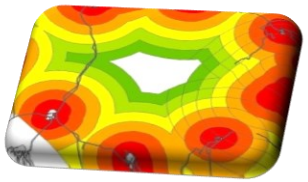


GIS Applications : Network Analysis

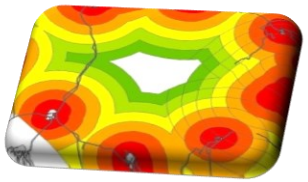
EGS 2401

GIS in Utilities

Lecture No. 08

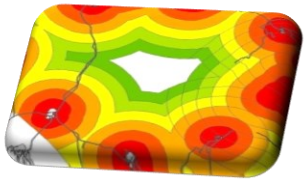
Felix Mutua, Ph. D

Wednesday, October 25, 2023



Lecture Plan

Week	Topic		Week	Topic	
1	Overview		8	Networks – I (concepts, network problems)	
2	Review of GIS analysis Techniques		9	Networks – II (building networks, optimization)	
3	GIS in Agriculture (concepts, application areas, Crop Suitability Analysis)		10	Networks – III (routing, tracking)	
4	Natural resource Management – I (concepts, application areas)		11	Utility Management	
5	Natural resource Management – II (Groundwater, forestry)		12	Health and Disease control *(concepts in epidemiology)*	
6	GIS in Business (store location, consumer profiling)		13	Governance *(crime, districting, LIS, census)*	
7	CAT I		14	CAT II	



Introduction

- Utility Sector is one of the fastest growing of the many fields in which Geographical Information System (GIS) software is used.
- GIS is emerging as an important planning, implementation management and operations management tool for the utility industries such as
  - Telecom,
  - Transportation,
  - Energy and
  - several Urban utilities such as Water Supply, Waste Water and Health.
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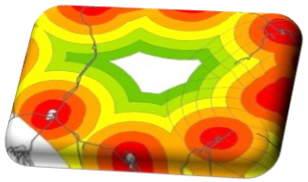
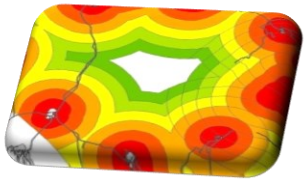


Introduction

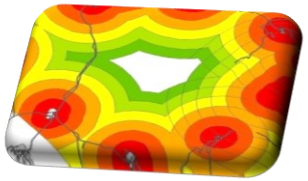
- Utility lines are the backbone of rapid urbanization and modern infrastructure. Power lines, water supply lines and gas mains are some of the crucial utility supplies for maintaining today's lifestyle.
- It is important that all the components of these utility lines function properly without break down.
- Since it is difficult to manage them manually, technologies like GIS are used to provide spatial dimensions in their monitoring.

