

Research Article

The Development of the Carrier Aviation Support System Architecture Using DoDAF

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Abstract: This study describes a development of aircraft carrier aviation support system architecture using DoDAF. The aircraft carrier, warship doing role of mobile sea airbase in offensive and defensive mission, is super system that is comprised of carrier itself and carrier-based air wing. Performing critical role in step with aviation operations in carrier-air wing interactions, the aviation support system of aircraft carrier is also system of systems. It is required to complex and integrated approach based on systems engineering in establishing concept of this complex systems. In this view, this study established an operational scenario and derived operational requirements by identifying aviation operations environment on deck of aircraft carrier. It is presented the operational architecture of the carrier aviation support system by using DoDAF and CASE tool CORE.

Keywords: Aircraft carrier (system), aviation support system, carrier air wing, DoDAF (Department of Defense Architecture Framework), super system, system of systems

INTRODUCTION

In modern warfare, the aircraft is the essential power and using this proper time, proper place is that is, the way of winning the war. In future warfare, the aircraft is also will be able to mobile farther and faster and use larger range, hence it will be continue to keep the key position of military power in whether manned or unmanned systems.

The aircraft carrier is the warship doing the role of sea airbase for offensive and defensive mission using this aircraft and the super system comprised of carrier itself and embarked air wing (Hermann *et al.*, 1991; Defense Science Board Task Force, 2002). And the carrier aviation support system, performing the key role in carrier-air wing interactions in step aviation operations from launch to recovery, is also the system of systems. The carrier aviation support system is essential to integrate effectively the distinctive systems of warship and aircraft and operate the aircraft safely on limited deck and therefore it is very important establishing the operational concept of this system. Establishing the operational concept of this complex system requires complex and integrated approach based on systems engineering. Recently in the U.S. Navy and several University, a number of study about modeling aircraft carrier air operations was performing (Angelyn, 1998, 1999; Erdem, 2003; Jason, 2003).

In this viewpoint, this study describes the develop process carrier aviation support system operational

architecture by systems engineering approach. This study draws the operational scenario and operational requirements by identifying the carrier's mission and aviation operations' environment on deck in stage air operations and presents the carrier aviation support system operational architecture using CASE (Computer Aided Systems Engineering) tool CORE (David, 2011).

Problem statement: The ROK Navy is operating the ROKS Dokdo the largest warship in Asia from 2007. The ROKS Dokdo has a platform type large flight deck and hangar deck for operating aircraft effectively, but air operations is somewhat limited due to small displacement and simultaneously carrying amphibious force. In 2013, at the Confirmation Hearing, the new Joint Chiefs of Staff mentioned the need of acquiring carrier and at the Inspect of the Government Offices, there was a report that the ROK Navy is studying a plan ROKS Dokdo rebuild to light carrier capable of operating STOVL and acquire two 30,000 ton class carriers until 2032. This plan would be an intention developing the concept of carriers as a main role operating aircraft based on ROKS Dokdo. Meanwhile, the ROK Navy have accumulated sufficient infrastructure and knowhow required to build ship itself by ship acquisition program, but building and employing the system operating a number of aircraft on board is another issue. In this view, it is essential to understand about carrier aviation support system and it needs to advanced research.

