Unmanned Air Vehicle System's Data Links

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***Abstract*—Together with the development of technology, Unmanned Air Vehicle System (UAVS)'s usage is growing day by day. Accordingly, producing and using UAVS is a big competition among the countries. So it is very important that UAV's have to be firm and reliable. Another important point is the data links; data transmission must be accurate and continuous. Nowadays UAVS are produced by many companies. But information security problem still continues. Therefore the growth of the UAV number and the need for reliable data transfer have caused question marks about frequency management, the way of data transmission. For this reason lots of research and development efforts are being handled. This document has been briefly mentioned the UAV systems and communication subsystems.**

***Index Terms*—UAVS, data, security, frequency, data link**

I. Introduction

The most critic subsystem in UAVS is communication. Although UAVS are produced by many companies, information/data link security problem still continues. Beside data transmission over long distances, it has big importance to send the accurate information to the right point. Another problem of the data transmission is the outside interference.

Demoz Gebre-Egziabher Zhiqiang Xing's work described issues associated with the design of concepts of operation or for small unmanned aerial systems [1].

Arda Mevlütoğlu examined the needs, design and procurement for UAV system [2].

Yüksel Kenaroğlu tried to find out the answer of "How reliable are the UAVS?" [3].

Ersin Arslan's article touches on military satellite technology and types of unmanned air platforms [4].

Elham Ghashghai's report addresses the communications challenges associated with integrating current and future intelligence, surveillance, and reconnaissance (ISR) assets effectively with weapons platforms and the weapons themselves [5].

Zuhal Kale Demirkıran has examined UAV communication systems in her article [6].

Tamer Kök has aimed at to determine the spectrum needs for data links and navigation systems [7].

Arda Mevlütoğlu searched for the UAV integration to the command and control system infrastructure [8].

In this document UAV systems, data link/communication subsystems, frequency allocation are touched on and measures to be taken like crypto are discussed.

II. UAV's Definition

Generally known as drones are a kind of plane that controlled remotely. They can be used for assault as well as ISR. Besides, they serve the purpose of atmosphere monitoring, weather forecast or scientific research, pipeline tracking, path control, search and rescue operations, aerial photography, oil, gas and mineral research [9].

A. The Elements of UAVS

UAV systems are formed by the four elements shown in Fig. 1.

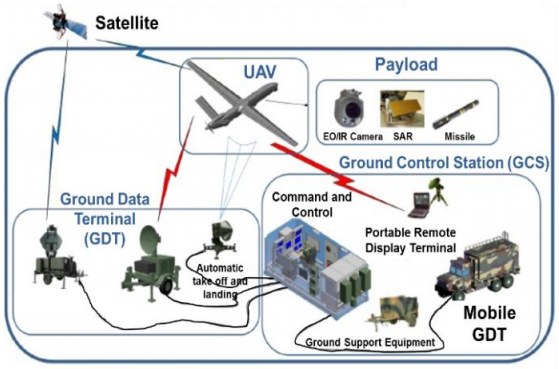

Figure 1. UAV Elements [10]

These elements are: UAV, GDT, GCS and Payload. And the ground support equipment consists of generators, tools and capture cable.

1) UAV

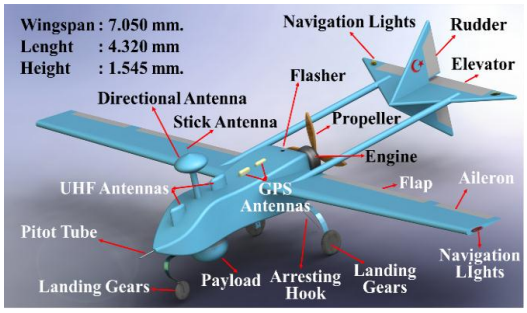

Figure 2. UAV parts[1]

The general parts of a UAV are presented in Fig. 2.

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[1] The 3D UAV model has been designed for PhD thesis.

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2) GCS

It is mobile/stationary unit which controls the UAV and payload. GCS also receivers the UAV and payload reports. You can see the mobile/stationary GCS in Fig. 3.

Figure 3. Sample GCS [11, 12]

3) GDT

Ground Data Station provides the communication between UAV and GCS over Q, C, S, UHF bands, etc. Like GCS it can be both mobile/stationary. Sample GDT's are shown in Fig. 4.

Figure 4. GDT [13, 14]

4) Payload

The plugins on the UAV that can serve different purposes and perform different tasks are called as payload. This plugins sometimes may be weapons, camera (day / night), relay, radar or mine detection equipment. It changes according to UAV lifting capacity.

III. UAV and Payload Control Logic

It is a two way communication:

- The command given from GCS sent to the UAV via GDT (wireless),
- The UAV telemetry (flight data) and the video images from the payload sent to the GCS in the opposite direction through GDT (wireless).

In addition, there is a cabled communication between GDT and GCS (Fig. 5).

