UAV Mission Planning using MAS – Common KAD Methodology

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ABSTRACT

The Unmanned Aerial Vehicle (UAV) mission planning is a very sensitive, complicated, time consuming and costly procedure. Currently, Most UAV missions are planned manually, and stored in the plane's own computer, which may contribute to some human errors and the risk of inaccuracy is still eminent.

In this paper, we build up a computer-based system for UAV mission planning. The suggested approach for developing such system is to investigate the possibility to utilize and integrate several problem-solving models and techniques in an integrated intelligent and traditional environment. The proposed system will use integration of Multi Agent System (MAS) and Common KADS (Knowledge Acquisition and Documentation, Structuring) methodologies to obtain accurate mission planning system.

Keywords
Artificial Intelligence, Intelligence Operation, Detection, Agents Elicitation, Agent oriented system, Problem-solving.

1 - INTRODUCTION

Unmanned Aerial Vehicles (UAV) is making an ever increasing part in the military and civilian environment. The intrinsic pilotless features of UAVs make them a low risk platform for the execution of missions which may be hazardous to a pilot, or applications where rapid mission results are desired with lower cost air platforms. The mission of the UAV may be greatly enhanced through the utility of a Mission Planning system which understands the operational performance parameters of the aircraft and allows an operator to apply the aircraft in a desired mission, thus optimizing the data aggregation process and improving the final result of the designated mission.

The Mission Planning approach offers a user the ability to insert aircraft and intelligence payload system models into the mission environment to optimize the mission outcome and minimize aircraft and surveillance area risks, thus optimizing the on-station time and reducing equipment and personal risks.

The planning approach affords an automated overall mission integrity validation designed to thin out the initiation of human mistakes.

This paper presents a proposed mission planning system for UAV using MAS-Common KAD methodology, and is divided into six sections. The first section is the introduction. The second section focuses on the related work. The third section discusses overview on unmanned air vehicle UAVs. In the fourth section we introduce BACKGROUND OF Common KAD and MAS methodology. The proposed system will be reviewed in the fifth section. In the sixth section, we have concluded the research with some recommendations for the future work.

2 - RELATED WORKS

Daro exposures to UAV missions in his technical report [1]. Many researchers like Newell, Steels, Wielinga and David dissect in detail AI, Knowledge-Based System, KADS and Common KADS [2], [3], [4], [5], [6]. *Jose Aguilar et al in their paper they classify the agents into two categories: control agents and service management environment agents.* To define these agents they have used an extension of the MAS-Common KADS methodology for Multi Agent Systems is based on the MASINA methodology which has an extension of MAS-Common KAD methodology to incorporate other [7]. Khozium et al illustrate in their paper the meaning, definitions and importance of intelligent software agent by contrasting agents with objects. Furthermore, their paper highlights the Multi Agents structure, methodologies and common applications and provides surveys that allow researchers/developers to determine the directions in which agent-oriented methodologies are best suited to achieve goals of a particular project or system. [8]

Biabani et. al. present in their paper [9] a model of Multi-Agent System (MAS) dedicated to the Project Chain Management (PCM) through Radio Frequency Identification (RFID). It describes technical research on the troubles of privacy and security and explores solution for its problems using five phase agent models. [9]

Khozium proposes in his paper a methodology to determine, clarify and differentiate between agents during development of multi-agent systems using goals and functionalities grouping approach. A step by step case of study is presented to explain the proposed methodology for the creation of an Online Intelligent System (OIS) for Board of Directors guide using Multi-Agent System to facilitate online communication between the board members and their president to monitor the policies and productivity of the company. [10]
Khozium in his *paper [11] discusses how to integrate Multi-Agent Systems construction concepts with LMS prospects. The paper concludes with a practical pattern for learning management system overview using Multi-Agent System approach. Also Khozium in other two papers handles* Proposed Structure for High Level Security Enhancement and Indicators Classification for Software Assessment *[16], [17].*

3 - OVERVIEW ON UNMANNED AIR VEHICLE (UAVs)

3.1 Definition of the Unmanned Air Vehicles (UAVs)

The Unmanned Air Vehicles can be defined as the aircraft or the aerial vehicle which can be controlled together with its equipment and platform by an electronic circuit; it can be controlled by two methods as follows:

- Directly by sending specific orders to the UAV to execute during the whole or most of its flight duration.
- Automatically through its computers, this can be fed to a preset program to execute a specific mission.

