"Intelligent Pipeline Health Display System for Healthy Utilities using real time GIS Web Services and Data Analytics"

Kiran Kumar t [1]

Principal Consultant, GIS CoE, Infosys Limited

Survey No. 241, Manikonda village, Lingampally, Rangareddy (Dist.), Gachibowli, Hyderabad, Telengana 500032

Abstract:

With advent of different easy field data capturing tools and availability of high resolution satellite data, GIS has become a powerful 2D or 3D or 4D Visualization, decision making tool that can be integrated with Data analytic systems to build an intelligent asset health monitoring system in Utility landscape. This paper presents a methodology to build an intelligent web application that will display asset self-health in terms of Structural Risk, Operational Risk and Commercial risks in near real time using integrated GIS web services, Map visualization and data analytic tools. The proposed methodology is based on integration of ESRI based web GIS application consuming REST near real time map services with risk related statistics data which is outcome of open source data analytic tools. This solution will enable pipeline operators contextually visualise different data sources such as pipe center-line data, ILI anomaly data, strain data, dig/repair data and Geo Hazard data on GIS map in near real time which will provide health of the Pipe line assets and help preventive actions by the management

About the Author:

Mr. kiran kumar t

17+ years of experience in Service Offering, Solution Architecting, GIS project formulation and Implementation, Project Estimation, Project Management and Technical Guidance. Excellent Domain Knowledge in GIS, Energy sector, Electrical sector, Remote Sensing, Disaster Management and Water Utility. Has played a key role in helping organizations establish and accomplish their strategies and design roadmap for Enterprise GIS integrated with several other systems.

E mail ID: kiran_tirumandyam@infosys.com

Contact: +918971888076

Introduction

With the availability of new plug-in with other IT systems and Data Analytic tools, the current GIS capabilities are reaching new heights. With these integrating application programming interfaces, the GIS landscape is also changing a lot not limited to spatial databases but providing more insights into all kinds of data with respect to space, time and patterns. With the availability of real time data from sensors and big data, there is a need to unfold these structured and unstructured information and present the information in an easy understandable map view that will help not only GIS users but also non GIS users.

The current paper presents an approach that showcases how a gas pipe line system in a transmission network can display health of the assets in the network on a GIS map in near real time that will enable Pipeline operator able to track risks through intuitive GIS visualization in near real time and manage the predictive maintenance workflows, integrate risk management process across the various departments of the organization, automate-digitize-integrate field inspections and be able to create reports to be submitted to the regulators.

In earlier conventional approaches where algorithms are built on some platform to get derived data results then do mapping with spatial data to bring into GIS data utilizable formats. The current approach utilizes Pipe line data stored in PODS data model, ready available integrating interfaces in Data analytic tools like.. Which has capability to mine huge pipe line data and provide required data results which can be directly consumed by ESRI JavaScript API and map services from ESRI ArcGIS Server to build an intelligent pipeline health display system in near real time.

The initiative has been tested on a sample data that will flow in real time and the results have been encouraging.
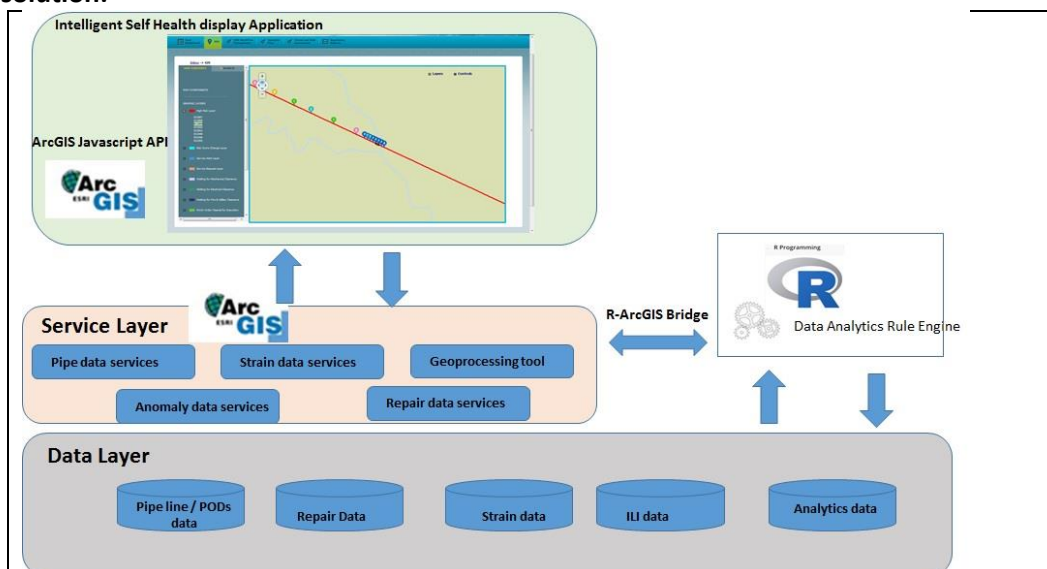
Design Considerations:
High level solution:

