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RESEARCH ARTICLE

PRELIMINARY DESIGN OF IRAQI SPECTRUM MANAGEMENT SOFTWARE (ISMS).

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Abstract

Spectrum is a basic natural resource as water, air energy, and so on, which has to be shared as the other natural resources due to new emerging technologies leveraging and new approaches developing to enable more effective and efficient use of the limited electromagnetic (EM) spectrum. Fortuitously, evolving software radio managements will lead to the emergence of adaptive systems that offer the potential for quantum improvements in spectrum efficiency. Central to the current systems in the range (2-6GHz) will be the main contribution of this project controlled by rules of radio spectrum management tools, directly guided to the manner in which the system uses the EM spectrum. Study of the possibilities of preventing a harmful interference to other users or services will be our main target. The obvious question is: How does this new spectrum management tool would affect the spectrum plan in Iraq. Procedures to support, guide, and manage the behaviour of signals according to different services will be taken. This work will address this central question as it relates to Spectrum Management Software for Iraq.

Introduction:-

Spectrum is like a river. We use it and it is our responsibility to keep it clean. Achieving the full promise of this vision will largely depend on how well we structure our spectrum management tool. We will have to make hard choices to achieve the tradeoffs that will bring the best balance, most capability, and greatest interoperability for the least cost. Our readiness and the force structure needed to execute our operational tasks between now and the year 2019.

It serves as the basis for focusing the strengths of each individual Service or component to exploit the full array of available capabilities and allow us to achieve full spectrum dominance in the mentioned range. It will also guide the evolution of joint education, and training to assure we will be able to achieve more seamless joint operations in the future. Lead to a success software technology aspects and basic facts must clarify, as follow:

Technology:-

Demand for radio spectrum is growing steadily due to technological, market and regulatory developments and spectrum availability will become soon a key element for future systems. This is not balanced by additional radio spectrum becoming available through the introduction of new and more, efficient technologies such as digital radio systems in the areas of broadcasting and mobile/personal communications. Technology could play a pivotal role in minimizing the interference and allowing for uniform access to the spectrum. Maximum power levels could be

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increased in rural areas so that service can be provided over larger areas at lower cost. In congested urban areas, where high transmitter power levels on one frequency can often adversely impact the use of other frequencies, the enabling of the use of lower power transmissions will be considered.

Basic Facts:-

Spectrum has some specific characteristics:

- It can be reused nearly in definitively as we increase the number of the base stations and so the infrastructure cost (Major role of economic factor).
- The service given by spectrum usage is dependant on infrastructure design (MS to BS distance) and on highly variable propagation conditions.
- Different parts of the spectrum have different characteristics in particular in propagation.

In general sense, the coexistence and sharing between systems is a recently critical issue due to emerging new technologies and spectrum scarcity. At WRC-07, ITU-R allocated many bands for IMT systems (IMT-2000 and IMT-Advanced) on a co-primary basis along with FWA, FSS and WiMAX systems. Therefore, coexistence and sharing requirements like separation distance and frequency separation must be determined. Spectrum management tool is software established to assess these requirements. Furthermore, the effect of interference in terms of Interference to Noise (I/N) ratio of co-channel and adjacent channel, Carrier to Interference (C/I) ratio as well as Carrier to Noise (C/N) ratio can be predicted by this spectrum management tool. Also, additional isolation needed for co-sited and non co-sited base stations for adjacent channel would be estimated.

Propagation models are used extensively in network planning, particularly for conducting feasibility studies and during initial deployment. They are also very important for performing interference studies as the deployment proceeds. These models can be broadly categorized into three types; empirical, deterministic and stochastic. Empirical models are those based on observations and measurements alone. The deterministic models make use of the laws governing electromagnetic wave propagation to determine the received signal power at a particular location. Deterministic models often require a complete 3-D map of the propagation environment. An example of a deterministic model is a ray tracing model. Stochastic models, on the other hand, model the environment as a series of random variables. These models are the least accurate but require the least information about the environment and use much less processing power to generate predictions.