Classifications of the Unmanned Aerial Vehicles:

3.2 The method of controlling the Unmanned Aerial Vehicles

The remotely piloted vehicle (RPV)
It is the aircraft which achieves its missions, according to the orders remotely sent to it from the ground control and guidance center.

The self-guided Unmanned Aerial Vehicles (Drones)
It is the Unmanned Aerial Vehicle that cannot be guided from the ground control and guidance center, but it executes its missions, according to a preset program adjusted to its airborne computers.

3.3 The possibility of recovery
Consumable Unmanned Air Vehicles (expandable).
Recoverable Unmanned Aerial Vehicles.

3.4 The outer frame.
Fixed wing remotely piloted vehicle.
Remotely piloted vehicle with upper propellers.
Remotely piloted vehicle shaped as a guided missile such as KADAR.
Remotely piloted vehicle shaped as a deceiving target such as SAMSON.

3.5 ***Range, flight duration, weight, and performance.***
The first kind, (Long Endurance/ Maxi RPV)
The second kind (LOW PERFORMANCE / “MIDI RPV”)
The third kind (LOW PERFORMANCE/ MINI RPV)

3.6 ***Launching methods:***

The target of launching the aircraft is to give its airframe and equipment a suitable acceleration so as to reach the speed at which the aerodynamic forces affecting its surface are enough to lift the aircraft, then the engine pushing force is adequate to keep the aircraft flying , one the following methods is used for launching:

- Launching using under carriage or vertical take-off using propeller or jet or turbo engines like the helicopters.
- Using special equipped launchers which carry the aircraft and launch it, these launchers are classified into three kinds:

Hydraulic launcher

Pneumatic launcher

Using booster rockets where the rocket is attached to the aircraft when it is on a carrier and the engine is running, when the boosting rocket operates, the aircraft flies with a an acceleration until its speed is enough to lift it, then the rocket leaves it to depend on its engine (this takes from 0, 7 up to 2 seconds) Launching through dropping the aircraft from a transportation aircraft or a heavy fighter bomber or a helicopter.

An "electromechanical multimode" micro UAV is being developed by Robert Michelson and his design team at the Georgia Tech Research Institute

Manual launching

The Sentry features a pneumatic launcher, which permits launches from confined, restricted or unimproved sites

3.7 *The Unmanned Aerial Vehicles recovery methods*

Good and continuous training on the Unmanned Aerial Vehicles recovery operation should take place since it lessens the probable losses, besides it is very important to restore the aircraft safely to get the information registered on its computer. The following are some ways used for the recovery operation:

- Using the aircraft built in parachute.
- Landing on runways or flat landing areas using wheels or sliders.

- Using the recovery net of the launching station.
- Using helicopter aircraft.
- Recovery from water surface using the pontoon bridges.

3.8 Missions of UAVs

a) Surveillance for search & rescue (peacetime "SAR" & compact "CSAR"). [1]
b) Deception operations. [15]
c) Maritime operations:
   - Naval surface fire support (NSES).
   - Over-the-horizon targeting (OTH-T).
   - Ship classification.
   - Antiship missile defense (ASMD).
   - Antisubmarine warfare (ASW).
   - Search and rescue (SAR).
   - Mine defense support.
d) Electronic warfare (EW) (including electronic attack "EA"), signals intelligence (SIGINT), and directed energy sensor reconnaissance.
e) Nuclear, biological, and chemical (NBC) reconnaissance.
f) Meteorology missions.
g) Route and landing zone reconnaissance support.
h) Adjustment of indirect fires and close air support (CAS).