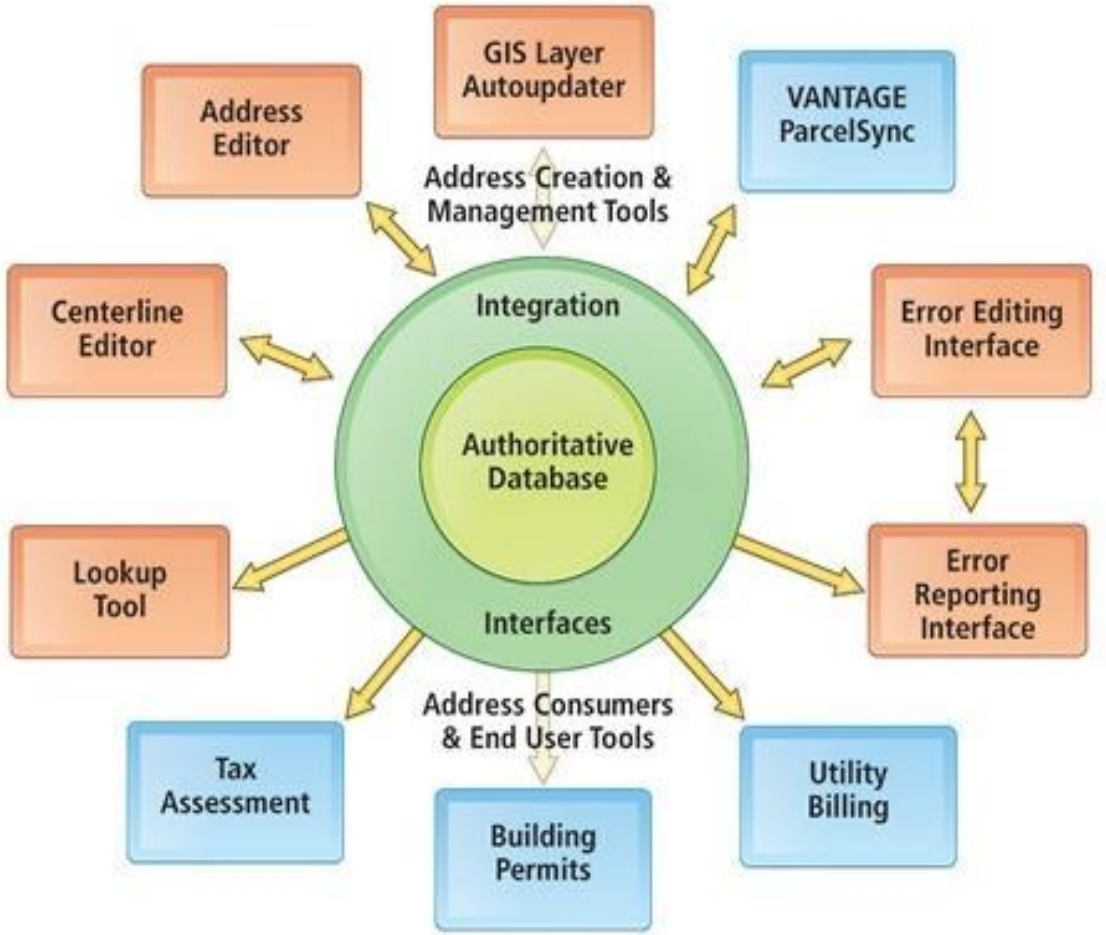


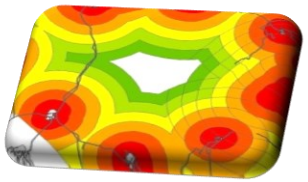
Introduction

- Utility being the nerve center and basic infrastructure requirement, utility execution team must ensure that all the components are functional with no breakdown.
- The authorities should ensure regulation in consumer services and attend to breakdown on SOS basis. This is a challenging task.
- To facilitate management of such a system, the task is made substantially flexible and the system condition if presented visually on a geographical data, it facilitates easy tacking and attention.
- Executing a GIS with a defined system design basis will go a long way in successful utility management.

GIS in utility projects

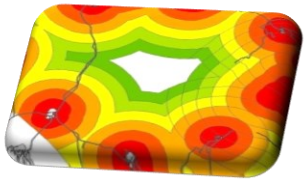






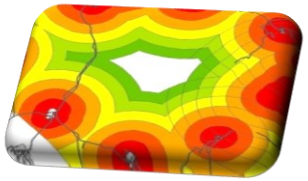
Telecommunications

- The telecommunication industry rapidly expanding. For business growth company should know where their facilities and customers exist.
- Also, locational information about this data is useful.
- GIS database can have the potential to work on these queries.



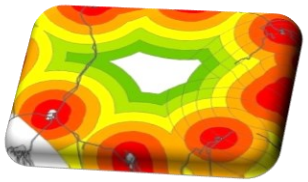
Water and wastewater utilities

- Integrating data from various sources and with geospatial data one manageable system is formed by many water and wastewater utilities.
- This system can be beneficial for the management of the flow of wastewater to businesses and service homes by tracking the location of water and meters, hydrants, valves, project consumer survey, water and energy examination, flow meter installation, hydraulic modeling, and GIS mapping components included.
- Water flow connectivity and associated consumers can identify through maps is an advantage of this GIS-based project.