The current surge of new techniques and systems being applied to telecommunications requires radio propagation information, especially for short range propagation within buildings, long range propagation into buildings and vehicles, better knowledge and modeling of atmospheric ducts, and the influence of climate and ionospheric parameters on propagation modeling in general. The challenges to seek frequency allocations is our aim and to satisfy the ever-increasing global radio communication requirement. Most new systems and techniques require radio propagation information to assess their frequency sharing capabilities

Background:-

The radio spectrum is a limited and valuable resource, and as a result of the drastic growth demand for wireless communication applications, radio spectrum regulation and management have become increasingly significant (J. Mitola (1999)).

Due to scarcity of the frequency spectrum, many bands are allocated for more than one radio service and thus the sharing is necessity. Therefore, the increased sharing of spectrum translates into a higher likelihood of users interfering with one another (SDRF Technical Report 2.0, (1999)). Interference between two wireless communication systems (intersystem interference) occurs when these systems operate at overlapping frequencies, sharing the same physical environment, at the same time with overlapping antenna patterns which leads to capacity loss and coverage limitation.

The economic implications of spectrum misallocation (wrong pricing, scarcity, congestion) were recognised early (Herzel 1951; Coase 1959; 1960; Levin 1966; De Vany et al. 1969) but its manifestation only became obvious with recent shifts from wireline to wireless systems in telecommunications markets. This radical transformation of the spectrum user market considerably increased demand for specific bands, altering, in various countries, the methods commonly used to assign user rights.

International Telecommunication Union for Radiocommunication (ITU-R) has become involved with the spectrum allocation for next generation mobile communication services in WRC-07. During work performed within ITU-R working party (WP) 8F, several of the frequency bands had been identified for the future development of International Mobile Telecommunications–Advanced (IMT-Advanced) systems (Joint Tactical Radio System (JTRS) Operational Requirements Document (ORD), (1998)). These bands are already being used for current services like Fixed Wireless Access (FWA), fixed satellite services and WiMAX systems in many countries around the world including Iraq, which means that the probability of happening of the interference is probable. Therefore, the spectrum management and propagation prediction issues should be preceded by sharing and coexistence verification between current services and future systems(Federal Communications Commission, (2000)).

The radio frequency spectrum is a key strategic asset for the economies of industrialized nations. It is used for a broad range of business and consumer communication, R&D and IT purposes, such as private and public telecommunication operations (e.g., Fixed satellite receiver, wireless internet communication, aviation, shipping, defense, public safety), broadcasting, radar, astronomy and various other applications including countless short-range, low-power wireless devices. Sound and socially efficient management of electromagnetic spectrum usage is a key input into the performance of these markets. Flexible regulatory regimes and technologies that make spectrum use more accessible to start-ups and other small innovative operators offer significant potential to reduce lead times from innovation to market for communication products (Berggren et al. 2004; Chapin & Lehr 2007).

By contrast, current control and command arrangements in most countries rest on administrative licensing regimes that allocate blocks of spectrum to specific uses and entities (often large operators) as the need arises. Originally, control and command through licensing presented desirable properties in terms of interference control, international harmonization of frequency allocation and new products standardizations. However, as demand for spectrum rights grew spectacularly over time, the problem of spectrum scarcity became the main issue(E. M. Noam,(1995)).

Frequency Management Systems Use of GIS:-

Canada could be a good example since it has an international reputation for its ability to efficiently manage its frequency spectrum. Many of these spectrum management techniques and business practices have been incorporated into Automated Frequency Management System (AFMS) over the last decade.

In the frequency engineering realm analytical systems have been used for more than a decade. These tools are part of the solution telecom companies employ when designing telecom infrastructure and applying for frequency allocations. Spectrum regulators have only recently employed GIS as a means of speeding their application process in response to the growing demand for frequency allotments by telecom companies. More and more national regulators are focusing on the Technical Analysis and GIS components of Frequency Management systems (W. Kennard, FCC Chairman,(2000)).