4 BACKGROUND OF MAS-COMMON KAD METHODOLOGY

4.1 Artificial Intelligence (AI)

Artificial intelligence can be defined as "The sciences of making machines behave in a way that would generally be accepted as requiring human intelligence" [6]. From a practical standpoint the goal of AI is to make computers more useful for humans. This can be achieved by producing computer programs that assist humans in decision making and intelligent information search or simply by making computers easier to use with natural language interfaces.

4.2 Common KADS

The CommonKADS approach for knowledge modeling [4], [5] is firmly based on Newell's ***knowledge-level*** approach [2]. However, Common KADS aims to go beyond KADS to produce state-of-art, conceptual modeling language based on a unification of existing approaches to ***knowledge-level modeling***. Central to this is the synthesis of the original KADS four-layer expertise model [12] with the components of expertise framework [3]. The Common KADS conceptual modeling framework is based on broadly the same principles as those which underline the KADS modeling approach. The original KADS four-layer model of expertise has not been radically changed; instead it has been revised and extended in a number of areas. The Common KADS modeling framework consists of two major components:

• **Application knowledge model:** This represents knowledge related to the actual application. It consists of three epistemological categories of knowledge, namely ***domain, task, and inferential*** knowledge. It therefore corresponds to the lower three layers of the original KADS four-layer expertise model. Application knowledge represents the main reasoning capability of a problem solving agent and the way it interacts with its external environment. Domain, task and inference knowledge categories in CommonKADS are broadly similar to their counterparts, although they have been refined and extended.

•**Problem solving knowledge model:** This represents knowledge relating to *how the* three layers of the application knowledge model are constructed. It takes the form of a three-layer model itself, and consists primarily of ***problem solving methods and strategic knowledge***. It therefore corresponds to the topmost strategy layer of the original KADS [13], [14].four-layer expertise model.

The ***domain knowledge*** is broadly similar to KADS domain knowledge but has been revised and extended. It consists of: ***domain ontology***, which defines the vocabulary used to construct the various elements of domain knowledge, ***domain models***, which is a reformulation of the domain ontology that is better suited to the required reasoning process, and ***case model***, which contains information about the specific case, which is being reasoned about by the problem solver.

The ***inference Knowledge*** *is* broadly similar to KADS inference knowledge, in that it is a declaration of *what* primitive inferences can be made using the domain knowledge. A primitive inference is a body of knowledge that establishes a relation or function between various elements of the domain knowledge. Domain knowledge elements are referenced in an inference via knowledge roles, which are equivalent to KADS Meta-classes. Dynamic knowledge roles refer to elements of the "dynamic" case model and are linked together by inference. Static knowledge roles refer to elements of the "static" domain models and are used by inferences in order to establish the above links. Like KADS, Common KADS also has inference structures, which represent the chaining together of a set of inference and knowledge roles. The notation and rules of syntax for a CommonKADS inference structure diagram remain basically the same as those of KADS.

The ***task knowledge*** is similar to KADS task layer. The CommonKADS task knowledge describes the task that must be carried out in order to achieve a particular problem solving goal and also exerts control over the execution of these tasks. CommonKADS has extended the original KADS task description, with the result that it now consists of two parts:

1. The task definition is a declarative specification of the goal of the task, which consists primarily of a definition of the relation between the task's input and output knowledge roles.

2. Task body, which is a procedural specification of the activities, which enable a task to achieve its goal. There are three possible forms of task body, according to the type of task involved (primitive task, transfer task or composite task). The task body also contains a specification of the control, which is imposed over the execution of a task, which varies according to the type of task involved.

The ***problem solving knowledge*** is the second major component of the CommonKADS conceptual modeling framework. Its knowledge about the knowledge modeling process itself: *how to* organize, link and apply domain, inference and task knowledge in order to construct an application knowledge model, which can accomplish a particular problem solving task. It broadly corresponds to the *strategy* layer of KADS, however CommonKADS problem solving knowledge is not an epistemological knowledge category (i.e., the problem solving methods are not made fully explicit in CommonKADS, instead they are "complied out" inside the four-layer model of expertise).