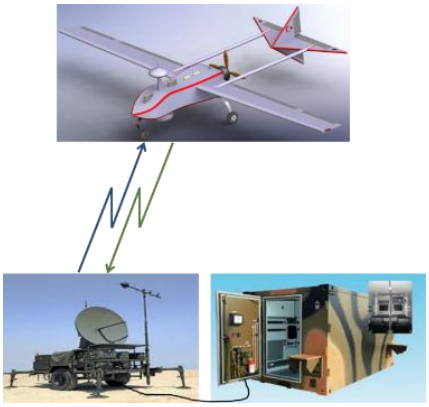

Figure 5. Commanding logic

IV. UAVS Communication Subsystem

The UAVS has two uplinks (UHF and C/L/S/Q/KU), one downlink (C/L/S/Q/KU). The reason for this; even a downlink problem occurred, the UAV still can be controlled, whereas the UAV control is lost if there is a problem with uplinks. Therefore UAVS has two uplinks with different frequency range and transmit simultaneously.

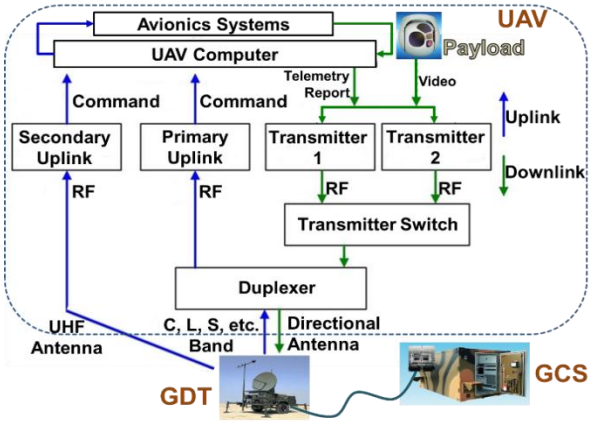

Figure 6. Communication subsystem (Payload [15])

The commands pilot and payload operator give transmitted cabled from GCS to GDT, therefrom commands transmitted to UAV via two different uplinks.

The signal arrives at two different receivers on UAV and sent to the UAV computer.

On UAV there is one C/L/S/Q/KU band antenna for both transmitting and receiving. Owing to duplexer the signal traffic can be managed as needed.

The Fig. 6 shows a sample communication/data link of UAVS.

For C/L/S/Q/KU band there are two antennas in UAV and GDT; directional and stick. The link between UAV and GDT operates according to the principle of sight. Because during the takeoff and landing the distance between antennas (UAV and GDT) it is hard for them to follow the other one. To solve this problem stick (undirected) antenna is preferred for short distances. For long distances the situation is vice versa; directional antenna should be active. Antenna exchange is handled by the pilot.

With the aid of GPS's on UAV and GDT the system automatically calculates the antenna directions and angels in order to point each other.

The communication distances according to the antenna types are in Table I. The distances may change according to the weather and terrain conditions.

TABLE I. DATA LINK DISTANCES (KM.)

			GDT		
			C/L/S/Q/KU		UHF
			Directional Antenna	Stick Antenna	
UAV	C/L/S/Q/KU	Directional Antenna	200-250	3-5	-
		Stick Antenna	200-250	3-5	-
	UHF		-	-	150-180

V. DATA LINK SYSTEMS

It is a system that enables data (telemetry, image, video, etc.) transfer from UAV to GCS, land and aerial platforms, also from GCS to UAV.

In order to assure the certain and effective communication among different UAV systems and operational units, standardized interoperable RF systems are getting preferred presently. In this context, after working long time on data links, NATO create a UAVS interoperability standardization document which is named NATO STANAG 7085 (Interoperable Data Links)

Three types of data links are generally used for UAV communication;

- Line of Sight (LOS)
- Beyond Line of Sight (BLOS)
- Tactical data communication.

A. LOS

LOS needs point to point high speed communication systems. LOS can use different bands; especially C and Ku band. They can transmit payload images from UAV thanks to high speed and bandwidth capabilities. Data transfer rate is about 274 Mbit/s.

It consist of two units; aerial and land. To ensure its capabilities LOS needs two directional antennas: one on UAV and the other on GDT. The communication distance is 200-250 km. To increase the distance relays must be integrated and used.

B. BLOS

BLOS is a communication system uses satellites for data link. It does not need LOS. Because of this the communication distance is far more than LOS. The easiest way of this data link type is microwave. BLOS uses the satellites in orbit over world.

C. Tactical Data Communication

Tactical data communication enables the capabilities below:

- Supports the UAV mission areas,
- Allows simultaneous communication among multiple UAVs, aircraft and the ground system,
- Supports network-centric operations,
- Regulates the close networks work in the same operating environment without interfering with each other,
- Includes secure data transfer features.

The most known tactical data communication link is Link-16 Joint Tactical Data Communication. Link-16 constitutes the basis of Network Enabled Capability infrastructure. It uses low bandwidth [16].

