A Real Time Synchronous V - C System with the Extracted Data from Buffering Function

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Abstract—**This study introduces the state-of-art of the Real-time LVC (Live-Virtual-Constructive) interoperation systems that are being used for the purpose of warfare training and presents the first Real-time V-C (Virtual-Constructive) interoperation system building project in Korea, recently performed by ROKA (Republic of Korea Army). In this project, we have developed a new UAV (Unmanned Aerial Vehicle) image simulation system, which corresponds to V (Virtual) system and made it interoperate with the existing C (Constructive) system, ChangJo21, held by ROKA. Through this V-C interoperation, it became possible for the UAV image simulation system to simulate surveilance of a large group of troops like a real battlefield. But this V-C interoperation system can be suffered from severe overload caused by lots of data transmission between two systems. To solve this problem, we apply buffering function on data extraction procedure and use different data transmission strategies on the types of object. As a result, we have decreased more than 53% of amount of data transmission needed for V-C interoperation.**

Keywords-simulator; simulation; Interoperation system; Live; Virtual; Constructive; LVC; data extraction

I. INTRODUCTION

Due to rapid progress in IT technology over the decades it is anticipated that the theatre of the future is dependent to the network-based operational environment [1].

For now, it is said that combat training based on LVC training environment is the most economical and effective way for combat training because LVC virtually presents the real battlefield using computer and network technology.

In LVC training environment, “L” means a “Live” training system where real people operate real systems such as a pilot flying a jet. “V” means a “Virtual” training system where actual players use simulated systems in a synthetic environment. “C” means a “Constructive” training system where simulated players use simulated systems in a synthetic environment. Constructive training system is often referred to as “wargame”.

Any of L, V, C systems, which is inadequate to simulate complex battlefield situations by oneself, can complement each other by interoperating with one another, leading to a more realistic combat simulation. In general, LVC requires that at least two of three types, which are Live (L), Virtual (V), and Constructive (C), are involved.

To make L, V, C systems interoperable, assets, models, and effects from one training environment should be seen, affect, and be affected within the rest of the training environment. This implies that huge amount of data transmission between several training systems is needed. Therefore, it is important to effectively exchange and process data in real time which is served as the foundation for strategizing tactics and allocating commander and staff in punctuality [1][2].

Recently, we have developed a new UAV (Unmanned Aerial Vehicle) image simulation system, which corresponds to V system. As the next step, we have constructed a real time synchronous V-C interoperating system by making the UAV simulator interoperate with the existing C system, ChangJo21 [5], held by ROKA. In order to enable interoperation between the UAV image simulation system and ChangJo21 with different resolution(UAV simulator: entity-level, ChangJo21: unit-level), unit information of ChangJo21 is disaggregated into individual objects (entities) of UAV image simulator and individual objects of UAV image simulator are aggregated into units on real-time basis (within a second) [5]. We also reduced the amount of data transmission by applying buffering function on data extraction procedure for information exchange and use different data transmission strategies on the types of object.

The rest of the paper is organized as follows. In Section 2, we will introduce some restricted L, V, C training examples that are being operated in developed countries [3][4]. In Section 3, we will introduce a new V-C interoperating system consisting of a UAV image simulation system (V) and ChangJo21 (C). And then, we are going to describe the problems and our solutions for interoperating two heterogeneous simulation systems. Some modifications in simulation logic for supporting V-C system interoperation will be described in Section 4. Finally, we conclude our work in Section 5.

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II. Related Research

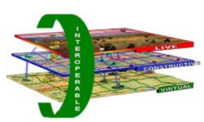
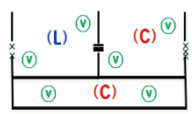
A. LVC examples in developed countries

1) U.S. Army

U.S. Army has tried to construct STOW (Synthetic Theater of War) as in Table I since 1994. However, they recognized some problems such as difficulty in sharing battlefield situation between Live (L) and Virtual (V), Constructive (C) training systems. It was very difficult to achieve different training goals for each system at the same time. A large amount of budget has to be injected to solve these problems. Instead, COP (Common Operation Picture) Based LVC (not to interoperate systems but gather unit identifications on COP to utilize in commander / staff procedure training) integration has been adopted in training.

In U.S. Army, Live training is mainly applied to an individual or a team and Virtual training is applied to middle echelon such as a brigade or a division. Constructive training is used for joint military exercises [1].

TABLE I. Transition of LVC system

STOW : '94～'01 (Synthetic Theater of War)	**L.V.C : '02 ～** (Live Virtual Constructive)
	
● Concept - Synthesis of L.V.C in the same theater ● Restriction - Restriction on situational description for L, V and C - Difficult to achieve all the purposes of various training - Need to secure network stability reliance	● Concept - Divide L and C, coexist with V ● Restriction - Restriction on situational description for L, V and C

2) German Army

The German Army thought that verification is needed to figure out if LVC really boosts effects in training. They are also worried that LVC might create situations that cannot happen in reality and lead to discontinuities in situation [4]. Table II shows the German army's evaluation results of the effects that LVC interoperation gives to combat training.