One of the major advantages of CommonKADS over the other approaches, is that a lot of efforts are done to provide a library for expertise modeling [12], which covers some generic tasks (e.g., diagnosis, assessment, design, configuration, assignment or scheduling, and planning). However, part of our research goal is to enhance results, and add more components to the CommonKADS library.

4.3 Multi Agent Systems (MAS)

The objective of multi-agent systems is to understand how independent processes can be organized. An agent is a computerized entity like a computer program or a robot. An agent can be described as autonomous because it bears the capacity to adapt when its environment changes. A multi-agent system is made up of a set of computer processes that takes place at the same time, i.e., several agents that exist at the same time, share common resources and communicate with each other. The key issue in multi-agent systems is to formalize the coordination between agents. [8], [9], [13]

Multi-agent systems can be applied to artificial intelligence. They simplify problem-solving by dividing the necessary knowledge into subunits-to which an independent, intelligent agent is associated-and by coordinating the agents' activity. In this way, we refer to distributed artificial intelligence. This method can be utilized for monitoring an industrial process, for instance, when the sensible solution that of coordinating several specialized monitors rather than a single omniscient one- is adopted. [8], [14]

Fundamental research is being conducted on the problems associated with the representation of agents' decisions and protocols for communication. The main applications for MAS are for telecommunications, internet, and physical agents, such as robots. A group of scientists has specialized in the simulation of agents' societies in the fields of ecology and social sciences. Research on modelling distributed systems has also been carried by computer scientists, ecologists, and social scientists. Here, we discuss a few references and some of the issues involved. [9], [10], [13], [14]

An agent can be a physical or virtual entity that can act, perceive its environment (in a partial way) and communicate with others, is autonomous and has the skills to attain its goals and tendencies. It is in a multi-agent system (MAS) that holds an environment, objects and agents (the agents being the only ones to act), relations between all the entities, a set of operations that can be executed by the entities and the changes of the universe in time and due to these actions. [11], [13]

5 FRAME WORK FOR THE PROPOSED SYSTEM

5.1 The proposed system overall structure

From MAS point of view we have three Agents that are Mission Generator, Verifier and Emergency Identifier which is the basic component of the system. Each of these components manipulates and uses its own type of data. These basic components are:

Mission generation environment component which deals with the initial mission plan data and UAV performance data. The main objective of this component is to interact with the system users to generate an initial mission plan which will be further elaborated by verifier.

Verifier component which deals with current mission generated by the first component and the restricted area data. The objective of the verifier is to obtain a correct mission that agrees with all mission requirements and constrains.

Emergency event identifier which deals with emergency knowledge and this component is an additional facility that provides the correct identification of events that might cause an emergency case.