Electricity Mapping

- Collection of geospatial data of distribution network of electricity lines (i.e. HT-High tension line and LT-Low tension lines)
- mapping of all electrical assets with electricity network distribution information using GIS techniques.
- the actual location of the poles, electricity lines, and actual consumption of the electricity.
- Using the collected information to balance loads, introduce new substations e.t.c

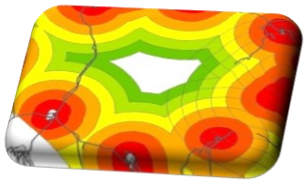


Benefits GIS for Utility Management

Increased efficiency for field operations

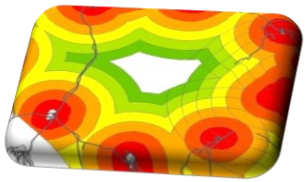
- Utility field operations are essentially a cycle of inspection and maintenance.
- Utility inspectors examine assets, document what they find, and schedule or perform any necessary maintenance.
- Keeping up with consistent inspection and maintenance is a formidable task faced by two primary roadblocks: huge territories that generate massive amounts of geo-located data, and budgetary restraints that restrict manpower.

- GIS digitizes the inspection and maintenance process: minimizing opportunities for error, eliminating manual data transfer, and reducing rework.
- With cloud-based GIS or a mobile GIS app (to supplement the desktop system), field teams can collect data directly into the GIS and then transfer to the office via digital means.
- Rather than storing data across a variety of devices, all data is automatically organized by location and stored within the same unified system.



Benefits GIS for Utility Management

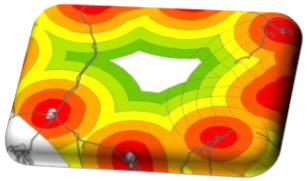
- **Effective data storage and management**
  - Historically, data management relies on a combination of paper maps, Excel spreadsheets, and even DVDs. Taken to the scale of most utility providers this approach becomes problematic. In part, it's simply an issue of volume.
  - GIS enables utilities to automatically organize information by location and store all network data in a single platform - one that doesn't require boxes of documents or burning DVDs.
  - Moreover, finding and accessing data within a GIS doesn't depend on the knowledge of a single person: anyone can open the program and, as long as files are saved appropriately, immediately access the data they need.



TYPICAL APPLICATIONS

1. GIS for utility asset management

- Utility asset management refers to the tracking and analysis of an asset's location, maintenance requirements, lifecycle stage, and overall performance.
- In the short term, effective asset management allows utilities to deliver reliable services. In the long term, it decreases operational costs while increasing asset and network lifespan.
- Infrastructure networks spread over vast territories and consist of thousands, if not millions of distinct assets: pipelines, gas meters, power lines, and so much more.



1. GIS for utility asset management

- Collecting, organizing, and sharing data effectively in such a context can be difficult; however, with GIS tools companies can streamline and simplify their approach.

- For example, with GIS for water utilities, you could place a map of pipelines, meters, and water treatment facilities over a street map, over a topographic map - creating a near instant overview of the territory.

- Project managers can share that same map with field crews, who can then add data directly to an asset while still in the field. In this case, data might include photos, videos, notes about asset's state, or even drone imagery.

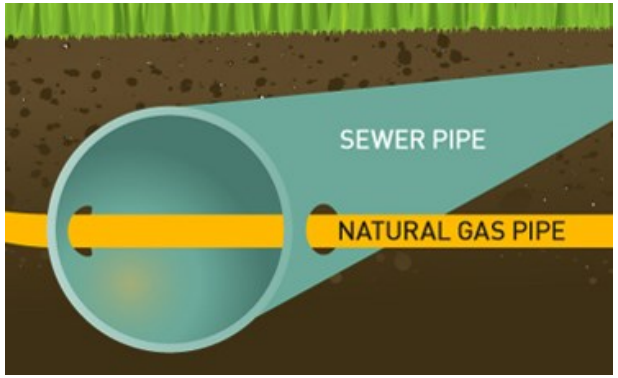
- GIS helps utilities track asset health proactively: extending an asset's lifecycle and reducing operating costs.
- Cloud-based GIS is a particularly good fit for asset management in the field. These programs enable real-time updates, reduce manual data transfer, and tend to be more user friendly than your average desktop GIS platform.