TABLE II. The German Army's evaluation results of the effects of LVC interoperation in combat training

Sorting	Virtual (A)	Live (A)	Constructive (A)
Virtual (B)	+	-	◦
Live (B)	-	+	-
Constructive (B)	◦	-	-
+ (Expected effect), ◦ (Restricted effect), - (Insufficient effect)			

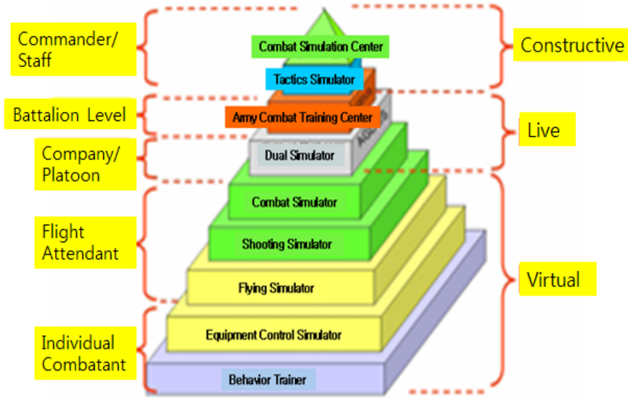


Figure 1. Diagram of scientific training system for the German Army.

Combat training systems are classified by the size of training into an individual - a crew - a platoon ～ battalion - a commander or a staff officer training. They are also divided into L, V, C according to application system.

The German army's LVC concept is similar to STOW (Synthetic Theater of War) of the U.S. Army. However, it is different from that of U.S. Army because each system operates solely by stages as in Fig. 1.

LVC training exercises continues step by step as follows. At first, individuals and crew are trained by virtual simulators (Virtual). Next, teams and platoons are trained interactively in real situation with dual simulator (similar to MILES: Multiple Integrated Laser Engagement Simulation), which are considered as Live training. Finally, commanders and staff officers are trained in virtual situation with war-game model (Constructive) [4].

B. Characteristics and development of virtual training

The purpose of virtual training is to make teams and individuals experience battle fields indirectly and execute tactical training by utilizing developed simulator in case of restriction in armament because of high price and danger.

However, most of simulators that ROK (Republic Of Korea) Army possess or currently under development are just for acquiring simple skills [3].

There is no simulator for tactical training linked to other systems in ROK Army. Therefore, a simulator which can facilitate the training environment in accordance to the training characteristics and interests has to be taken in place in the near future.

1) System Operations

When we develop simulators, there are many things that should be considered such as acquiring cost, developing range according to purposes of training, adjusting to environment, evolving concepts of operating battle, and developing new technologies.

There are little data that can approve the effect of PC game-based simulator training and it needs to be checked by many types of experiments. Especially, PC game-based simulator training has to be used as an auxiliary

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tool for real maneuver in an echelon from a soldier to a battalion, not just simulation or simple game method.

Simulator for instrument training in the past was just for acquiring skills. However, it is being developed to be used in tactical training for a platoon or a company, and synthetic theater in the same environment of the crew.

Therefore, it should be used to train operating instrument, controlling and managing in various environments as preceding training instruments.

2) System construction / development

Simulators need to be made according to the purposes such as acquiring skills and tactical training. Simulators for acquiring skills should be settled in institutions and simulators for tactical training should be settled in field units to practice tactical training.

However, all of the simulators in ROK Army (24 types 175 items) are put in practice for acquiring skills. Therefore, all the simulators should be used in training connected with the same system.

Ongoing simulator development project is developing simulators for tactical training. However, connection with other systems is not considered at this moment. Therefore, simulators in the future should be connected to not only the same system, but also the other systems for integrated training.

Simulators should be constructed for enabling not only improvement in controlling and firing ability under various virtual reality training environment but also training for a team, a platoon, or a company.

In the future, simulators should be developed in the way of satisfying requirements such as interoperation property, ease in improving capacity, ease in setting up and supporting military demands, ease in movement and operation, ease in various kinds of training, adjustment to environment, and cost effectiveness.

Like the above, virtual training is the training that real forces participate with simulation equipments. It can give opportunities for acquiring equipment control skills / proficient training method and HITL (Human-in-the-Loop), such as human reaction process, decision process, human-machine interface, etc. [1].

However, it can only be used in training of a person or a small force for simultaneous training.

C. Characteristic and development of a war-game model

War-game (Constructive) models that ROK Army possesses, ChangJo21 and Combat21 [13], do not reflect the characteristic of terrain of Korea and brand-new weapon systems.

Future development of war-game model has to move toward improving the performance of training model currently being used and making possible to interoperate with newly developed simulation models for auxiliary functions. It is also moved in the direction of developing a war-game model which is able to train upper and lower echelon in collective way and to train and test various echelons, and to train multi-function echelons [6].