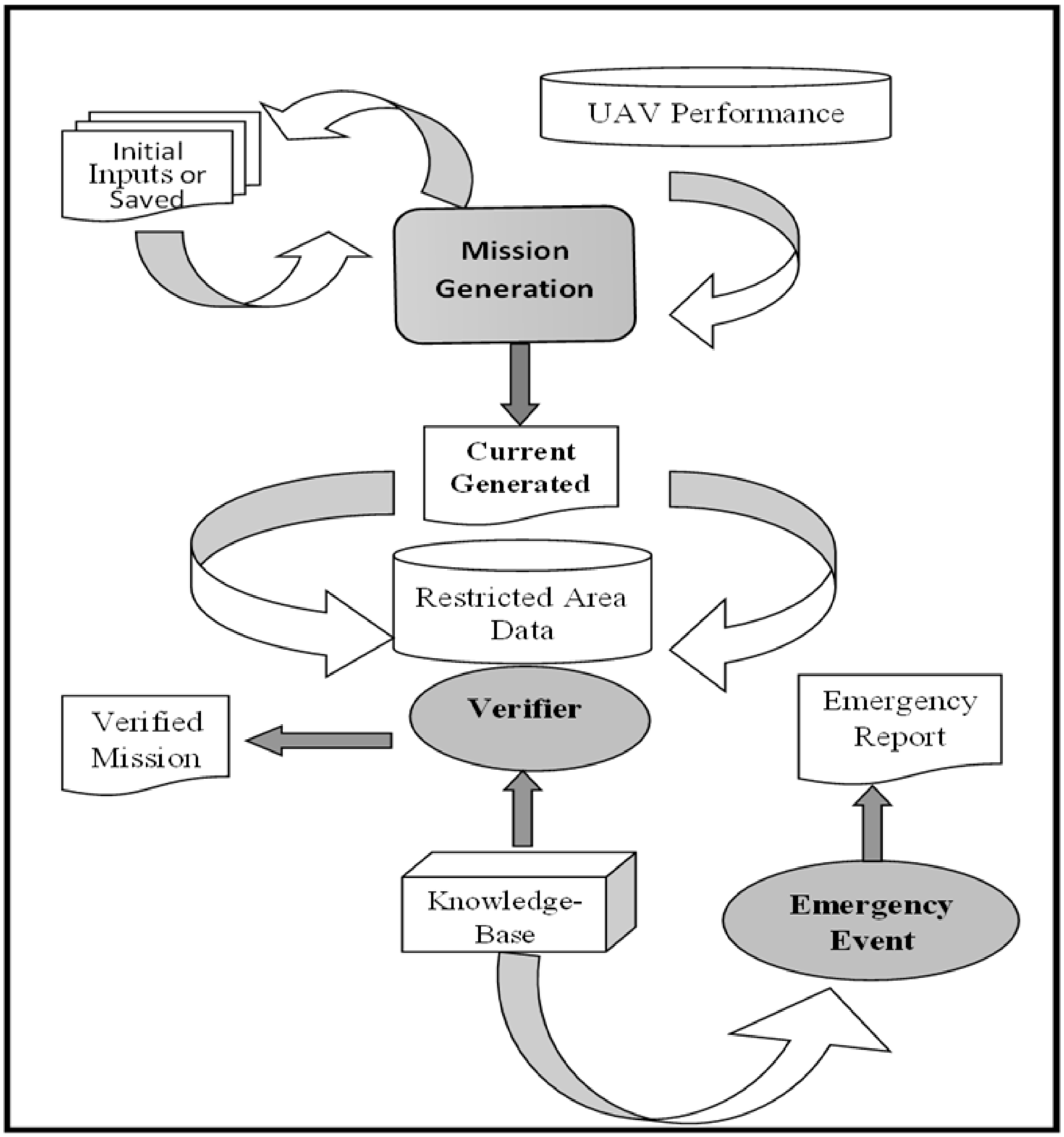

Figure 1: System Architecture

To introduce the system in a simple and clear way we may look at the system from the data movement and communication point of view. As shown in **figure.2** the system contains three types of components: manipulation & control component, static component, and results (report) component. **Figure 3** shows these components.