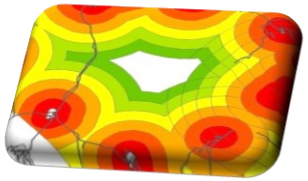
2. Outage management

- Power outage management is a perfect use case for GIS in utilities.
- Power failures cause massive financial losses for electricity providers and local businesses.
- GIS can help prevent some of these losses.
- GIS for electric utilities can enhance power outage management with real-time data mapping i.e. creating a map of the system's physical assets and showing a graphic display with the size and effect of atmospheric events.
- GIS enables faster response times for maintenance crews by helping to forecast the location and severity of potential outages.
- The faster a crew is dispatched, the faster damages are resolved, the faster power is restored. Less time between outage and restoration means more money saved by the provider and less inconvenience for those in the affected area.

3. Cross bore detection and mitigation

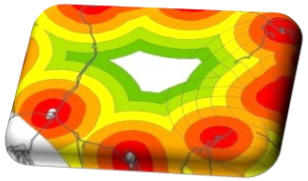
- Cross bores are the intersection of an existing underground utility by a second utility i.e. a gas line accidentally bored through a sewer line.
- Usually a byproduct of trenchless drilling, cross bores are quite dangerous and have caused numerous gas explosions
- Manual inspection is the most effective way to detect and resolve a cross bore, however with that much pipeline the process is slow and difficult to manage.
- GIS can help utilities increase the efficiency of their cross bore detection and mitigation programs by streamlining field data collection and management of historical data.





3. Cross bore detection and mitigation

- With GIS, program managers can create a map of the work area and assign parcels to inspection crews with a few clicks.
- Field crews can then upload inspection data directly on the map.
- All data is automatically saved to it's location on the map for convenient future access.
- Though GIS can't actually fix a cross bore, it can help cross bore detection and mitigation teams work faster and more efficiently - increasing safety for all.

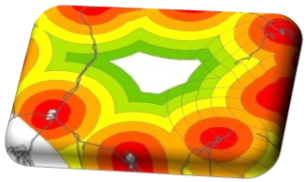


4. Telecommunications

- Telecommunications is one of the fastest-growing GIS markets in the world.
- GIS in telecommunications had a compound annual growth rate of 11% from 2013 to 2018.
- Real-time information for strategic planning is cited as the primary driver of increased demand.
- Telecommunications networks are expansive and create large quantities of geographically dispersed asset data.
- GIS provides the ideal tool for managing that data. GIS mapping enables telecom providers to enhance network planning, deployment, maintenance, operations, and even sales and marketing.

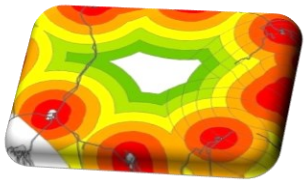
4. Telecommunications

- **Benefits of GIS In Telecommunications**
  - Increase access to and reliability of infrastructure data
  - Decrease operating costs
  - Improve operational decision-making
  - Simplify planning for future networks
  - Improve response time to network issues
  - Invest resources effectively
- Ultimately, these benefits boil down to improving operational efficiency by streamlining daily processes and increasing access to vital data.



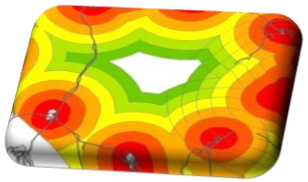
4. Telecommunications

- Telecom operations can be broken into two broad categories:
  - network planning and deployment, and
  - operations and maintenance.