1) Development of simulation capabilities according to battle field function

A war-game model should be developed to provide Command and Control/Communication capability similar to reality in a network environment on the way that directions deliver, and this enables Command and Control/Communication training. It also should simulate the procedure to collect information by analyzing, processing, merging secret information gathered by a number of secret information collecting system. Especially, it should be able to provide collected data with images and photos with same form to real system.

Since mechanized corps has high mobility and strong combat capability, a close combat must be differentiated according to simulation level. Also, a war-game model should provide detection-decision-fire procedure for operating integrated fire-power and simulation of a precise strike by a high precision projectile weapons [12].

In addition, the model must be able to simulate air defense, automation system, real time air observation and radio system as well as details about a combat service support system of a whole army.

2) Development of image information field

When simulating a field of information, although it is possible to operate equipments such as a UAV, TOD (Thermal Observation Device) and a RASIT (Radar Surveillance Intercept), the fact is that training of a field of information is restricted because detection results are offered dissimilar report form to actual fighting.

On the other hand, the U.S army practices using methods providing virtual image information produced by collected data from UAV interlocked with CBS (Corps Battle Simulation) model for direction command center in every 10 minutes. Therefore, ROK Army needs a system that can give information analysis training opportunities in ASIC (All Sources Intelligence Center) by providing image information that is similar to real system to command center.

As stated above, as a method for scientific corps practice using computer simulation in order to enhance combat direction abilities, war-game models are economical and offers us large scale integrated practice environment, but, have defects that they cannot embody actual fighting combat situations (equipment controlling exercise and the rest) [11].

D. Development of LVC integrated simulation system

The purpose of constructing LVC integrated simulation system is to provide a virtual integrated battle field environment similar to a real combat circumstance, by interlocking Live (L), Virtual (V) and Constructive (C) system with inter-working interface.

If providing a virtual integrated battlefield environment by using available M&S (Modeling and Simulation) system, it is possible to do integrated training; a training from an individual to theater level, the staff and the director training by function, and an individual soldier training.

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1) Working system

Most LVC working systems of U.S army have the main purpose of providing a natural integration of LVC training assets and a large scale distributed environment by integrating weapon system simulators, and constructive simulations which depict a large scale battle-ground with a huge military strength in order to conduct training which considers operation situation of theater level.

Live Assets should be selectively connected to provide highest level of tough-to-feel considering the restricted usefulness of real system integration and various safety precautions. In addition, it should provide integrated simulation that scenarios like actual fighting, real-world protocols and interfaces are integrated with other systems to support pertinent training of live asset managers.

A virtual simulator asset should provide flexibility of training with a low cost by establishing an integrated synthetic training environment and training of strategies and tactics under dangerous areas or virtual situations. It should make it possible to conduct flexible training through simulating sensors and tough-to-feel three-dimensional terrain and pause/resume function not in reality.

A war-game (Constructive) asset encourages to provide construction synthetic environment for sufficing a established training goal, production of a number of friendly forces, enemies and neutral forces, and a perfect training atmosphere complementing a platform produced by combatants in real and a virtual simulator, as well as dynamic training environment by creating unexpected conditions and enemies.

2) Establishing and development of System

Steps of establishing and development plan for a LVC integrated simulation system of ROK Army is like below [3]; Table III, Table IV and Table V.

- Step1: Establishing each model separately considering interoperation in the future ('14 ~ '20).
- Step2: Establishing interoperating system between the other systems after between the same systems
- Step3: Establishing division level/ brigade level LVC interoperating system ('19～'25).

TABLE III. ESTABLISHING AND DEVELOPMENT OF EACH SYSTEM

Live (L)	Constructing a foundation system interlocked with other systems when promoting project with a brigade level (～'14)
Virtual (V)	Developing a simulator which allows integrated simulation for tactical training (～'24)
Constructive (C)	Developing a brand-new army's combat direction training model which enables to be interlocked with other systems and models (～'17)

TABLE IV. INTERLOCK BETWEEN THE SAME/OTHER SYSTEMS

V-V	Support L, C system by establishing connection between V systems
C-C	Support a war-game training by establishing connection between C systems
V-C	Firstly construct an interlock system (V-C) considering effect of training and technical level

TABLE V. ESTABLISHMENT/DEVELOPMENT OF LVC SYSTEM DEPENDING ON ECHELON

Division level LVC	Establish LVC system considering training demand and technology after training interlocked between same systems.
Brigade level LVC	Establish with minimizing errors by analyzing division level LVC cases

If we establish the LVC integrated simulation system as above, we attain vertical integration by echelons and horizontal integration by function. The system allows conducting unified combat training based on network by integrating various training capabilities such as detection asset, decision of direction, and means of attack.

