Education Office

Call for Proposals

Contents

1. Project Background and Objectives

The ESA Education Office is setting up a Global Educational Network for Satellite Operations (GENSO). GENSO aims to increase the return from educational space missions by forming a worldwide network of ground stations and spacecraft which can interact via a software standard.

Educational space missions are often hampered by the relatively small communication windows offered by their typically low orbits and local ground stations. GENSO allows each ground station on the network to communicate with non-local spacecraft and share data with the spacecraft controllers via the internet. This will dramatically increase the level of access to the spacecraft and greatly increase the return from educational space missions.

The design and implementation work is being carried out by a distributed set of student and radio amateur teams worldwide and with over 80 educational spacecraft currently planned there is a very large demand for such a project.

GENSO aims to provide:

- Unparalleled near-global access to the mission operators of educational and radio amateur spacecraft
- Remote access for operators to real-time mission data, even in cases when their local ground station is experiencing technical difficulties
- Scheduling of remote uplink sessions via trusted ground stations
- Optional automatic remote control of all participating ground stations
- Downlink error-correction by comparing multiple data streams
- Definition of an optional standard solution for educational ground-segment hardware, designed to optimise return from GENSO at minimal cost
- Recommendations for future educational space hardware in order to enhance mission return utilising GENSO
- Close collaboration with the amateur radio community to support a common interface for applying for frequency allocation and coordination.

GENSO is expected to attract a large number of like-minded people and projects. This community will be a valuable resource, not only for increased access to spacecraft, but also for advice, technical support for ground and space hardware, object identification on busy launches, assistance during critical mission operations, and many other possibilities.

2. Current Status of Project

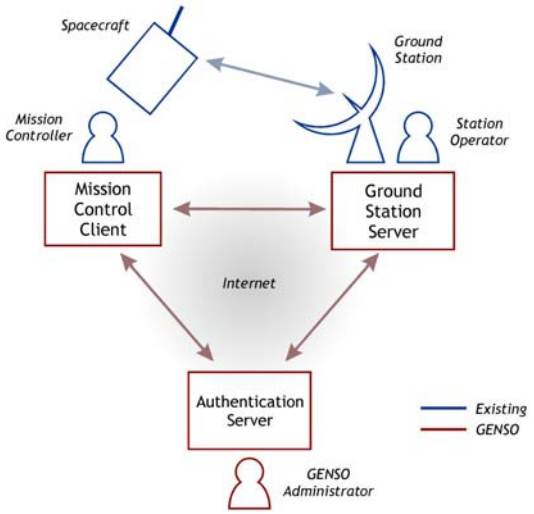
The project has been running for two years and a proof of concept has been demonstrated. A review and consolidation of requirements and software design is underway and advanced development will soon begin. The software will be developed according to an evolutionary model with overlapping lifecycle phases and incremental releases. The first operational system is due for release in September 2009.

Project Timeline

January - June 2007	Preliminary Design and Development Phase
July 2007	Preliminary Design Review
July - November 2007	Preliminary Implementation
December 2007- August 2008	Core Development and Alpha Testing (with 5 ground stations)
September 2008 - March 2009	Consolidation of requirements and software design
December 2008 - July 2009	Advanced Development and Beta Testing (with ~20 ground stations)
April 2009	Critical Design Review
July - August 2009	Preparation for Network Deployment
September 2009	First public software release
September 2009 - March 2010	Enhanced Development and Testing
April 2010	Second public software release