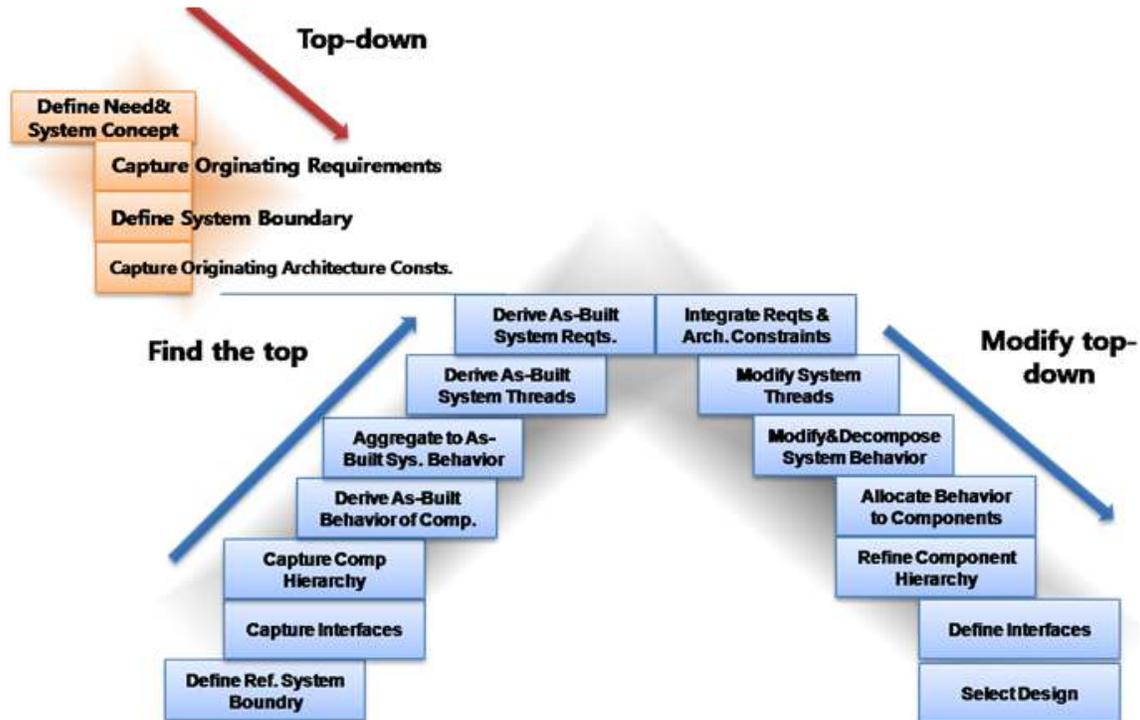


Fig. 1: System re-engineering process

METHODOLOGY

System engineering process: In general, the development precedents can be found for commercial system development projects. The risk and operational burden can be mitigated significantly if the legacy architecture is reused.

Sage defined the product re-engineering as reconfiguration of conventional products' internal mechanism or functions into functional and non-functional form through the inspection, research, identification and modification of such internal mechanism or functions in order to apply new technology while achieving essential objectives of conventional products (Sage and Lynch, 1998; Sage and Rouse, 2009). According to the definition drawn by Sage, re-engineering means the product process that involves the sequence of forward-engineering, reverse-engineering and re-engineering. Figure 1 presents a diagram of the re-engineering process. The re-engineering process implements the net-engineering process that carries out the requirement definition process by identifying the needs and system concepts of initial stakeholders. In addition, the re-engineering process carries out reverse-engineering process that derives system requirements by analyzing the reference system. Finally, along with the requirements that have been derived in that way, the re-engineering process is implemented to carry out the solution definition process again by integrating the requirements that have been generated earlier.

While performing the re-engineering process, the interface obtains interface relationship between the

system of reference system or sub-components in the process of reverse-engineering and is identified through the solutions definition process for the target system in the re-engineering process. The interface, which has been identified by implementing the re-engineering process in the aforesaid way, is managed through CASE Tool.

CASE tool: Currently, many system engineers are using the 'Computer Added System Engineering Tool' to perform the Model-Based System Engineering design and many related cases can be found (Do and Cook, 2012; Bonanne, 2014; Matar *et al.*, 2014; Scheeren and Pereira, 2014; Góngora *et al.*, 2015). MBSE presents reasonable alternative systems through the modeling and simulation from various viewpoints at system level and the response to the vast amount of information by using the computational support tool, thereby reducing the number of prototypes that are created. Moreover, MBSE can ensure trace ability for various requirements ranging from stakeholders' requirements to system validation requirements and increase productivity of works. The system design data, built into database, can facilitate the use and reuse of information related to the existing system in the development of similar systems.

In this regard, the use of System Engineering Computational support tool (CASE Tool) will facilitate system engineering process implementation ranging from the analysis of requirements to the realization of system architecture. Using this tool, the carrier aviation support system project provided simultaneous