E. Restriction on establishing LVC integrated system

Provided that we utilize LVC integrated simulation system, we can achieve the goal, "A training likes a combat, a combat likes a training." for directors, chiefs and combatants by attaining upmost effects similar to real combats by implementing virtual simulation environments. However, there are some restrictions for building LVC integrated system as follows.

First, a standard architecture which is able to satisfy all interoperability demand or interlock system (middle-ware) is absent.

Since each L, V, C system is developed based on field-specific requirements of various users they differ so much in communication protocol, object model, and so on. It implies that data converting and mapping process are required when interlocking between systems, which not only increases complexity of the system but also causes a bottleneck due to the tremendous amount of data it has to deal with

Second, when interlocked between simulation-systems which have different simulation resolution (degree of depiction: object unit, corps unit), the systems need disaggregation and aggregation process due to difference of resolution of information. While ChangJo21 training model of ROK army like Fig. 2 depicts battles in a corps unit, the UAV simulator depicts battles by individual weapon systems.

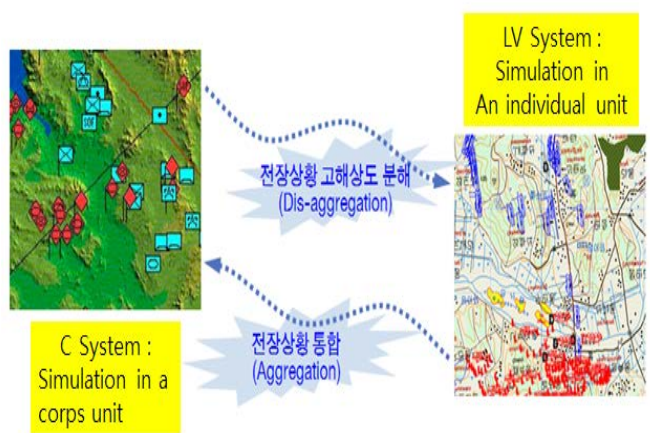

Figure 2. Aggregation/Disaggregation process between LVC systems.

Because the simulator is unable to depict such a direct combat between corps and individual weapons, it is required that corps is disaggregated into individual equipment in necessity or numerous individual weapon systems aggregated into a unit. After several rounds of disaggregation and aggregation process, it is difficult to maintain accuracy and consistency of information due to loss of information.

Third is a technical problem concerning about how to transmit status information of corps/objects depicted in each L, V, C training system to the counterpart systems. We have a technical problem about transmitting various status information including position information in V training system (UAV) to C training system (ChangJo21) and how to apply to V training system when damages occur in combat in C training system [3].

Another technical problem is due to the network overload caused by transmission of about 49,000,000 byte per second (participated corps * combat equipment possessed by corps, the number of supporting equipment * fixed objects). This data transmission quantity of 49,000,000 byte/sec is hard to operate and apply to different systems (V-C) in short amount of time. Thus, it is hard to guarantee actual combat condition.

III. DEVELOPMENT OF NEW V-C INTEROPERATING SYSTEM

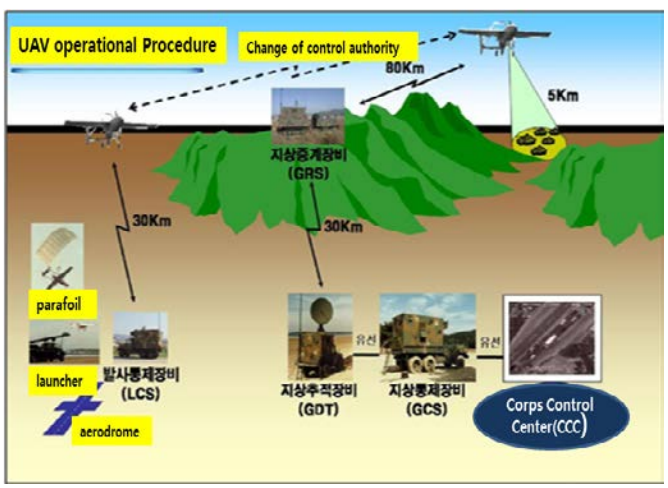

Figure 3. Operations of Real UAV System.

A UAV system is operated as in Fig. 3. UAV flies without pilot by remote control and performs a reconnaissance mission. Images acquired during reconnaissance flight are transmitted to GRS (Ground Repeater System) by the radio, then transmitted to CCC (Corps Command Center) [4][11].

ChangJo21, one of the constructive training models that are owned by ROK Army, can simulate several information assets (UAV, TOD, RASIT, etc.). Among these, UAV automatically detects units / armaments of enemy located within radius of 2km by applying certain probability when inputting flight-related information (flight route, prior-target decision, etc.) as in Fig. 4.

Figure 4. ChangJo21 UAV Simulation (Result of target detection).

However, ChangJo21 provides the reconnaissance result of UAV simulation in text-based report without analysis procedure of target detection result. The result is that realistic training is restricted [5].