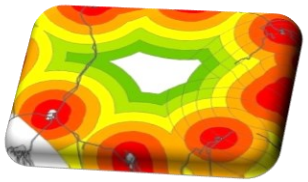
4.1 GIS in Network Planning & Deployment

- The goal of good network planning is to effectively address the needs of both operator and subscriber.
- Broadly speaking, network planning has three primary components: topological design, network synthesis, and network realization.
  - **Topological survey:** Deciding where network components should be placed and how they should be connected
  - **Network synthesis:** Deciding what size components to use
  - **Network realization:** Creating strategy on how to meet capacity requirements and maintain network reliability
  - Once network planning is complete, it's time to move to deployment.
- GIS allows users to integrate a wide variety of project **data**, including topography, population density, and predicted population trends.
- This helps create a single source of project data, enabling providers to track progress and streamline communication between field and office.



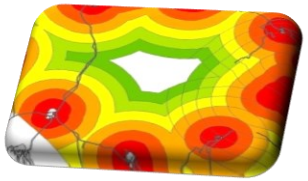
4.1 GIS in Network Planning & Deployment

- Another important aspect of network planning is determining potential market size prior to expansion.
- GIS can help telecommunications providers assess potential areas for customer growth.
- With detailed demographic information such as employment, affluence, and neighborhood characteristics, providers can **generate maps** that help to pinpoint ideal areas for network expansion.



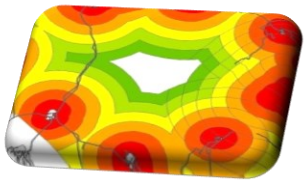
4.2 GIS in Maintenance & Operation of Existing Structures

- GIS mapping can be valuable in the maintenance and operation of network existing structures.
- The confluence of data management and location provides the ideal system for **documenting infrastructure status** and maintenance history.
- When organizing everything by location, it’s much simpler to track all the various network components: cables, ducts, towers, and even splice points.
- Once network assets have been added to the map, companies can **easily create a geo-located record of asset inspection**s, past maintenance, and notes for future work.
- As with planning and deployment, GIS essentially acts as a **unified repository for all for operations and maintenance data** - helping to provide a reliable record for future work.
- With all network data in one place, **historical asset data is easily accessible** and field inspection teams need less time for onboarding.
- **Accurate data, especially when it's available in real-time,** also helps ensure work is done correctly the first time - significantly reducing rework.



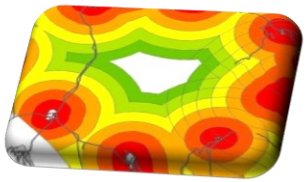
4.4 GIS for Sales & Marketing

- GIS can also be used for market analysis. Telecom companies can compare consumer preferences, lifestyles, and demographics to create well-informed market strategies.
- Using GIS for telecom market analysis allows organizations to:
  - 1. Identify new opportunities
  - 2. Analyze past and current sales
  - 3. Monitor customer sentiment
  - 4. Enhance understanding of market demand
- Telecommunications companies need to cut costs, attract new customers, and stay ahead of their competition.
- It’s not as simple as finding the oldest equipment and giving it an update — companies must focus on the areas most likely to bring in more customers.
- By enabling the ability to layer different types of information on a single map, **GIS helps telecommunications providers effectively identify areas of potential growth** - increasing the chances of good return on investment.



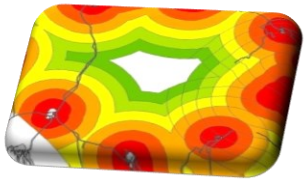
4.5 Cloud GIS for Fiber Optic Network Deployment

- Fiber optic network planning and deployment is a great example of how GIS can benefit telecommunications providers.
- As technology has advanced, old copper wire and long-distance landline networks are being replaced by fiber-optic cable. 5G networks are also dependent on fiber optic cable, as they require more speed and bandwidth than their network predecessors.
- GIS can be used **to prioritize which areas most need improvements**, determine a plan for network layout, and inform strategies on how best to meet capacity requirements.