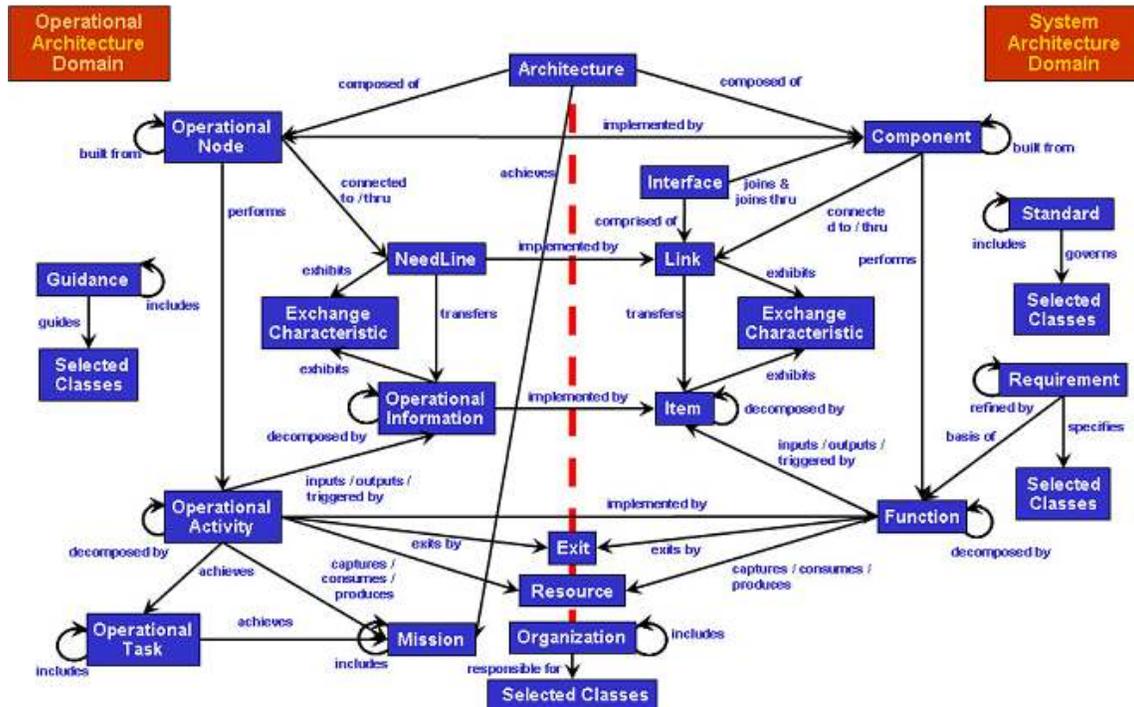


Fig. 2: The schema for system architecting and modeling using DoDAF (Joseph and James, 2002)

development environment of many developers and particularly, system design environment. In this study, the Vitech CORE was used as the tool.

Then, to build the integrated systems model environment that uses the computational support tool, the definition of schema is required which defines the data elements, relationship among such data elements and attributes of the elements.

Figure 2 presents the schema built for the system design and architecture using DoDAF in this study (Joseph and James, 2002). The following Chapter describes the re-engineering process for making up systems architecting that has been explained above and the system design activities using the computational support tool that supports the system model environment within the re-engineering process.

CASE STUDY: CARRIER AVIATION SUPPORT SYSTEM

Concept of carrier air operations: The carrier is the warship as the role of airbase at sea and operating aircraft is the primary goal. Therefore, the carrier has no means of warfare except self-defense and is the ship performing combat with only embarked combat aircraft. The aircraft carrier is defined in [Naval Terminology Dictionary] .

“The warship as a role centerpiece of naval task force, having be able to embark, launch and recover the fighter. Having the advantage of approaching quickly to the enemy, launching, attacking and recovering the

Table 1: Carrier classification (by displacement)

Classification	Displacement (ton)	Number of embarked aircraft
Super carrier	More than 70,000	More than 70
Large carrier	50,000~60,000	40~50
Medium carrier	30,000~40,000	30~40
Light carrier	10,000~20,000	Around 20

*: Launch and land method: CATOBAT, STOBAR, STOVL

aircraft and retreating without exposing position at a unseen great distance. Four features of aircraft carrier are high speed (more than 30 kts cruise), long time operation capability and sea keeping, capable of carrying aircraft and independence maintenance capability. As being emphases more offensive than defensive, heading for a large scale for maximizing air operations capability.”

Now around the advanced nations, 10~12 nations are having or would be having carriers in the world. The carriers are classified in more than 70,000 ton class supercarriers, 50,000~60,000 ton class large carriers, 30,000~40,000 ton class medium carriers and 10,000~20,000 ton class light carriers by size as shown in Table 1; CATOBAR (Catapult Take Off But Arrested Recovery), STOBAR (Short Take Off But Arrested Recovery) and STOVL (Short Take Off and Vertical Landing) by launch and land method; and also multi-mission Carrier (CV), Attack Carrier (CVA), anti-Submarine Carrier (CVS), Escort Carrier (CVE) and so on by mission. Particularly carrier above medium size and CATOBAR method is called “regular carrier” (Hong, 2009).