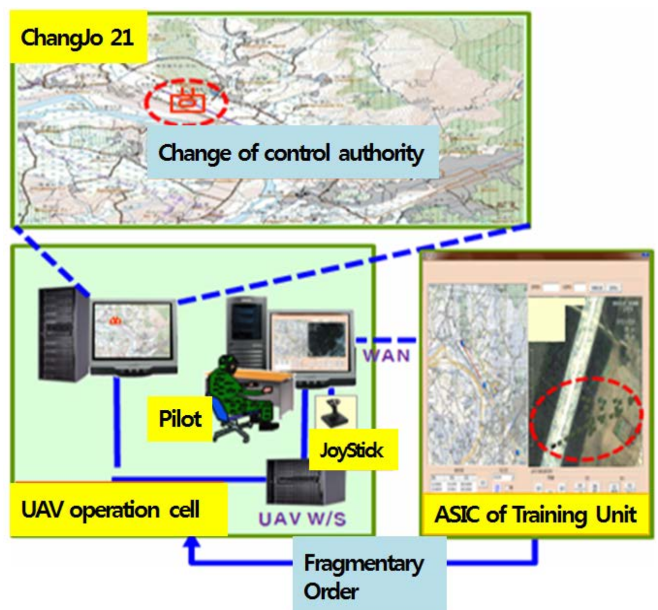

Figure 5. Newly developed V-C interoperating simulation system.

In order to overcome this restricted training condition, we have developed a new UAV image simulator and made it interwork with ChangJo21 constructive training model as in Fig. 5. The UAV simulator can produce reconnaissance images close to the level of images produced by real UAV. This V-C interoperating simulation system provides similar effectiveness to real training through virtual simulation environment and enables training for commands and staffs in intelligence field by simulating target detection/analysis /processing functions and mastering UAV image photographing at the same time [9][10].

A. Problem of interworking between ChangJo21 training model and the UAV image simulator

1) Object data transmission reduction strategy

There is a problem in supporting real-time (1 second) training using our V-C system due to the network overload caused by 49,000,000 byte of object data transmission.

To solve this, we have applied a dispersion method that only considers objects in the inner section of UAV detection capacity. First, the required information (approximately 18,000,000byte) within UAV detection capacity (40km) is transmitted. Then, we applied the strategy that the updated information within detection territory is transmitted differently on the type of object such as fixed object or moving object.

Different transmission strategies of object information are shown in Table VI.

TABLE VI. TRANSMISSION STRATEGY OF OBJECT INFORMATION

Item	Transmission Strategy	Remarks
1. Transmission of initial data	Transmit data only within detection territory considering UAV detection capacity (30Km)	- Reduction of 80% of load - Increase in complexity of related logic
2. Transmission of fixed object	Need to register or delete of object along the UAV flight	- Increase of load - Increase in complexity of related logic
3. Transmission of moving object	Register or delete objects only within detection territory considering UAV detection capacity (30Km)	- Reduction of load - Increase in complexity of related logic

a) Designing Concept

As in Fig. 6, the UAV image simulator transmits objects within detection territory (40km) which is determined by applying buffering function (10km) to UAV detection capacity (30km) to prevent frequent addition, deletion of objects. Reconfiguration also has been made to have average network load at the moment of large capacity.

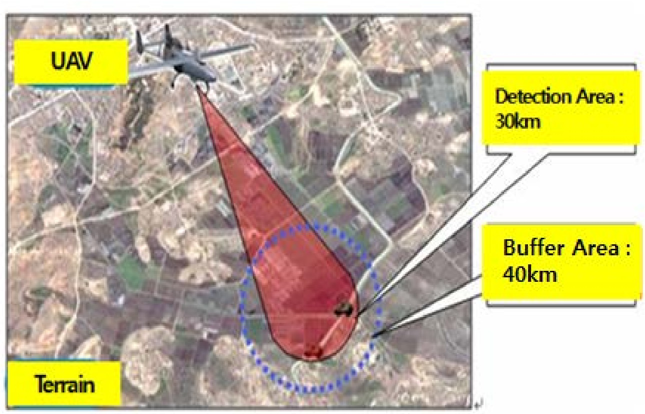

Figure 6. Domain of object processing that is capable of buffer function.

b) Comparison of reduced load caused by reconfiguration

Table VII is a table of results that measures and compares quantity of data that has transmitted to the UAV system. This is based on the assumption that the number of participated military units is about 6,000 in ChangJo21 constructive training system, and the average number of combat equipments and supporting equipments is 30.

TABLE VII. RESULTS OF MEASURING DATA QUANTITY SENT TO THE UAV SYSTEM

Classification		Transmission (byte/sec)	Remarks
Quantity of transmission before reconfiguration		49,000,000	
After applying detector capacity area	Initial (40Km)	18,000,000	First Reconfiguration
	Fixed object	30	
	Moving object	78,000	
After applying buffer function	Initial (30Km) +Buffer	900,000	Final Reconfiguration
	Fixed object	30,000	
	Moving object	15,600	

If the image diameter (width) of image sensor is 40km, radius of area that object information should be exchanged between our V-C interoperation system is more than 40Km, which is too large to continuously transmit in real-time.