Fig: 1- High Level view of the solution

The overall architecture is ESRI's ArcGIS JavaScript API is used to build the GIS functionality framework. The Pipeline Data is stored in PODS ESRI spatial version 5.1.1 Data Model which provides the database architecture to store critical information and analysis data about the pipeline systems. PODS data model manage the pipe line data geospatially in a linear-referenced database which can then be visualized in Map viewer built using ArcGIS JavaScript API. The PODS Pipeline Data Model allows to store the asset information, inspection, integrity management, regulatory compliance, risk analysis, history, and operational data that is mission-critical for pipeline companies for successful management of natural gas and hazardous liquids pipelines. Proprietary algorithms are built to calculate various risk like Operational Risks, Structural Risks and Commercial Risks and also to calculate Pipeline Integrity Business Risk Score (PIBRS) using open source R, a domain specific language for statistics. ESRI's data required for calculation is read in R using R-ArcGIS Bridge. R-ArcGIS Bridge is used to access R code through geoprocessing scripts to get Operational Risks, Structural Risks and Commercial Risks and Pipeline Integrity Business Risk Score calculated in R system.

Detailed solution:

PODS ESRI spatial version 5.1.1 Data Model : The required PODS ESRI data model is represented within ArcGIS geodatabase environment in the form of following elements. All of the feature classes are organized under "Transmission" dataset and required to be in same coordinate system. Data like Pipelength, pipejoin, CathodeProtectionStation, CIPS, AGM, DCVG, SoilResistivity_1m, SoilResistivity_3m, SoilResistivity_5m, Anomaly and TownshipBoudary are maintained as feature class layers. Other data like pipeline, repair, strain and ILI data is maintained as object and relational tables.
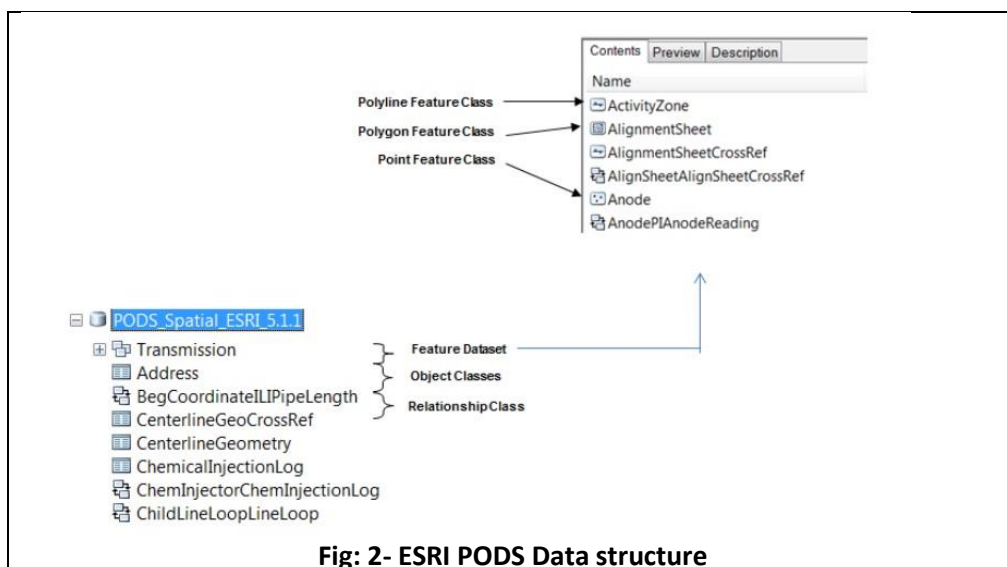

Fig: 2- ESRI PODS Data structure

Asset Health parameters calculation using R tools : Proprietary algorithms are built to calculate Structural Risk Score, Commercial Risk Score and Operational Risk Score. Structural Risk Score for a given line section to be computed from POF algorithm. Pipeline Integrity Business Risk Score to be computed as a weighted average of Structural Risk Score, Commercial Risk Score and Operational Risk Score. When a PIBRS score changes for a given Line Section, the Pipeline Integrity Business Risk Score risk scores are to be automatically recomputed and aggregated up to Pipeline Section level and Pipeline Network level. All the required data is read from the geodatabase maintained in ArcGIS system.