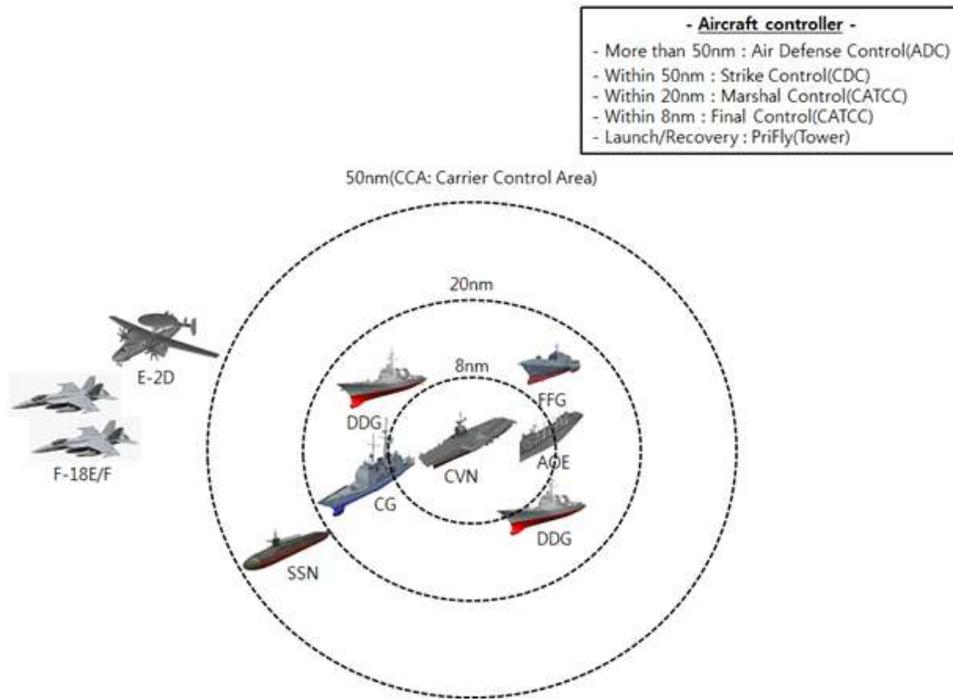


Fig. 3: CSG composition

The aircraft carrier system, Carrier Task Force or CSG (Carrier Strike Group), is large scale system of systems comprised of carrier air wing, AOE, SSN and Escort with carrier itself as the central figure (Fig. 3). In here, aircraft carrier play a role in airbase, air wing play a role in offensive and defensive main combat power, AOE play a role in sustaining support (fuel, ammunition, supply and so forth) and SSN and Escort play a role in defensive mission of CSG (Hermann *et al.*, 1991).

In carrier's deck, hundreds of crew and a number of equipment do the Launch, ATC (Air Traffic Control), Recovery and Handling activities by each role and interactions in flight operations steps for supporting harmonious aircraft operations. This is similar to flight operations of ground airbase but more strain and dangerous environment in point of acting a number of aircraft and person simultaneously in small space. Launch is taking off aircraft activity using catapult or ski-jump and ATC is controlling launch and recovery or guiding airborne aircraft activities using communication nets. Recovery is landing aircraft activity from its mission using arresting gear or by vertical landing method and handling is arming/de-arming, refueling, equipment fitting/unfitting, freight loading/unloading, moving, maintenance and so on activities in flight deck or hangar deck. Aircraft carrier is also comprised of subsystems of propulsion system, combat system and navigation system, but in particular the systems collectively called aviation support system related to step-by-step flight activities. This study focused on aviation support system of regular aircraft carrier.

Operational environment: The most important role of carrier is executing support activities such as preparation, launch, ATC, recovery, handling/maintenance and so on for aircraft's performing mission. Required activities for operating aircraft on board carrier is similar to activities airbase on land, but it is important operating carrier itself and air wing systematically in space no more than 20% of land airbase. Carrier provide control of all kinds systems or equipment and movement required for operating aircraft and aircraft of each squadron under air wing plan, execute, review missions with supporting carrier. On the flight deck repeating this activities every day, getting entangled tens of aircraft and equipment, hundreds of crew, jet fuel and arming, an aircraft is launch and recovery every minute and about 200 sorties mission execute mission in a day. In these on board, a few seconds and several cm of error is that ultimately led to a huge disaster. Carrier as a warship and air wing is systemic and culturally very foreign organizations that are each other. Mutually reinforcing and buffer gave them tours of interaction between these disparate parts to give the carrier aviation support system and organization operating the system of carrier air department.

Concept of operations carrier aviation support system: Carrier aviation support system is system of systems integrated into systems required to support mission in flight steps and this system is in charge of air department under carrier.