3. GENSO System Description

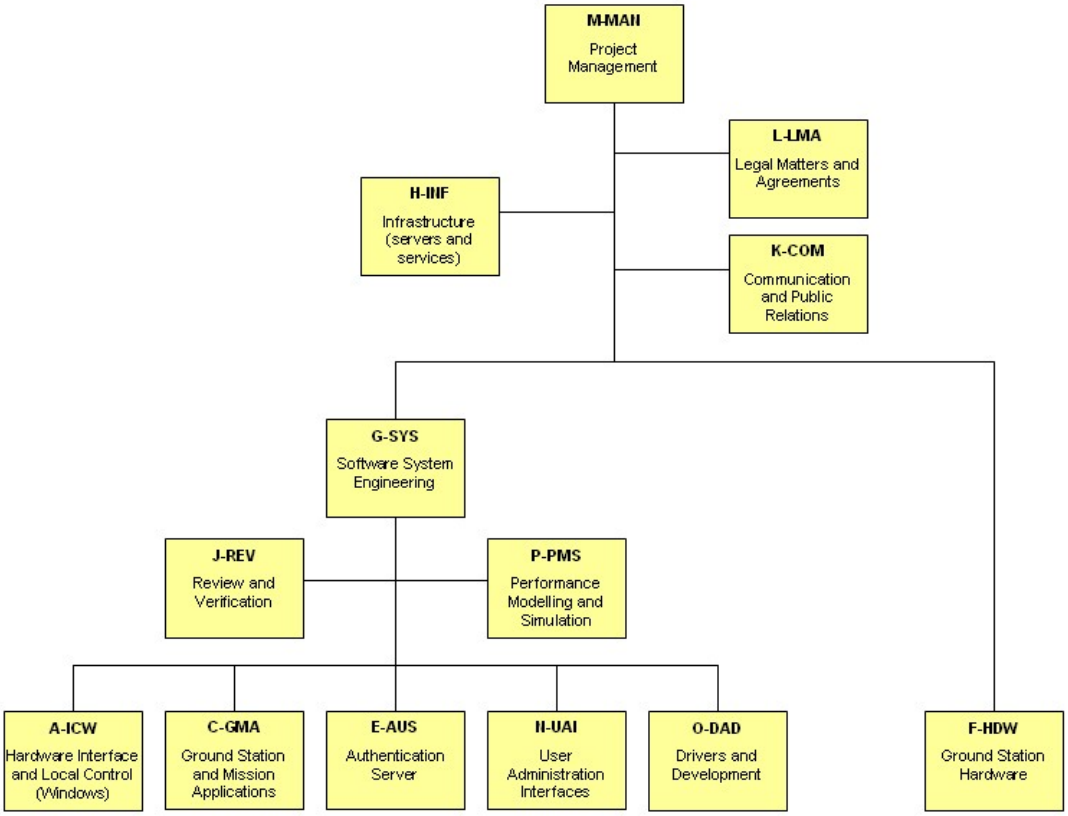
At the heart of GENSO are two software applications: the Ground Station Server (GSS) and Mission Control Client (MCC). These are installed at the local ground station and mission control, respectively. All instances of the GSS and MCC will connect to the Authentication Server (AUS) which controls the network. The AUS allows ground stations to automatically track and establish downlink sessions with all compatible participating spacecraft and allows spacecraft to be automatically tracked by all compatible participating ground stations.



For a detailed system description and discussion of the benefits of GENSO, see the paper IAC-08-B4.3 (Page, Preindl & Nikolaidis, 2008).

4. GENSO Team Structure

The diagram below shows the distribution of the work amongst the project teams, under the management of the ESA Education Office. The majority of participants are students, however the project is also supported by radio amateurs and an industrial contractor.



4.1 Team responsibilities: Software system development teams (coordinated by G-SYS)

G-SYS: System Engineering
Responsible for leadership of the software development. This includes: identifying stakeholders' requirements; defining, developing and controlling all interface specifications; coordinating functional testing plans and progression; and taking project-level technical decisions.

Assigned under contract to: Vega Group PLC

A-ICW: Hardware Interface and Local Control (Windows)
Responsible for design, development and implementation of the Hardware Interface and Local Control modules of the Ground Station Server, for Microsoft Windows. Also responsible for developing the interface between GENSO and the Japanese Ground Station Network (GSN) via the Ground Station Remote Operation Web Service (GROWS).

Assigned to: University of Tokyo, Japan

C-GMA: Ground Station and Mission Applications
Responsible for design, development and implementation of the core applications:

- Hardware Abstraction Layer (HAL)
- Ground Station Server (GSS)
- Mission Control Client (MCC)

Assigned to: Aalborg University, Denmark

E-AUS: Authentication Server
Responsible for design, development and implementation of the Authentication Servers and the Network Interfaces.

Assigned to: TU Vienna, Austria

N-UAI: User Admin Interfaces
Responsible for design and development of interfaces for the administration of end users and the end user database. Finished interfaces will be handed over to H-INF for operation and maintenance. Also responsible for drafting user manuals and system operational procedures.

Currently unassigned

O-DAD: Drivers and Development
Responsible for the coordinated development of a library of appropriate device drivers and operation of the development ground station at ESTEC.