Current Challenges:-

As mentioned previously, frequency management systems have only recently incorporated GIS. The following is a list of the current challenges both regulators and telecom applicants' face.

1. Regulators are not set-up to allow secure external access to information, therefore limiting applicant's ability to assess their application against the national database.
2. Regulators use worst case propagation modeling there by limiting their ability to use natural and man made barriers to propagation and limiting the number of potential frequency allocations for a given area.
3. Regulators and telecoms may not use the same map information for their assessments resulting in different analysis of frequency coverage.
4. Length of time required for interaction between regulators and telecoms penalizes growth.

The GIS Framework is an architecture that solves a specific requirement. In this case the requirement is to utilize spatial information and GIS processing for a more effective management of frequency allocations and take advantage of automated processes and imbed the functionality within the overall application workflow (Alex LIGHTMAN, (2002)).

Objectives:-

A spectrum management tool contains objectives and activities for radio frequency management and spectrum monitoring and control, including:

- To verify the feasibility of coexistence between the two systems depending on the input specification.

- To determine the separation distance and frequency separation to coexist the two systems.
- To estimate the additional isolation to decrease interference and achieve coexistence and thus spectrum efficiency.
- Analysis of channel occupancy measurements.
- Technical measurements: frequency, bandwidth, signal strength, signals & systems analysis, etc.
- statistical data for frequency management purposes
- frequency planning
- Estimate the coverage based on the ITU models.

Scope of work:-

To carry the previous objectives of spectrum management tools and to achieve sharing and coexistence between systems all necessary formulas should be included in a data base as a library. All required standard coexistence and interference criterion values should be adjusted. Specifications, lowest and highest parameters values have to be assessed and Suitable radio propagation models and its parameters and standard values should be estimated. All the date required will be covered by study and analysis and the parameters will be taken according to the ITU recommendations, in term to prepare high accurate software according to the Iraqi environment. Later on, the results should be applied in the software by using computer language in order to obtain the objectives within a good looking (as mentioned by the methodology) (Radiocom Agency, (2002).

the principal components of a spectrum management program would involve the following activities like co-ordinate bilaterally the allocation of frequencies, depend on standards for radio equipment and systems (like ITU), establish operating procedures, and ensure radio apparatus are approved for use.

The propagation prediction part will be carried out by applying all the formals for the chosen ITU models, the antenna parameters such as radiation pattern, antenna gain will be assessed according to the standard values, propagation model will be suggested to the user based on different scenarios.

Design flowchart:-

Spectrum management software looks into both the technology and law side of the problem and recommended ways in which we can make more efficient utilization of the spectrum to achieve our objectives, the research divided into three parts in order to cover propagation prediction and interference investigations:

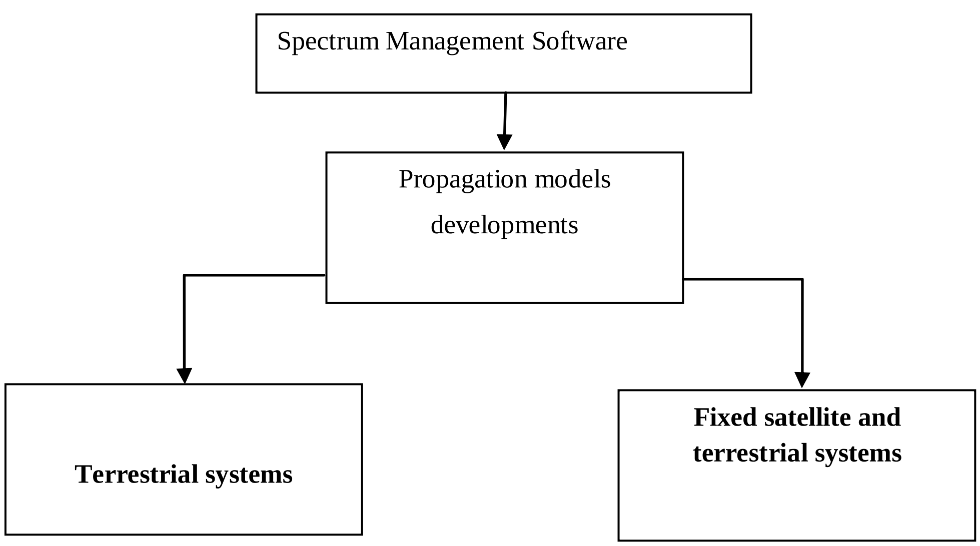

Figure 1: Spectrum management software main divisions.