We have accomplished more than 53% of data reduction by reconfiguring V-C interoperation system in order that only object information inside detection territory including buffered area is transferred with different transmission strategies depending on the types of object, while satisfying requirement of interoperation system that has to be provided by V system, which requires real-time information exchange.

2) Information resolution conversion between systems

ChangJo21 training system describes battlefield in unit (battalion) while UAV simulator describes battlefield in individual entity (tank, armored vehicle, etc.). This difference of information resolution between two systems implies that information resolution conversion function is needed to interconnect them. A Unit should be disaggregated to individual entities, or many of weapon systems should be aggregated into one unit as in Fig. 7.

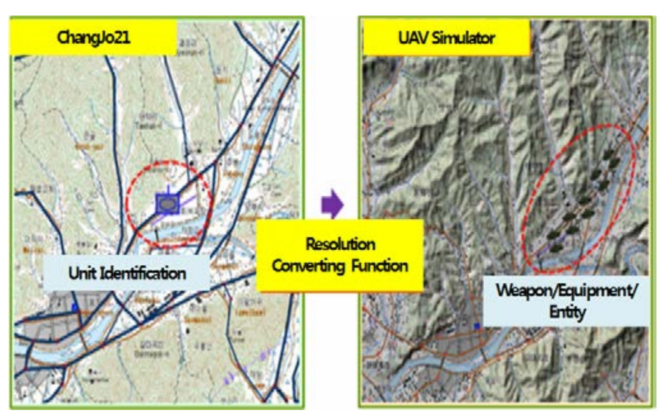

Figure 7. Information resolution conversion / exchange.

In addition, state information (location, state of equipment, etc.) for the UAV is transmitted from the UAV simulator to ChangJo21 model in real-time as in Fig. 8. It makes operating UAV simulator impossible when it is damaged by air defense weapons.

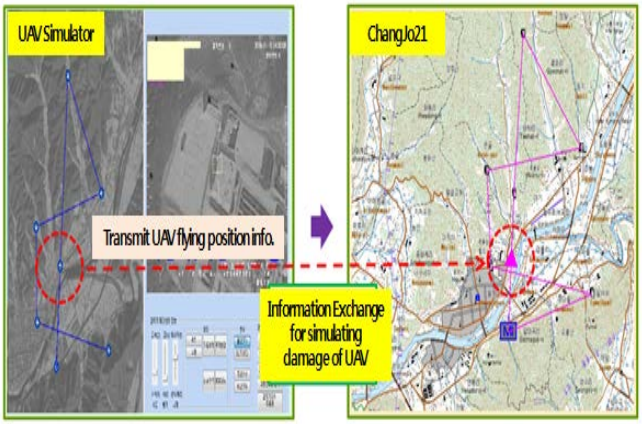

Figure 8. Transmission of UAV state information.

3) Correspondence of topographical information between ChangJo21 and the UAV simulator

Due to differences of topographical information between ChangJo21 and the UAV simulation system, unrealistic situations may occur. For example, tanks may move along rivers or mountains as in Fig. 9. In this case, it is required to match topographical information between two systems. Through this work, objects (tanks, etc.) can move along the roads.

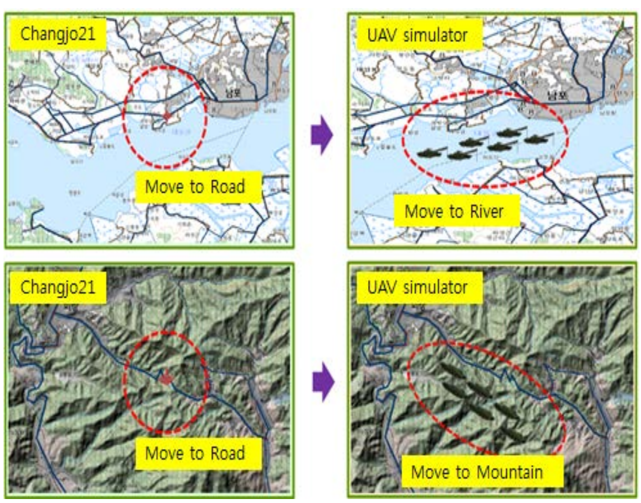

Figure 9. Inconsistency of geographical information between systems.

4) Optimization of simultaneous target processing for UAV simulator

More than 7,000 military units are operated in corps combat-command training using ChangJo21, and approximately 350,000 objects (entities) are operated when units are transformed to objects (weapons) in order to be expressed in the UAV simulation system. It is impossible to operate systems normally due to overload caused by processing such a large amount of objects simultaneously.

We have reduced system loads by processing only updated objects located within feasible photographing regions by UAV sensor (with diameter 00km) as in Fig. 10.