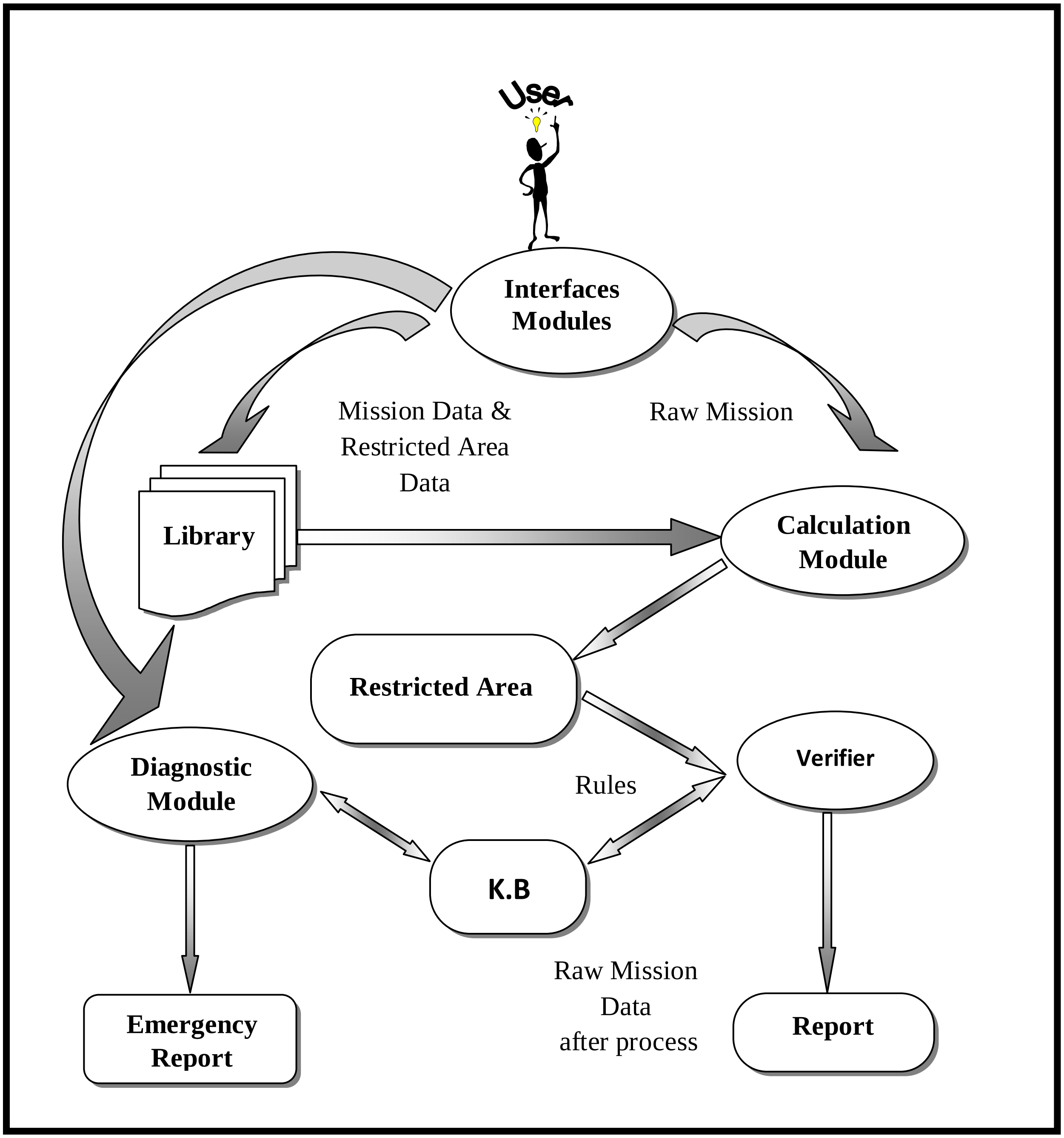

Figure 2: Data Movement and Communication

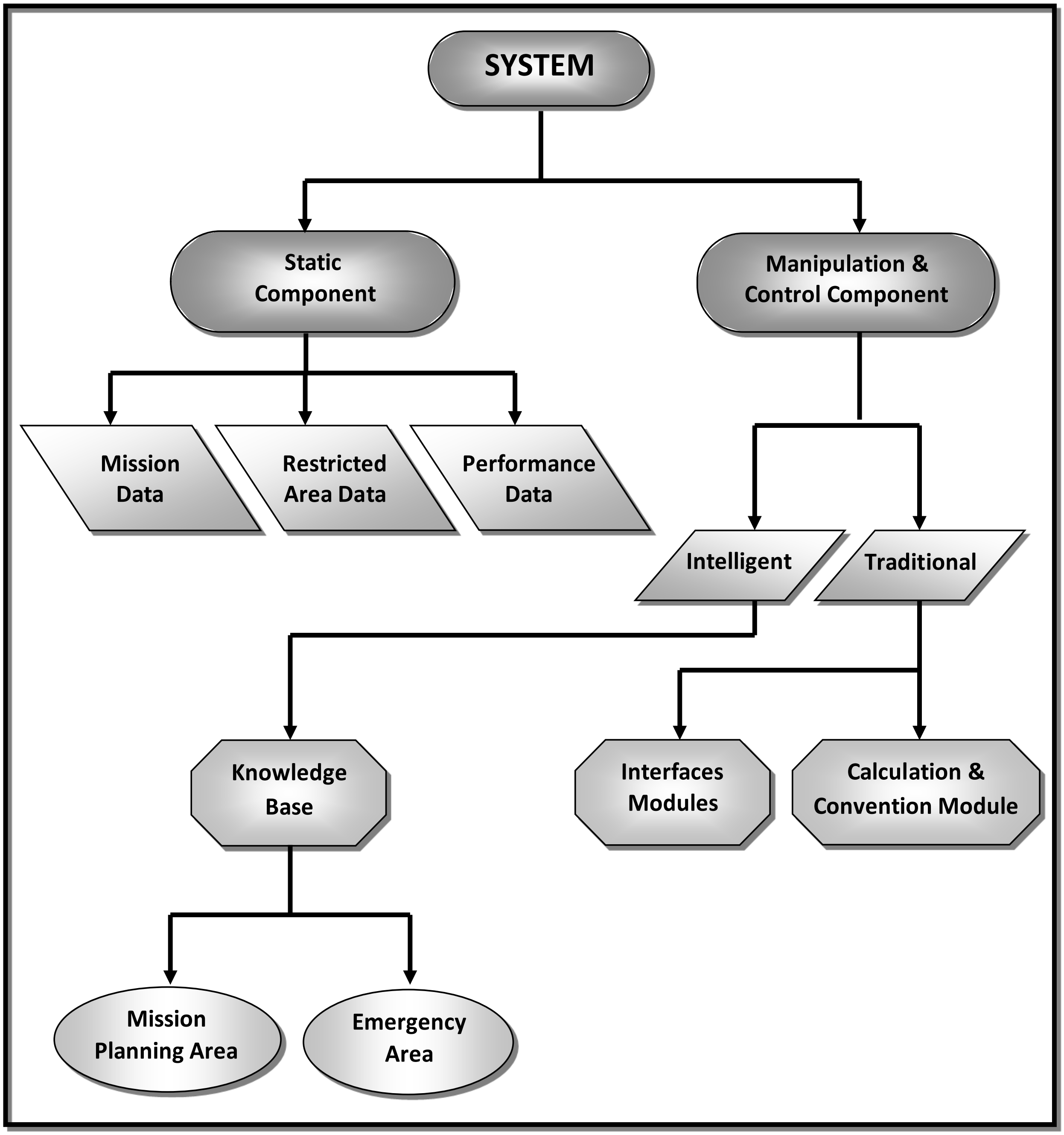

Figure 3: Component of the System from Data Movement Point of View

5.2 Manipulation & Control Component

This component includes mainly different types of modules to provide an environment for mission data filling in addition to a set of aiding tools to support users with all utilities which cover their requirements. This environment contains two main modules: traditional and intelligent modules.

Traditional module

The traditional module contains all interfaces modules in addition to calculation module.

6. CONCLUSION AND FUTURE WORK:

In this paper, an automated system was designed to check and verify manual planned mission in order to avoid human mistakes, which may lead to the damage of the plane itself. This system also replaces the manual planning of the missions. Some features are added to the system which enables it to provide the capability of interacting with the mission planner and suggests solutions for existing errors, Such as the capability of adding new restricted areas. During this paper, we provided an open architecture that enables adding future components; also the modification and deletion of current components are available.

We have several ongoing activities for the future work, all concerned with extending our work to be more powerful and applicable. In what follows, we present some of these activities:

- Make integration between the system and a GPS activity in the internet.
- Make integration between the system and metrology broadcast.

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