Spectrum management propagation models developments :-

Phase 1: Propagation model library development

In this stage the all the formals from the chosen ITU models will be developed in Dynamic linked library files (Dll) using C++ programming language all related information for the propagation models will be taken into consideration.

A Dll is a library of functions that is not included in executables and that can be loaded and used dynamically .Dynamic Link Libraries are useful way to run simulations or computations on various Microsoft application with only one single file that contains all functions .It allows an easy and flexible management of the upgrade of Dll Functions (Special Issue of IEEE Personal Communications, August 1999).

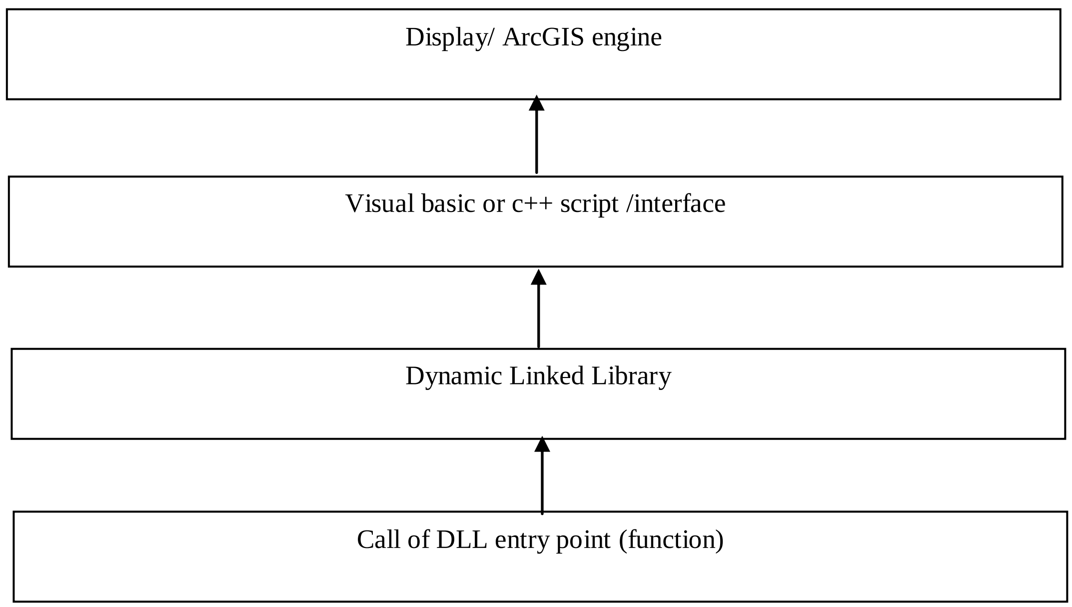

Figure 2: Spectrum management library development

Phase 2 (Inputs): Antenna parameters database will be build in ASCII format to be accessible by the propagation models. The standard types of the available antenna database will developed. The general parameters of the antenna will be accessible for adjusting purposes (TIA,(2002)).

Phase 3 (Outputs): Coverage prediction, Interference calculation will be base on the input scenario and the results will be displayed which allow the user identify the possible coverage based on chosen model and the specific scenario used (Cengiz EVCI et (2001).