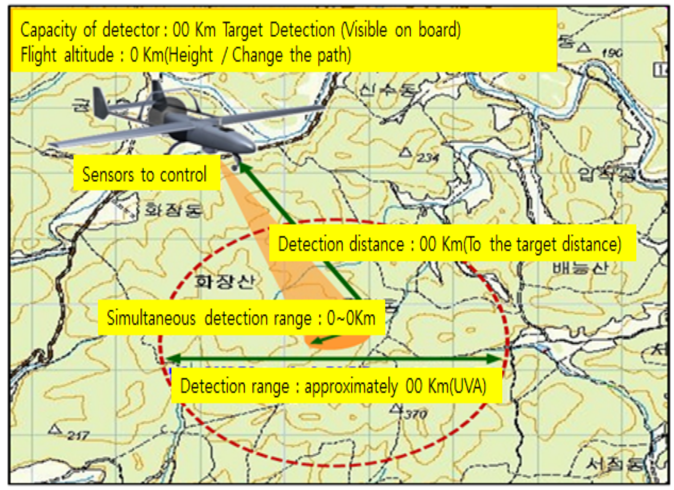

Figure 10. Target detection / Discerned territory.

B. Construction of a real-time UAV image sharing system

Gamers who are responsible for controlling combat units in combat command training by corps are located in BSC (Battle Simulation Center) and CCCs (Corps Command Centers) are located in that corps. That is, BSC and CCCs are placed and operated in different locations. The UAV image simulation system is operated in BSC's information simulation department.

We have constructed a real-time UAV image sharing system by transmitting acquired secret information of UAV image to ASIC and CCCs as in Fig. 11. It enables commanders and staff officers to have exercise for information analyzing /handling process.

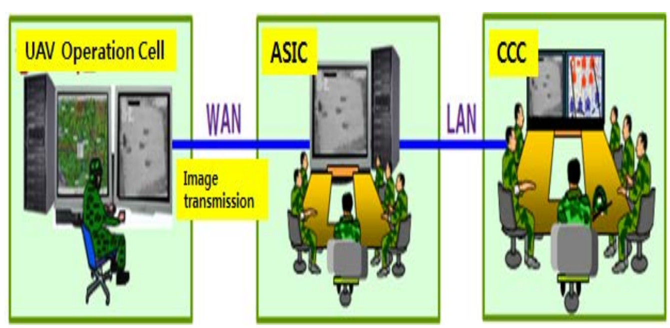

Figure 11. Architecture of real-time UAV image sharing system.

C. Comparison of UAV image systems held by Korea and U.S

Fig. 12 shows the differences in a visual aspect between our UAV image simulation system and MUSE, UAV virtual reality system that has been used to real training since August 2003 by U.S. Army.

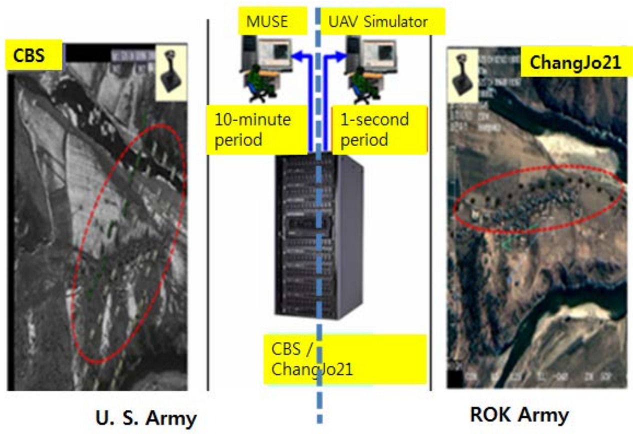

Figure 12. Comparison of UAV image systems in Korea and U.S.

Table VIII also describes system configuration for each system in detail.

TABLE VIII. COMPARISON OF KOREA-U.S. UAV IMAGE SYSTEM

Item	Contents
MUSE (U.S. Army)	• MUSE operator: located in ASIC • Map image: Black / White • Sensor capacity: Diameter 0Km • System overloads due to the transmitting information of all units within operating area (by minute)
UAV (ROK Army)	• UAV system operator: Located in simulated Information team ⇒ transmitting UAV image to ASIC • Map image: Color • Sensor capacity: Diameter 00Km • Minimize system overloads by selected transmission of data which is in UAV screen (by second)

IV. MODIFICATION OF SIMULATION LOGIC FOR V-C INTEROPERATION

A. *Visual factor*

In order to reflect shielding effect to the objects (weapons) by applying altitude to plateau/ridge considering 3-dimensional topographical characteristics, we have to match topographical information in training model with those in the UAV simulator. In addition, topographical information should not be applied to simulator in artificially edited way.

Unfortunately, 3-dimensional topographical map of our UAV simulator does not support forests (plants), civilization, and topographical shape (mountains, clouds), so that it is necessary to consider the effect of detection of hidden and concealed objects in real theater as in Fig. 13.

