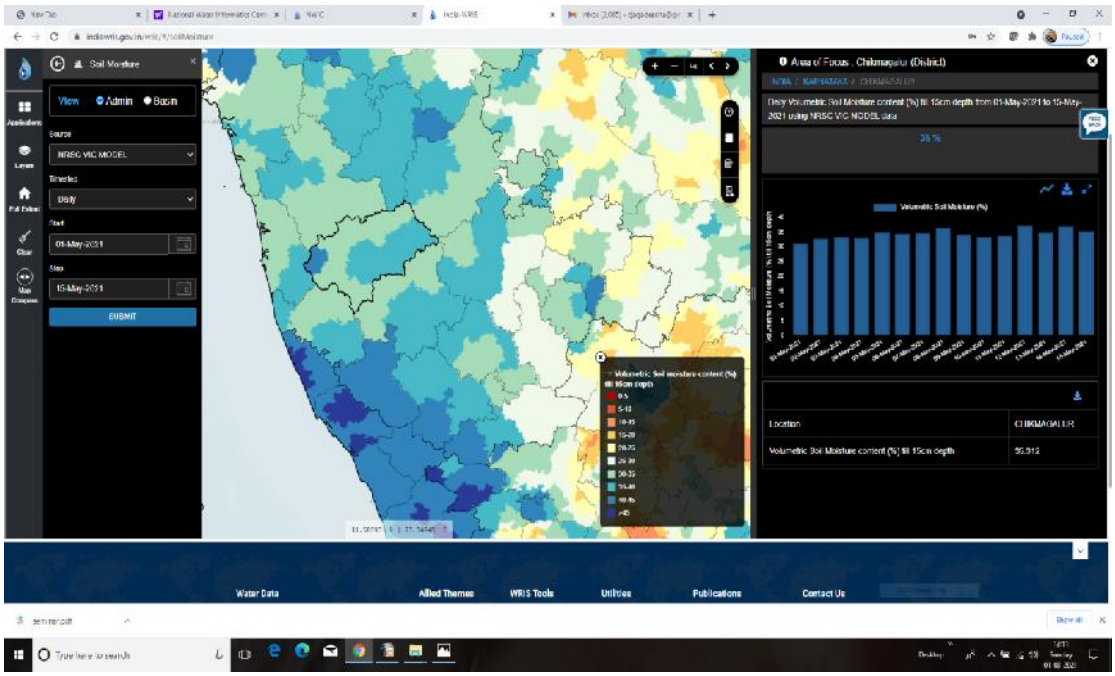

Fig.3: Soil Moisture Maps of Watersheds from Satellite Data

- **India WRIS:** Vision of India-WRIS (water resources information system) is to provide a 'Single Window Solution' for all water resources data and information in a standardized national GIS framework. It will allow users to Search, Access, Visualize, Understand and Analyze comprehensive and contextual water resources data for assessment, monitoring, planning, development and finally Integrated Water Resources Management (IWRM).The website has following has horizontal menu which has the following as the contents http://www.india-wris.nrsc.gov.in/wris.html
- **MOSDAC**

MOSDAC - (the **Meteorological and Oceanographic Satellite Data Archival Centre**) is a data repository for the missions of the Indian Space Research Organization (ISRO) and Government of India, dealing with meteorology, oceanography and tropical water cycles. The web site also hosts weather services including cloud burst and heavy rain alerts, genesis of tropical cyclones in the Indian Ocean along with track and intensity prediction and a three hourly weather forecast for the next seventy two hours. The weather alerts are supported with a decision support system, where collateral information in terms of land use, land cover, DEM, population, administrative boundaries, roads, rivers etc. can be interactively overlaid. On its main page , we have got the following portals/icons which gives the necessary data.-http://www.mosdac.gov.in

- **NDEM-National Database for Emergency Management**

Towards supporting the country's efforts in efficient management of natural disasters, ISRO has evolved a comprehensive space-based Disaster Management Support (DMS) Programme and institutionalized the same in association with concerned ministries / agencies. The DMS programme addresses disasters such as flood, cyclone, drought, forest fire, landslide and earthquake. Earth observation satellites together with meteorological and communication satellites and aerial survey systems form the base for providing timely support and services for disaster management. http://www.isro.gov.in/national-database-emergency-management-ndem-services-tackling-disasters

The India Government websites for water and dissater contain lot of geospatial data for BigGeodata Analysis:

- India WRIS- CWC- ISRO
- BHUVAN –NRSC-ISRO
- MOSDAC-SAC-ISRO
- VEDAS-SAC-ISRO
- NDEM-NRSC-ISRO
- NIC (CGWB-GW)-GOI
- MoEF (ENVIS)-GOI
- NRDMS/SRDMS-GOI/GOS
- Remote Sensing Centers of States and State GIS Websites(like KGIS)
- CPCB / SPCB
- Inspector of Factories and boilers (Large industry and MSME databases)
- Private websites like India Water Portal – in Atmanirbhar Bharath with plenty of opportunities for startups in Water Resources Engineering at less than District level, these websites are the sources of information for innovation.
- NWIC – Jal Shakthi Ministry newly opened three years back

Digitalisation, Virtualisation and Intelligent Automation

We have to democratize the data for cross-functional application. You also need to make sure all stakeholders can make sense of all the IoT data without a hassle; this is possible with better data visualization and the resolution of previous information silos. The idea is to make sure everyone, from regulators to engineers and operators to the general public, can understand the operation of these systems based on accurate, up-to-date information.