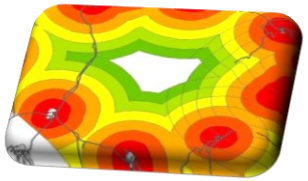
4.5 Cloud GIS for Fiber Optic Network Deployment

- Generally speaking, the fiber-optic network deployment process goes something like this:
  - Planning: Identify coverage area and optimal cable routes
  - Engineering: Design the network and estimate costs
  - Management: Gather information for maintenance and expansion after the system is in place
  - Building the GIS Database: Store and organize geospatial data
- With cloud GIS, all planning, engineering, and data are stored in one place, and all of that data can be updated and viewed in real-time.
- Companies can combine aerial and underground imagery, then add geo-located asset data in order to quickly create layered, data-rich maps. This kind of clear documentation decreases opportunities for error and streamlines communication throughout the organization.
- Cloud GIS can be accessed via any web browser, and often comes with native mobile applications - offering significant benefits for any kind of locationally dispersed work.
- Field teams can use a smartphone to capture data and make updates as they're inspecting assets and/or performing maintenance. Office teams can use their desktop computer to create maps, while project managers use a tablet to assign tasks and view



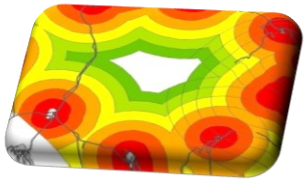
5. Oil and Gas

- Oil and gas are an integral part of the infrastructure and economy in most countries. From location and extraction, to field work management, to resource transportation - geography plays a significant role in how this industry operates.
- GIS for oil and gas enables advanced mapping and spatial analytics, increasing operational efficiency through rich location intelligence.
- With GIS oil and gas operators can:
  - Capture, analyze, and store data about potential drill sites
  - Layer data for effective pipeline mapping
  - Manage field teams remotely
  - Conduct analysis of exploratory wells
  - Receive real-time updates about site or pipeline status
- Oil and gas is a massive industry: processes have long timelines and projects span significant distances.
- Broadly speaking, oil and gas operations are broken into three categories: upstream, midstream, and downstream.



5.1 Upstream Applications

- Search - Recovery – Production : Upstream oil and gas covers both exploration and production: encompassing the search, recovery, and production of crude oil and/or natural gas.
- One of the most significant activities during this phases is the drilling and operation of exploratory wells.
- Desktop GIS technology is particularly helpful during this exploratory phase.
- Upstream oil and gas operations require precision and a high-degree of technical sophistication. Desktop GIS provides the heavy duty analysis and visualization tools necessary to manage these processes.
- Once a resource is extracted, the upstream phase is considered complete.

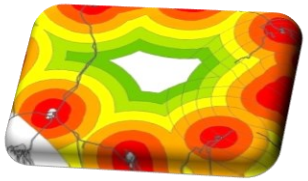


5.2 Midstream (Gas and Oil)s

- Processing - Transportation – Storage: Midstream operations connect the upstream and downstream sectors.
- In the midstream sector, oil and natural gas are processed, stored, transported, and sometimes marketed to wholesale customers.
- Here the primary concerns are generally logistical: focusing on how resources can be moved and processed most effectively.

- Midstream assets include pipelines and other transport systems. Daily operations involve moving crude oil from production sites to refineries, or from natural gas plants to downstream customers.

- There is a some amount of overlap between upstream, downstream, and the midstream sector. In other words, few operators are strictly midstream and many upstream and downstream operators manage some midstream components.

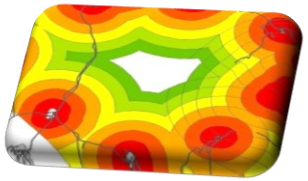


5.3 Downstream (Oil and Gas)

- Refining – Sales: Downstream oil and gas operations focus on refining both crude oil and raw natural gas, as well as sales and distribution to customers.
- Unlike upstream and midstream, the downstream sector is responsible for retail operations, so a significant facet of downstream operations is marketing.

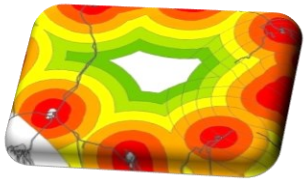
- Downstream oil and gas assets include petrochemical plants, natural gas distribution outfits, oil refineries, and retail operations such as gas stations.