Assigned to: AMSAT-UK / ESA radio amateurs

J-REV: Review and Verification
Responsible for planning, organisation and implementation of project reviews and design and product verification.

Assigned to: CalPoly, USA

P-PMS: Performance Modelling and Simulation
Responsible for performance analysis, modelling and simulation of GENSO functions prior to

software releases.
Currently unassigned

4.2 Team responsibilities: Other development teams (coordinated by M-MAN)

M-MAN: Project Management
Responsible for the overall project management. This includes: planning; identifying, recruiting, and coordinating network participants; financial support of teams and activities; interfacing with ISEB; and organisation of workshops.

Assigned to: ESA Education Office

H-INF: Project Infrastructure (servers and services)
Responsible for design, implementation and maintenance of appropriate infrastructure to support the project, including IRC, NNTP, FTP and HTTP servers. Also responsible for operation and maintenance of user interfaces, once these have been defined by N-UAI.

Assigned under contract to: FH Technikum Vienna, Austria

K-COM: Communication
Responsible for design and content of the project website, graphical identity of project and interfacing with the general public and media.

Currently unassigned

L-LMA: Legal Matters and Agreements
Responsible for investigating relevant legal issues and developing user agreements.

Assigned to: University Jean Monnet, Paris XI, France

F-HDW: Ground Station Hardware
Responsible for description of the functionality necessary for a GENSO ground station, making recommendations for hardware design and providing advice for the set up of various ground stations in support of the network.

Assigned to: AMSAT-UK, UK

5. Responding to the Call for Proposals

The call is open to students and amateur radio enthusiasts from any country, although preference will be given to students from the member countries of the ISEB Agencies, in particular if their participation is well supported by their universities.

The projects outlined below have been identified by current team members as tasks which are distinct enough to be suitable for a university project or thesis, while still forming a valuable addition to the overall GENSO project. Combinations of projects or new, original projects relevant to GENSO may also be proposed.

Expressions of interest should be submitted to genso@esa.int using the template provided. Prior to submitting a proposal, interested parties may contact the same address with any questions.

The initial deadline for responding to the call is 12 December 2008. After this time, any projects still open or future opportunities that arise will be advertised on the GENSO project website at http://genso.org. A separate call for ground stations to test the software is envisaged in early 2009.

6. Open Projects – Statements of Work

Below is a description of each of the projects which have been identified by the current team members as opportunities for new students or new teams to join the project. The effort needed is estimated according to the following key:

S – Small university project or practical – 1 semester (4 months), 4-6 hrs per week
B – Bachelor's thesis / final project – 1 semester, 20-30 hrs per week
M – Masters thesis (M) – 1-2 semesters, 20-30 hrs per week, higher level than Bachelor
P – PhD thesis – 2-3 years, full time, research project
[*project of high priority for the first software release]

A-ICW

1. Adding modem support to GMS
   - S - 1 person

This project aims to update / upgrade the Ground Station Management Software (GMS) so that it will include the drivers for the Terminal Node Controller (TNC) in order to support the modem to operate in such a way that it receives and/or transmits packet data from and to a spacecraft.

2. Adding rotator support to GMS (AZ & EL 1000 [RC2800] / G-5500 [GS-232B]) (driver)
   - S - 1 person

This project aims to update / upgrade the Ground Station Management Software (GMS) so that it will include the drivers for the M2 [AZ & EL 1000] and YAESU [G-5500] in order to support the Rotators and respectively their computer control interfaces (RC2800 & GS-232B). This will allow the GMS to control the rotators in an efficient and a safe manner (avoiding any jerky movements and probable future mechanical problems that can develop) so that it will track a Low Earth Orbit (LEO) spacecraft along its pathway above a ground station.

3. Adding audio support to GMS
   - S - 2 people minimum

This project aims to add Audio Support to the Ground Station Management Software (GMS). This will allow the GMS to transmit audio that has been captured directly from the Radio or from the TNC in an optimum manner. It shall also be investigated whether audio compression techniques can be applied without any quality compromise, so that mission control Operators can pick up these signals and further analyse them.

4. GENSO GROWS Gateway Server (UNISEC preferred)
   - B - 1 person

This project aims to create, update and improve the Gateway Server between the GENSO Software applications and the Ground Station Remote Operation Web Service (GROWS) for GMS.