Operational scenario: Carrier aviation support system is to ready and launch aircraft according to received flight plan, control aircraft during launch and recovery or airborne, recover aircraft completed mission, refuel and rearm returned aircraft and then repeat this activities for performing other mission. General scenario description is as follows:

- Carrier air wing make out flight plan a day.
- Air Ops decides launch/recovery time as follows flight plan and CATCC, Tower and LSO control aircraft.
- Aircraft ended maintenance in hangar deck is towed to elevator by towing car and moved to flight deck by elevator.
- The aircraft refuel and arm in flight deck.
- The aircraft, ready to flight, is shot out.
- The aircraft, shot out, is controlled initially by CDC (Combat Direction Center) and perform intercept mission by controlling air defense commander.
- The aircraft, completed mission, recover by controlling CATCC, Tower.
- The recovered aircraft is rearmed/refueled for next mission or if no further mission ended mission moving to hangar deck by elevator.

Operational requirements: Being drew out requirements of launch, ATC, recovery and handling systems as follows from missions and operational scenarios of carrier aviation system:

- Aviation system has to functions as independent system installed in carrier.
- Carrier-air wing-aviation support system have to exchange information and data by systematic interactions each other.
- All elements have to hold in common position and state in real time about aircraft, support equipment and person in flight deck and hangar deck.
- ATC system has to aware situation in real time about all aircraft in the air or on the flight deck.
- Communication network always has to possess all primary/secondary.
- Recovery system should be able to utilize all options of approach.
- Recovery and ATC systems have to prepare for bolter.
- Handling system has to grasp all towing car and person.
- All systems have to simultaneous act partially. And so on. There are requirements.

Systems composition: Carrier aviation support system is comprised of launch, ATC, recovery, handling



Fig. 4: Composition of carrier aviation support system

systems. The launch system launch aircraft on flight deck being comprised catapult and JBD (Jet Blast Deflector) as shown in Fig. 4. The ATC system control and monitor interval of launch/recovery and airborne aircraft being composed of all kinds of communication system and ATC radar. The recovery system decides approach method and then stops recovered aircraft on flight deck being comprised arresting gear, ICLS (Instrument Carrier Landing System), ACLS (Automatic Carrier Landing System), OLS (Optical Landing System) and JPALS (Joint Precision Approach and Landing System). The handling system takes part in movement, arming/de-arming, refuel, mission equipment installing/removing and maintenance aircraft being composed of towing car, jet fuel refueling equipment and arming equipment.

Context analysis: Identifying carrier aviation support system an object system and the boundaries of surrounding external environment (system) and then showing up input and output factors of object system with context diagram. The context has relations with system and interfaces exchanging information and data each other as shown in Fig. 5. The purpose of analyzing context is to use as a means of acquiring concept about high level of required system and it provides progressively developed references for identifying system interface requirements and input/output data.

The external systems of carrier aviation support system are 5 systems of CSG (Carrier Strike Group), air wing, carrier and aviation support system and it should be composed interfaces with 5 external systems.

Developing architecture using DoDAF: Being began at defining mission requirements, architecture was developed using DoDAF and each outputs was modeled with CASE CORE. Miguel *et al.* (2010) noted the method modeling total ship using DoDAF.

DoDAF: Beginning with C4ISR AF at 1996, the DoDAF (Depart of Defense Architecture Framework) was issued initially as DoDAF at 2004 and now the newest version is DoDAF 2.0 with gradually being improved. Benchmarking DoDAF, the ROK MND (Minister of Defense) also issued MNDAF but this study applied DoDAF. The DoDAF made a detailed