ESRI GIS Solution : Base map data from ArcGIS online, Township boundary, pipelength and other spatial data is published as map services using ArcGIS server. ArcGIS JavaScript API is used to build map viewer with navigational functionalities (Zoom in, zoom out, Pan, scale). Custom search functionality was built which will enable users able to search assets based on different attributes such as Risk score, Location and asset ID.
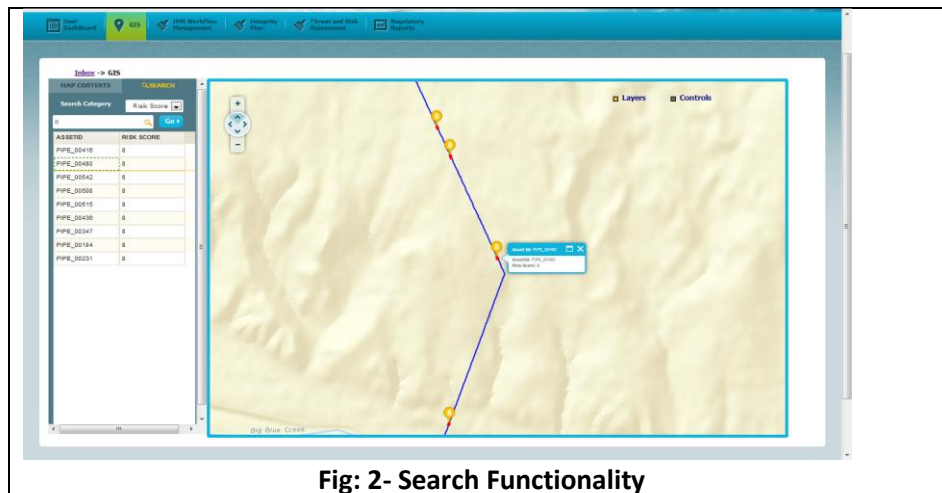
Fig: 2- Search Functionality

Operational Risks, Structural Risks and Commercial Risks and Pipeline Integrity Business Risk Score (PIBRS) computed in R system is read through R-ArcGIS bridge and these data along with other pipeline data is recomputed in GIS system into different asset health display layers like High risk layer, risk score change layer, service alert layer, service request layer, waiting for mechanical clearance, waiting for electrical clearance, waiting for fire & safety clearance (Fig : 3- Asset Health Display in the form of Layers). The risk scores are recomputed on near real time basis based on input of field collected data on regular basis. The risks information is also generated as alert popups in different colors on gis map for pipe line operators to take preventive action.

Fig: 2- Asset Health Display in the form of layers

Key functionalities offered

The key functionalities offered by the search engine includes the following:

1. Rich an intuitive GUI delivered through ArcGIS Server Java Script API. All the basic map navigation tools will be obtained through the Java Script API from ArcGIS Server.

2. Search functionality to search assets as per ESRI spatial data model

3. On & Off capability of Asset Health layers in different colors to immediately identify the assets in critical condition

4. Ability to generate asset & risk related information in the form of pop-ups on GIS map

5. Ability to pick a location in the map view and search all the related assets

The list of functionalities mentioned here is a snapshot of the endless possibilities that can be achieved through the solution. The future capabilities are a lot more, and this will act as a foundation for all the future initiatives.

Business Scenarios and Use Cases

The application mentioned above is meant for engineers & pipeline operator's working in transmission network which will help them to perform activity like:

1. Pipe line operations managers to identify high risk events and raise service alert to pipe line engineer.

2. Based on the Service Alert assigned to the pipe line engineer, an inspection service request can be raised assign it to a NDT Supervisor. When an NDT supervisor logs into the system, all the Service Alerts and all the related assets are highlighted in the map. The NDT supervisor can search all the related features across different feature classes and get it highlighted in the map.

3. The NDT supervisor can assign the critical assets work order request to the NDT inspector. The NDT inspector then can take preventive actions on ground.

These are some of the business areas that have been considered as a case study while developing the application. However the application can achieve much more and beyond this.

The solution will address the following business benefits:-

- The solution provides an efficient way to identify assets in critical condition
- Ease of searching and locating pipe line data
- Display of Pipe line health in form of different layers and alert popups for immediate attention

Conclusion

With the availability of easy consumable API's within Data analytics tools, ability of data analytical tools to read geodatabase data and send back data in compatible formats taken ESRI based GIS system capabilities to new height. The solution can be expanded further into a full pledge work flow solution for pipe line operators and can extend to mobile devices.

References

1. PODS ESRI Spatial version 5.1.1 Technical Specification