C-GMA (projects related to the Hardware Abstraction Layer)

5. Protocol transcoder
    - M – 1 person

This project aims to implement a Protocol Transcoder for the GENSO software applications. A framework prototype and examples for the most common protocols are already provided. The framework shall be extended by all necessary functions and additional protocols shall be added. Meta-information about packet loss rate and bit error rate shall be derived and provided to upper layers.

6. Software Modem
    - M – 1 person or B – 2 persons

This project aims to implement a Software Modem (MOdulator / DEModulator) for the GENSO Software Applications. It will be coded using mainly the Java Programming Language and form the first platform independent software modem framework. Meta-information about signal/carrier to noise ratio and bit error rate shall be derived and provided to upper layers.

7. Software Radio
    - M – 1 person or B – 2 persons

This project aims to implement a Software Radio for the GENSO Software Applications. It will be coded using mainly the Java Programming Language. Meta-information about signal/carrier to noise ratio and bit error rate are going to be derived and provided to upper layers.

8. Hardware Abstraction Layer (HAL) upgrade
    - S – 1 person

This project aims to update / upgrade the Hardware Abstraction Layer (HAL) that exists in the GSS Application. HAL is responsible for providing the interface between the Hardware Equipment and the user commands that are sent to them through the Java Programming Language. The goal is to further develop the existing HAL infrastructure in order to handle more commands and inter-operate with the drivers developed for the various hardware equipment used in ground.

C-GMA (projects related to the GSS and MCC)

9. Hardware configuration (graphical drag'n'drop)
    - B – 3-4 people

See also projects 16, 17.

This project aims to enhance the Ground Station Server (GSS) Application, especially the hardware capabilities configuration and the way a user interacts with it through the GSS. In the current situation, the GSS needs a manual configuration script for all possible pipelines to be matched with upcoming satellite passes. In the future there should be an option to define the hardware configuration of the ground station graphically using modern state-of-the-art "drag-and-drop" mechanisms. The provided sets of assembly parts for the configuration should mirror the available drivers in GENSO. The pipeline derivation out of the graphically assembled hardware configuration should be completely automated and could probably work out to be a classical computational "configuration problem" requiring sophisticated algorithms to identify dependencies and exclusions.

10. Real-time streaming (data/audio/voice) *
    - B – 1 person (at least)

This project aims to enhance the Ground Station Server (GSS) and the Mission Control Client (MCC) with secure Real Time Streaming Capabilities when these Applications come to a point where data/audio/voice exchange is needed and in real time as far as possible overcoming some major constraints. Investigation of compression techniques for data/audio/voice will be probably needed as well as any other techniques that will allow real-time streaming capability. The operation with the provided SSL API for secure and validated data transfers is mandatory.
This functionality is vital to the ongoing development of GENSO to support an active 2-way space link. There is plenty of scope to extend this project to address the issues of booking passes; however this is a complex area which overlaps with project 12, and the first priority is to concentrate on enabling the data flow.

11. "Wall plugs" (pass report delivery to user/API)
    - S – 1 person

This project aims to provide an Application Programming Interface (API) for the Mission Control Client (MCC) "Wall-Plug" feature. The "Wall-Plug" will be responsible for pass report delivery to the end users in a report style format as well as for providing a stream of data that derives from the MCC to other custom-made telemetry software applications. This will give the opportunity to mission operators to gather and store these data but visualize them in a separate software application of their choice and of course analyse them further.

E-AUS

12. Central Scheduler (optimisation, conflict resolution, knowledge based system)
    - P – one person
    - and / or M – several people

This project aims to study a potential Central Scheduler that could be used in GENSO. It will be responsible for predicting the best passes of spacecrafts for all the Ground Stations (GS) participating in the project, trying to optimise the efficiency of the system, maximizing in this case the return of data from space missions, as well as resolving conflict resolutions that will definitely appear due to spacecraft overlapping (two or more satellites having a pass above a ground station at the exact the same or slightly different time windows so that their footprints overlap one another). One of the input values for the scheduling decisions are the quality predictions derived from a current developer's PhD project work.

This is a classical, probably distributed, scheduling problem compared to flight plan calculations but most obviously novel in this domain – one approach could be the application of sophisticated knowledge based decision systems utilising a logical reasoner based on several input variables, e.g.

- Matching pipelines for an upcoming pass
- Load of the ground station (to avoid hardware damage)
- Availability schedule of the ground station
- Predicted pass link quality
- Fairness
- Prioritization (e.g. due to emergencies, affiliations...)
- Black-/Whitelists
- Duration of a pass
- .....