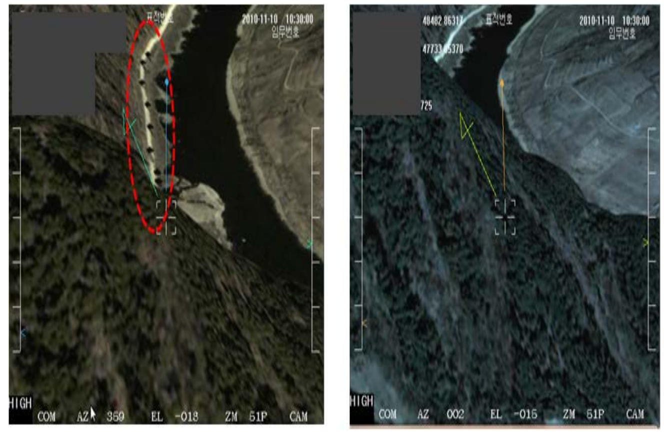

Figure 13. Shielding effect considering three-dimensional topography.

We have solved these problems by applying different detection rate on topographical factors in the training model. Specifically, we have applied 60% of detection rate on objects of stopped units considering various kinds of hiding and concealment in combat situation, and have applied 100% of detection rate on objects of moving units using roads except for infantry outfits. We decided the detection rates based on the experiences in real combat training.

B. *Weather factor*

In operation of real UAV, it is general to set up flying plans considering rainfall, snowfall, the direction of the wind/the velocity of the wind. Therefore, we have made UAV flight restricted considering weather condition in the UAV image simulation system as well. The flight is restricted when rainfall more than midway (0mm /H above) or snowfall more than midway (00mm /H above) occurs or when right wind 00m/s / side wind 0～0m/s occurs in respect of the direction and the speed of wind.

On the other side, it is necessary to carry out consistent research on special effects such as blurred image occurred by weather condition on sensor image photographing / diminished visible area.

C. *Application of moving distance depending on unit formation / armament*

We have applied different movement intervals depending on weapons (tanks, armored vehicles, etc.) and vehicles to provide each object location to simulator applying 6 formations (column, row, tripod, inverse tripod, right echelon, left echelon) and tactical intervals between objects.

Simulation logic for unit movement of training model has been modified, which made it possible for marching columns to follow along the bending roads instead of keeping straight disposition as in Fig. 14. This logic modification has brought a positive effect on not only damage estimation on moving units but also interoperation between simulator and training model.

Figure 14. Objects moving along the roads.

D. Further developments

Newly developed UAV image simulation system is the first system that supports V-C interoperation in ROK Army but is not perfect yet. There are several points to be complemented and further developed.

First, in terms of personnel / portable equipment, the reflection of three-dimensional image of objects, is restricted if the number of objects (military forces) is excessive. In case of considering all personnel, the system loads will be aggravated.

The reflection is also restricted due to limitation of three-dimensional image processing capability of portable equipments. Thus, it is necessary to estimate appropriate number of persons and reflect it to the system after system overload test for further personnel. Displaying of three-dimensional object images on portable equipment should be considered after developing three-dimensional image processing capability.

Second, it is necessary to complement reality such as blurred image effect and reduction of visibility range in target detection / discernment considering image photographing effect which includes weather condition like rainfall, snowfall, mist, cloud and the rest.

Third, real UAV operation has been executed mainly on providing target information associated with tactical plan and secret information for BDA (Battle Damage Assessment) evaluation. Consequently, newly developed UAV image simulation system supports 3D image photographing and represents objects considering combat damage as that objects destroyed by attack are deleted in real-time. However, the flame and smoke from objects (equipments) when damage occurs are not included in the image. Therefore, this weak point should be complemented.

V. CONCLUSION AND FUTURE WORK

Current simulation models (system) held by ROK Army have limitations on vicarious execution of mission and action of combat personnel. Moreover, there are restrictions on providing comprehensive training / exercise opportunity because simulator training is also restricted for upper level unit's commanders / staff training. Therefore, LVC training system is the most suitable means for commanders, staffs, and combat personnel to train together in ordered ways.

The purpose of LVC training system is to embody the system for accomplishing similar effect with real combat execution through providing virtual simulation environment similar to real world. Still, the embodiment of LVC integrated simulation system is currently restricted in ROK Army because LVC training system construction is planned from year 2019 to 2025 in successive manner.

We described about a V-C interoperation system first developed in Korea that connects UAV simulator (V) and ChangJo21 model (C). We have enhanced the performance of the V-C interoperation system by applying buffer function only to changed object information that is within the diameter of image sensor, and by constructing interoperation system.

As this study suggests, when V system has self-image and interoperates with C system in real-time, and when V system interoperates with war-game model (C) for a large troop, it is possible to do real-time data synchronization between two models.

We have developed the foundation of L-V-C system without trial and error that many of the M&S developed countries experienced in interoperation of different systems.

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