- This sector covers production and management of final oil and gas products. This includes obvious substances such as gasoline and diesel, as well as hydrocarbon based products such as fertilizer, preservatives, and plastics.



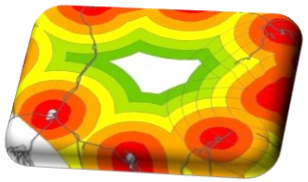
Benefits of using GIS for oil and gas

- **Well Planning (Upstream)**
  - With the rise of unconventional resources like shale gas, shale oil, and coal bed methane, GIS is being utilized more and more for well planning.
  - GIS helps users to plan well pad patterns around multiple surface drilling constraints, as well as optimize for the most efficient drill pattern configuration.
  - With GIS, users can integrate various data types, compare between current and prospective land holdings, evaluate potential sites quickly, and streamline internal decision making.



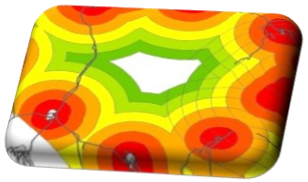
Benefits of using GIS for oil and gas

- **Pipeline Routing (Midstream)**
  - Building transport pipelines is an expensive process. If the pipeline doesn't take the best route from the upstream source to the downstream facility, overall costs rise quickly.
  - Pipeline routing can be simplified with a process called “least-cost path analysis.”
  - As the name suggests, this process identifies the route of least resistance between upstream and downstream.
  - Least-cost is determined not just by finding a straight path, but on the effort needed to pass. A user can create cost raster datasets that include information on slope and land-cover, using those variables to help determine level of estimated effort.
  - As an added benefit, GIS can also determine a more environmentally-friendly route.



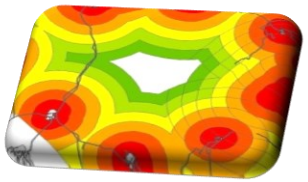
Benefits of using GIS for oil and gas

- **Refinery Management (Downstream)**
  - Refinery management involves organizing data, informing operational decisions, and reducing costs. Essentially, it's a type of asset management - a task for which GIS can be quite helpful.
  - With GIS, downstream operators can manage refineries more effectively: tracking status, managing maintenance schedules, and estimating asset lifecycle with greater accuracy.
  - With real-time data shared seamlessly between teams, refinery managers can use GIS to predict asset health and build a preventative maintenance schedule: mitigating risk and helping to avoid costly, unexpected breakdowns.



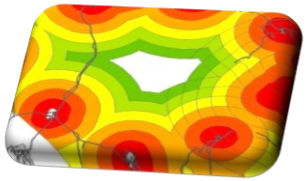
Benefits of using GIS for oil and gas

- **Emergency Response**
  - In the case of oil and gas, emergencies typically involve an oil spill or gas explosion. Fortunately, GIS can assist with both emergency planning and response management.
  - When an accident occurs, GIS enables quick access to all site data. This includes the number of field workers on-site, as well as their physical location (thanks to mobile device tracking).
  - Plus, the ability to share that information with stakeholders and even the public can be incredibly useful.
  - Ultimately, GIS enables better decision-making during emergency situations.



Benefits of using GIS for oil and gas

- **Environmental Monitoring**
  - Oil and gas companies must closely monitor environmental changes associated with their operations, especially given the current focus on shale play development.
  - Given its ability to integrate and visualize time-stamped data against a baseline case, GIS is an invaluable tool for environmental monitoring.
  - For example, if an extraction process starts causing subsidence (gradual caving or sinking in an area of land), GIS can help users quickly detect the issue, analyze it's severity, and propose an efficient plan for mitigation.



Home Work

Select an application in above discussed areas research on past implementations. You are required to develop a problem and solution in that sector. Specifically:

- Craft a problem statement of what issue you are focusing on
- Draft a flowchart showing the approach you will use
- Discuss the GIS techniques you will use in the solution
- Discuss the results that you will produce from the solution