Network and machine load has to taken into account. When heading for a knowledge based solution the creation of e.g. a Prolog prototype is supposed.

13. Redundant Server Clustering
    - B – 1 person

This project aims to study the Redundant Server Clustering for the Authentication Server (AUS). It has been foreseen that there will be three Authentication Servers in the GENSO Network, geographically dispersed, each one of them located in one of the following continents a)Europe, b)Asia and c)America. This is mainly for security and redundancy reasons, but also for covering as many different time zones as possible, in the case that administration issues are needed. The outcome of this project will be to find a way to replicate the GENSO Database (DB), in all three servers, in a secure and optimum way in order to keep the cluster of servers updated at all times without any fear of security compromise or network overloading issues.

14. Space Communication Quality Assurance
    - B – 1 or more persons

This project aims to collect data about satellite link communication quality and possible influencing parameters (surface weather, space weather, astronomical data), their aggregation and normalization and the integration in a pass quality prediction model.

15. NAT-Traversal
    - B – 1 person

This project aims to extend the current SSL network API and probably also the AUS, so that the GSS server no longer needs to provide an open TCP port to the public. A Skype-like ability of NAT traversal shall be achieved. The avoidance of open TCP ports significantly increases usability and simplifies setup and operation of a ground station server in restricted environments.

N-UAI

These are some of the highest priority projects for the GENSO release planned for summer 2008. The work is concerned with developing the user interfaces for the GSS (for Ground Station Operator), MCC (for Mission Operator) and central server (various users). This entails understanding the user requirements, and designing, building and delivering high quality, robust GUI and associated user documentation.

N.B. The N-UAI work package is not currently assigned to a particular university. The work may be partitioned in different ways, for example the GSS and MCC may be assigned separately, and/or the design and implementation phases combined. Preference will be given to team proposals covering more than one project – a team leader should be nominated.

16. Design of Graphical User Interfaces (GUIs) for GSS and MCC and web interfaces *
    - B – 3-4 people (Designers)

This project aims to design Graphical User Interfaces (GUI) for the Ground Station Server (GSS) and the Mission Control Client (MCC) Applications. This phase will take into consideration the purpose of existence of these software applications and will examine the needs of specific elements (2D or 3D Earth models with ground tracks in the mission control client and/or pipeline configuration and azimuth/elevation values for satellite passes for the ground station server) that should be present in order to maximise the amount of useful data that can be extracted from the applications, as well as be user-friendly with attractive graphics.

17. Implementation of Graphical User Interfaces for GSS and MCC *
    - M – 3-4 people (Java)

This project aims to implement the Graphical User Interfaces (GUI) for the Ground Station Server (GSS) and the Mission Control Client (MCC) Applications that have been designed. The software coding will be done in JAVA, as both GENSO applications are written in this programming language, with the help or using in addition any other compatible tool / programming language for succeeding this goal. There will be interaction with the design team, as well as with the software development teams, for better understanding and to achieve the optimal outcome.

18. Implementation of web interfaces (admin & end-users) *
    - M – 1-2 people (php)

This project aims to implement various Web Interfaces mainly for the Administrators and for the End-Users. The software coding will be done in PHP. There will be interaction between the design team and the Hardware team (radio amateurs), the Ground Station Operators, as well as with the software developers for better understanding of what is needed.

O-DAD

19. Drivers for a specified hardware item
    - S / B – many people, depends on drivers

This project aims to develop drivers for some specific ground station hardware which is not currently included in the GENSO driver library. Drivers will be needed for rotators and respectively for their computer control interfaces, for radios, TNCs, etc.

20. Iterative development and review
    - Needs an experienced software developer / mature student / professor on sabbatical

This project aims to explore the opportunities that exist for the Software Methodology of Iterative Development and Review of the Software Code in the GENSO Project. The applications are written using the Java Programming Language, the code is controlled and updated in a distributed manner using the Sub-Version system and there are Nightly Builds currently using the Cruise Control program but soon there will be an upgrade to Hudson.