Spectrum management between terrestrial systems:-

In the methodology of the spectrum management tool, there are number of stages should be follow to achieve the aforementioned objectives,

Phase 1 Database configuration: In which all the following should be formed and arranged: necessary formulas, required parameters and specifications for transmitters and receivers, type of deployment area, sharing and coexistence criterion. Propagation wave model also is a part of project requirements.

Phase 2 Interference Analysis: Perform an analysis on a frequency that has interference to determine the potential interference from existing transmitters or to existing receivers by determine the type of analysis model and interference scenario (co-channel, adjacent channel, guard band or overlapping).

Phase 3 results and Outcome: Desired and interference signal strength, Separation distance and frequency separation, additional isolation needed for each co-channel and adjacent channel either by spectrum emission mask model or adjacent channel interference model.

Phase 4 **Interference Report**: Create new interference reports and output them to the printer or to a file compatible with the system.

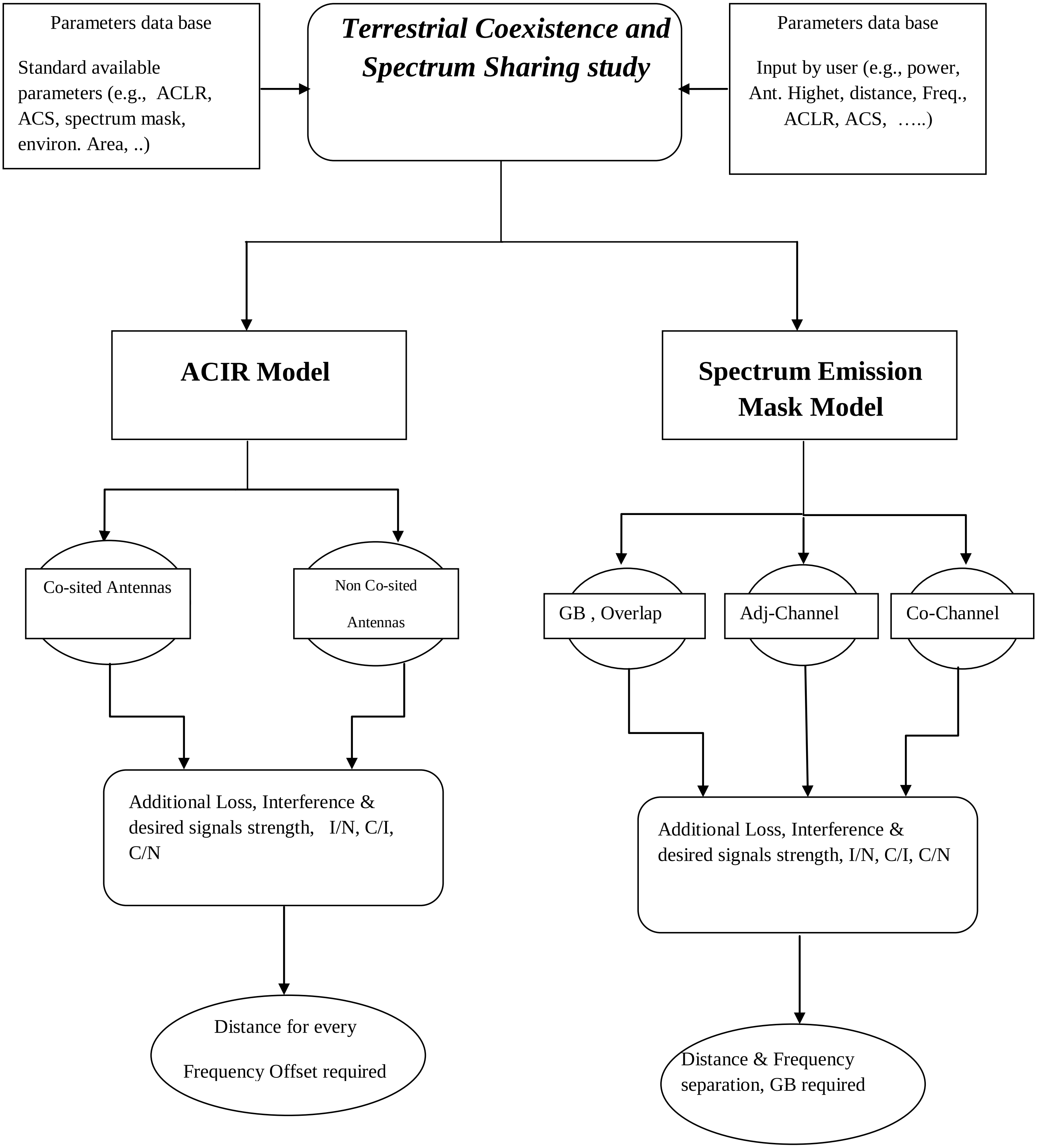

Figure 3: Flow Chart for Spectrum Management Tool Methodology Proposal.

Spectrum management between Fixed satellite and terrestrial systems:-

Phase 1 (Frequency Range): We chose the frequency range to suite the FSS and FWA band requirements. However, the FSS frequency range have already sat to be from 3400-4200MHz, at the same time we have the point to point FWA which suppose to operate on frequency range 3400-3600MHz. For FWA as point to multipoint we will cover this service because it's assigned globally by ITU to be work in frequency range 3400-3700MHz, so the software should be able to cover this service as well. Furthermore, we will cover the range 3300-3400MHz as an expected band for FWA because in a case that we will shift this services to be work on the band mentioned above we need a software to calculate the possibilities of deployments (Proceedings of 2nd.European Colloquium, (2002)).

Phase 2 (Inputs): Several types of information should be clarified, in term that we want a high capability and performance. For FSS inputs like propagation models (which will be base on ITU-R), select receiver type & specifications (ITU base) and multiple access technique (E. Goodman. (2004, Mar)). For FWA we should consider the propagation models, receiver/transmitter Type and coverage (base on ITU), multiple access technique.