As of March 2021, Trimble and VayaVision, a Leddar Tech company, have formed an alliance that will bring advanced perception technology to the agriculture, construction and mining markets. Trimble has been connecting the physical and digital worlds with raw data sensor fusion and perception software platforms that can enable intelligent automation in complex work environments. The alliance is focussed on advancing data fusions for multi-sensor systems such as LiDAR, IoT cameras and GNSS (gradually Indian NaVic also will be included).

Most businesses want to use digital and automation to enhance customer experience, reduce costs, improve efficiency, minimize waste, eliminate delays, maintain business continuity, and ensure their workforce and customers have a safe environment. These expectations are on target. It is also time to shift the automation focus from low hanging fruit to applying processes that make an impact – the answer lies in exploring the potential of intelligent automation to drive foundational changes in processes – and mind-sets – to achieve long-term strategies and business resilience.(Ref.6)

Automation, AI, Cognitive Process Automation (CPA), and Machine Learning (ML) are only as perfect as the data they rely on and the models that make systems intelligent. Biased data, flawed models, and less attention to ethical considerations can lead to automated systems making mistakes that can have damaging and unintended consequences.

*Low code and no code tool*s are application development tools that require little to no coding to implement. They democratize innovation by enabling nontechnical professionals to automate processes on their own at least to a certain extent. However, far from eliminating IT involvement, they should be used to foster business/ IT alignment. In fact, low code and no code solutions are often leveraged by IT to automate routine IT processes with minimal hassle. Though organizations were initially hesitant to embrace low/no code solutions due to fears surrounding increased shadow IT, technical debt and solution rigidity, this appears to be changing.

It is here in India that we have to make a rural IT workforce to make maximum use of low code and no code tools.

If the digitalisation is made effective, by intelligent automation techniques, in the informal sectors it becomes very handy for several start-ups coming from the space technology sector to plan for appropriate LEO/ GSO satellites broadband connectivity networks, even including 5G and 6G. NWIC has already collected in digital form all the decisions that are made on a day-to-day basis as well as weekly, monthly, seasonally also, in the field by state and central departments, from both formal and informal sectors related to resource management. Satellite operators are still debating go-to-market strategies for LEO[low earth orbits and GEO (Geo-Stationary orbits) broadband]. With the onset of 5G technology, regulators are looking to upgrade the required wireless connection in cars(transportation sector) to enable internet protocol-based communications. Simultaneously, these regulators have included satellite connectivity in recognition of the limits of cellular wireless networks. The disaster ridden India needs to study utilizing the broad band as well as narrow bands with 5G technology for handling risks of re-building infrastructure. Satellite has been an important technology to provide broadband in remote areas where it is challenging to deploy other terrestrial broadband networks. The COVID-19 pandemic spotlighted the importance of broadband connectivity in both social and economic aspects of work, learning, communication, shopping, and healthcare. Although network operators have managed the traffic surge contributed by home broadband networks well, governments around the world have witnessed that populations without efficient connectivity faced challenges to navigate through the pandemic. While households in the areas with limited fixed infrastructure need to rely on mobile networks to access the internet, there is clearly a digital divide across different markets which needs to be addressed.

Types of Envisaged Satellite Ground Segment Gateways -SGSG

In Satellite Ground Station gateways also the digitalisation, virtualisation and automation have to happen now itself. There are different markets opening up for SGSGs. A few which are discussed in SIA December 17 2021(Ref 2) are discussed here.

- As per Planet Aerospace SGSG may consists of (a) content delivery networks (b) Quality of Service and bench mark nodes (c) impetus to sharing of resources (d) IP addressable-remotely monitorable and controllable (e) WSN-wide area service netwoks enabled by software defined radios and direct device addressability (f) earth stations in motion (g) use of LEO/MEO/GSO lead to spectrum conflicts -use AI and chaotic communication concepts in optical networks.

- As per Thales Alenia Space – SGSG consists of several layers. Layer1 consist of Earth observation and telecommunications satellites (multi-band, multi orbit software defined radios and beam shaping and steering);Layer 2 consists of Ground transport infrastructure and remote site (electronically steered antennas, high rate digital conversion, bandwidth recording, RF over IP standards) ; Layer 3 consist of virtual platforms (having virtual network functions, private public cloud resources, resource/ service orchestration, APIs and application frameworks);Layer4 consists of end user services (enterprise services, end-to-end service chaining, big data analytics and assurance & intelligence)
- As per ASTROME technologies- SGSG -Factors defining a ground terminal are A] Standard-cost , data rate, power and SLA (in percentage); NewAGE] Multi-beam, high bandwidth mobility, stronger uplinks

Each one of these layers, factors, elements cost several thousand dollars in each SGSG geographic site based on the type of services worked out after consultation with stakeholders in the field and Digital governance principles. There is a dire need to work out consultations, collaborations and conflict resolutions in arriving at ground segment gateways.

Conclusions

Broadly following conclusions can be drawn:

- The agro-climatic zone based digital governance requirements need to be carried out for sustaining livelihoods and economic developments.
- The satellite ground station gateways architecture and orchestration should be a balance of keeping revenues high than investments.
- The continuous monitoring flexibility of ground segment networks (including mobility to certain extent) along with terrestrial 4G, 5G,6G networks adopted for crowd sourcing and resources governance needs of the geographies.
- There are about 75 agro-climatic zones classified for the globe as a whole and climate change will be redrawing the iso contours of zonal parameters and our dynamic SGSGs should be designed with digitalisation, virtualisation and flexiblity aspects embedded in them.

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