J-REV

21. Simulation Tool *
    - M – many people (individually)

This project aims to create a Simulation Tool for testing the GENSO Network. There will be Spacecraft simulator well as Ground Station simulation capabilities. In that way, we will be able to populate our simulation scenarios with various satellites and of course plenty of ground segments, with different Transmitting (Tx) and Receiving (Rx) capabilities / frequencies / modes. These entities will communicate natively by design with one of the three Authentication Servers (AUS) and the result will be to see a as far as accurate result regarding the Network stress but also discover some parameters that will derive automatically such as which stations of the network are more useful or which satellites (or equally satellite orbits) are in favour for maximum data downlink/uplink among others.

P-PMS

N.B. The P-PMS work package is not currently assigned to a particular university. Preference will be given to team proposals covering more than one project – a team leader should be nominated.

22. Performance analysis / modelling / simulation
    - B / M – many people individually or in small teams

This new team will be responsible for Performance Analysis, Modelling and Simulation of GENSO. In other words three key elements that needs to be studied carefully prior to any official release of GENSO. The team can make good use of the Simulation software that is under development by another GENSO team and based upon that reach the conclusions such as which stations of the network are more useful or which satellites (or equally satellite orbits) are in favour for maximum data downlink/uplink among others.

H-INF

23. Help / knowledge forum
    - S – 1 person

The intended Internet forum is a web application for holding discussions and posting user-generated content. The forum should be able to deal with specific sub-forums dealing with a distinct topic. Messages within these sub-forums are then displayed either in chronological order or as threaded discussions.

In our case the forum should support developments around forums that have regular users.

Membership and Anonymity

Anonymous forums may offer full anonymity or pseudonymity, allowing posts without registration. Captchas, e-mail authentication, and tripcodes are often used to prevent comment spam on such forums.

Registered members of a forum, who are identified by unique usernames, may have additional privileges, such as the ability to edit their previous posts, start new topics, and control their individual settings and profiles. The profiles tend to include graphical avatars and signature blocks which are appended to their future posts, sometimes consisting of elaborate shoutboxes. Members also have the ability to send personal messages to each other. In certain cases, members have been given the ability to close their own topics, edit previously posted comments, or delete posts in topics they have started.

Administrators and Moderators

A forum administrator typically has the ability to edit, delete, move or otherwise modify any thread on the forum. Administrators also usually have the ability to close the board, change major software items, change global skins, modify the board, and ban, delete, or create members. Moderators have a subset of these powers, which may include editing, deleting, and moving threads, mass pruning, warning members for offences, and changing minor forum details. It is often possible for moderator privileges to be delegated to other forum members.

A board's moderation system can include moderation of the moderators via a meta-moderation system. The board software may also allow administrators to create wordfilters, automated scripts which strip undesirable text from users' messages. Other features may include sticky threads, allowing moderators and administrators to cause significant threads to display at the top of the forum's index.

K-COM

N.B. The K-COM work package is not currently assigned to a particular university. Preference will be given to team proposals covering more than one project – a team leader should be nominated.

24. Communication content
    - S / B / M – 1-4 people

This project involves the communication of GENSO to various target audiences via the project website, newsletters, promotional material and events. A multi-national team is envisaged.

25. GENSO graphical identity
    - S / B / M – 1-2 people

This project aims to build on the existing logos and images to create a strong graphical identity to represent GENSO both online and in hard copy, around the world.

26. Teaching exercises
    - S / B / M – Trainee teacher or professional on sabbatical

This project aims to use GENSO as an inspiration to young people, to raise their interest in topics related to satellite communications. Exercises are envisaged to be based around physical demonstrations with ground station equipment, allowing young people to get hands-on experience, whilst increasing their scientific and technical knowledge.

L-LMA

27. Investigation of relevant legal matters and drafting of end user agreements
    - B / M – 1-2 people

New team members are sought to investigate Legal Matters that can arise in GENSO, given the unique nature of this project. Furthermore, there will be investigation and drafting of End-User agreements for those that will join the Network in the upcoming phases.

F-HDW

28. Survey and analysis of existing/future modulation techniques
    - B – 1 person

This project aims to perform a study and an analysis in depth of the existing and future modulation techniques that are and will probably be used by amateur and educational space missions in the forthcoming years. This, project will delve into Analogue and Digital Modulation Schemes (AM, FM, SSB, FSK, PSK, ASK) in terms of efficiency, usability, advantages and disadvantages as well as future trends in an era that systems are moving forwards from low data bit rates utilizing the VHF and UHF frequency bands to high data bit rates utilizing the L and S–Bands and moving towards the C and X Frequency Bands.