Phase 3 (Outputs): Interference calculation will be base on the input scenario and the results will be generated in a report which should include the interred case and the possible mitigations base on graphs. Recommendations will be provided (FCC. (2002, Nov)). Study will cover both co-channel and adjacent channel, for the adjacent channel all the possibilities of guard band will be included inside the library. However in the end we will be able to find the possibilities of deploy different services base on spectral power distribution.

Phase 4: Programming issues like data input, representing the date output, graphical design, generating reports and recommendations, ability to cover the mistakes, future developments base on the feedback and Compressions with the existing software.

System Outputs:-

The system output and results for this work are:

- Implementation of ITU-R propagation models for various radio services between 2 to 6 GHz.
- Verifying of the feasibility of coexistence between the two systems depending on the input specification by means standard criterion (e.g., I/N).
- Determination of the separation distance and frequency separation to coexist the two systems in case of Co-channel interference and adjacent channel interference.
- Estimation of the additional isolation to decrease the interference and achieve coexistence.
- Geographical Iraqi map based utilization and generation of the electronic report.
- Expecting recording frequency applications, frequency plans, frequency assignments, technical details and interferences.
- Identifying the priority of data items required for registration of stations in electronic data base.
- User-friendly data entry masks with on-line data validation mechanisms, if applicable.
- Signal strength calculation using propagation models within a selected area (coverage area), along a profile, along a polygon, at given points.
- Calculation of network coverage.
- Interference calculation around the concerned terrestrial transmitters and victim receivers.
- Interference calculation between Geostationary satellite Earth stations and BWA stations.
- Interference analysis for assigning frequencies to stations in given locations using relevant ITU-R recommendations, protection ratios and PSD (Power Spectral Density) masks of emissions.