VI. AERONAUTICAL DATALINK CHALLENGES

Designing aeronautical wireless datalinks is much more challenging than other wireless links. The key challenges are: Long Distance, High-Speed, and Spectrum.

A. Long Distances

Long distance results in significant power attenuation in the path and results in a very low spectral efficiency.

B. High Speeds

High speeds of the aircrafts result in a high Doppler spread and affect the spectral efficiency.

C. Frequency Spectrum

Aeronautical communications systems have traditionally used high-frequency (HF) and very high frequency (VHF) bands as well as higher frequency bands used for satellite communications (SATCOM). However, SATCOM systems are not always available during all phases of flight and the HF and VHF bands are getting very congested. Given the growth in the air traffic, it has therefore become necessary to identify new spectrum for air-to ground data links [17].

VII. INTERNATIONAL FREQUENCY PLANNING AND ALLOCATION

Frequency Planning is needed for that communication can be made via electromagnetic waves and electromagnetic waves can be used without disturbing each other.

Frequency spectrum planning and usage for certain services (land, aerial, naval, satellite, etc.) with different aims are regulated in the frame of Radio Regulation-RR (Determined by International Telecommunication Union-ITU) and sanctions of Commission of European Post and Telecommunications-CEPT. Besides, the studies made by international organizations like International Civil Aviation Organization-ICAO and International Maritime Organization-IMO are also important.

The international organizations mentioned above aim at efficient frequency usage without causing interference. New frequency plans report are presented to the countries via international meetings in certain periods. The member-state- agreed plans are published and put into practice. In the second stage the nations makes their own frequency planning and allocations [7].

VIII. Most Commonly Used Frequency Bands for UAVS

These communications are done primarily through the use of RF applications, usually, satellite communication links in UAS are used either in LOS (for military applications) or in BLOS mode. The most common frequency bands (Table II) of this type of links are:

- Ku band: this band has been historically used for high speed links. Due to its short wavelengths and high frequency, this band suffers from more propagation losses. Yet it is also able to trespass most obstacles thus conveying great deals of data.
- K band: possesses a large frequency range which conveys large amounts of data. As a main drawback it should be mentioned that it requires powerful transmitters and it is sensitive to environmental interferences.
- S, L bands: they do not allow data links with transmission speeds above 500 kbps. Their large wavelength signals are able to penetrate into terrestrial infrastructures and the transmitter require less power than in K band.
- C band: it requires a relatively large transmission and reception antenna.
- X band: reserved for military use [18].

TABLE II. Frequency Band

Band	Frequency
HF	3-30 MHz
VHF	30-300 MHz
UHF	300-1000 MHz
L	1-2 GHz (General) 950-1450 MHz (IEEE)
S	2-4 GHz
C	4-8 GHz
X	8-12 GHz
Ku	12-18 GHz
K	18-26,5 GHz
Ka	26,5-40 GHz

IX. UAVS Data Links Vulnerability against Electromagnetic Stirring

Two different data link systems can be used; cabled and wireless.

A. Wireless Data Links

Data links have limits; electromagnetic stirring, the physical distance, signal strength, physical barriers that affect signal, available bandwidth and only to use the allocated frequencies.

- With an impact to be made from the outside;
- UAVs control can be hindered by electromagnetic stirring and suppression;
- Enemy can take the control of the UAV and/or payload;
- The GCS is be able to prevent from receiving telemetry and video image;
- Enemy may receive telemetry and video image by infiltrating the downlink beyond UAVs crew knowledge;
- By transmitting fake downlink wrong telemetry and video image can be send to GCS;

It is assessed that these unwanted inputs may be caused by either intentional activities or some other data link signals over area.

B. Cabled Data Links

Because cabled data links is a small and secured part of UAV systems, it is not touched on in this manuscript.

X. Measures to Take

At present, the data is not encrypted before transmitting but ciphered with simple algorithms in some UAV systems.

When considering this matter the scope of the measures to be taken are below.

- A national encryption system must be created and all the data (image, video and telemetry) should be encrypted by this system,
- Number of GDT is to be increased in order to decrease the distance between UAV and GDT so to boost signal strength,
- National data link security systems have to be designed and implemented against electromagnetic stirring and suppression,
- Frequency planning and allocation should be checked and revised according to the present conditions if needed in order to prevent the conflicts over frequency usage,
- All of the UAV systems, parts and subsystems have to be designed and produced domestically.

XI. Conclusion

Although UAV usage is increased dramatically, problems with data links still continue. Studies over UAV communication systems are lied heavy on. Concordantly, producing and using UAVs has become a prestige issue for the countries. In this study, brief information about UAVs which are widely used with the development of technology is given and communication subsystems are summarized. It is very important that the

data between UAV and GDT is to be secured and correct. Although there is a lot of development of UAVs, information security problems still remain. Because of this reason, the increase in the number of UAVS and the need to ensure the security of data transmitted bring about the questions about frequency planning, frequency allocation and the ways of data transmissions.

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