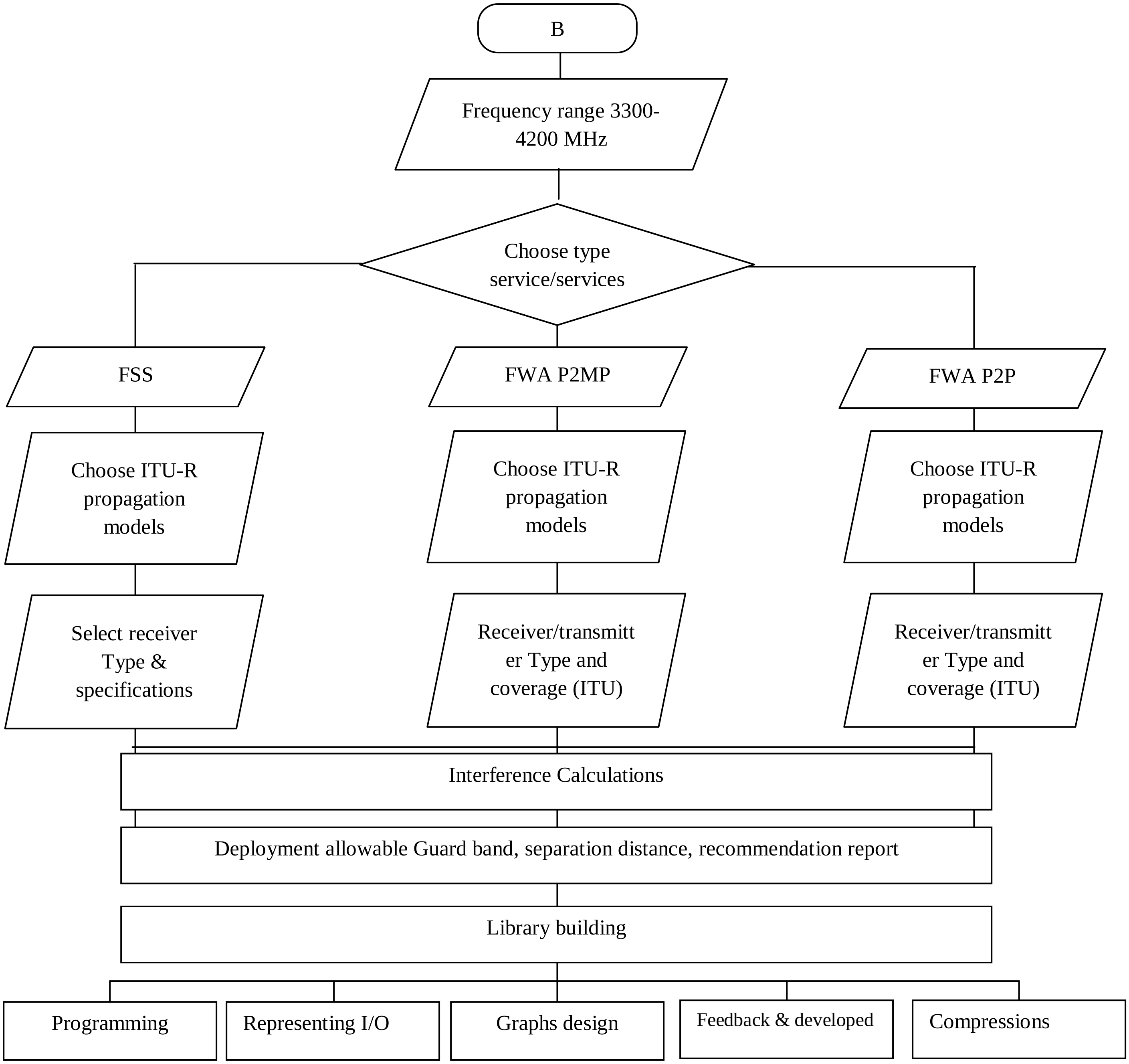

Figure 4: Flow Chart for Spectrum Management Tool Methodology Proposal

Conclusion:-

The information which will be gathered from this investigation will be extremely useful for Iraq to share with other countries through APT, WRC and other ITU forums. In addition to that new specialists to deal with new technologies on horizon will have a chance to explore more into this area. There will be good economic benefits for this project like: cost saving, revenue from consultancies, future estimation demand, and royalties from tools licensing.

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