Fig. 5: Carrier aviation support system context diagram

항모 항공지원시스템 시나리오

항모에서의 항공기 운용을 위해서는 항모의 Strike Ops에서 함 정동, 함 방어계획 등의 기초자료와 JFACC(Joint Force Component Commander)의 Air Master Plan을 제공받아 항모항공단(CAG) Ops에서는 항모 항공계획(Air Plan)을 작성한다. Air Ops는 CAG Ops에서 세운 항공계획을 가지고 항공기의 발진(Launch/이수 (Recovery) 시간)을 정렬하여 집행하고, 실제 항공기 동체는 CATCC, Tower(Prify), LSO 등에서 실시한다. 항공 계획 수립에는 항모 항공 관리 시스템(Carrier Aviation Management System)이 사용된다. 격납고(Danger Deck)에서 항모에 대한 정보는 Hanger Deck Officer의 지휘에 의해 Towing Car에 격납되어 엘리베이터를 이용하여 엘리베이터를 통해 비행갑판(Flight Deck)으로 이동한다. 비행갑판에서 항공기는 Handler의 지휘에 의해 Towing Car에 의해 격납되어 이동을 하여 Aviation Fuel Officer의 지휘에 의해 연료를 공급받고 항모에서는 Ordnance의 지휘에 의해 무장을 장착한다. 무장장착이 완료되면 발진 45분전에 비행소우양동에 의해 비행 전 검사를 수행하고 항공기에 탑승한다. 발진 30분 전에 항공기 시동이 되어 15분전에 Handler의 지휘하에 개시 (Taxi)하여 시종장치(C-13 Mod 2 또는 EMALS)에 배치된다. 시종장치에 배치되면 제트엔진 점화 시, 전항정지(Stop)와 풀러라고 Shooter에 의해 시종장치 후자가 항공기 노즈기에 알리며 최종 우양승함을 위한 후 오든 것이 안전하다고 확인되면 Tower에서 Air Boss의 지휘하에 발진이 허가되고 Shooter의 지휘에 의해 항공기는 사출된다. 사출된 항공기는 CDC(전투지원시스템)의 Strike Control에 의해 SP5-48, 49 레이더 또는 VSR(Volume Search Radar)와 무전기(UHF)로 이루어진 최종 관제가 실시되고 항모로부터 50nm의 범위 내 ADC(항공지원관제)의 Red Crown의 통제에 의해 Aegis시스템, 무전기(UHF) 또는 데이터링크로 유력업무가 수행된다. 발진과 항모로 돌아면 항공기는 ADC의 통제하에 항모로 접근하며 50nm 이내로 전항하면 CATCC(항공공통관제소)의 관제를 받는 데 20nm까지는 CATCC의 Marshall Control의 SPN-46,43 레이더와 무전기(UHF)에 의한 관제를 받아 착륙하는 항공기들이 고도/거리별로 정렬되어 순서를 기다린다. 20nm 이내로 접근이 허가되면 약 5nm까지 CATCC의 Approach Control의 SPN-46,43 레이더와 무전기(UHF)에 의한 관제를 받아 미세한 조정을 받으며 항모에 접근한다. 단 기상이 양호한 경우에는 이 거리부터 Tower의 무전기(UHF)에 의한 관제를 받으며 접근하고 Approach Control은 모니터링 한다. 5nm에서부터는 기상이 양호한 경우에는 계속해서 Tower의 무전기(UHF)에 의한 관제를 받으며 접근하지만 기상이 불안전한 경우에는 Final Control의 관제를 받아 접근방법을 결정한다. 접근방법은 세 가지가 있는데 항모의 Final Control의 SPN-41 레이더와 동시에 무전기(UHF)에 의한 관제를 받아 정렬하게 접근하는 Carrier Controlled Approach, 항모로부터 항모로 접근하는 정보를 항공기의 계기를 통해 항공기 고도와 최종 발위에 관련된 항공기 위치가 전사되는 정보를 조종사가 보면서 미세 조정하여 접근하는 ICLS(Instrument Carrier Landing System), ICLS와 유사한 항공기 고도와 최종 발위에 관련된 정보를 항공기의 자동비행장치(Autopilot)에 연동하여 자동으로 접근하는 ACLS(Automatic Carrier Landing System)의 방법을 통해 항모에 5nm 까지 접근한다. 여기서 항모가 조종사의 사각에 식별이 되면 Tower로부터의 착륙언급을 받아 LSO의 신호를 받고 조종사는 OLS(Optical Landing System)를 참조하여 착륙하게 된다. 또한 GPS 및 데이터링크 크와 관련된 자동정렬이 최종 착륙까지 완전 자동으로 실행하는 PALS(Precise Precision Approach and Landing System)을 적용하기도 한다. 항모 서각식별이 완료된 Missed Approach가 시행되고, LSO의 신호를 받는 과정에서 고도와 발위가 부적절하면 LSO의 지시에 의해 WaveOff를 시행하며, 착륙시도 중 Arresting Wire에 걸리지 않으면 스톱볼을 최대 능력으로 하여 Baber(착륙장착)을 사용하여 재접근을 시도한다. 이 과정에서 3 번째 착륙이 실패하면 공중급유기로 가서 재급유를 받은 후 다시 접근을 시도한다. Arresting Hook가 Mark 7 Mod 3 또는 AAGS(Advanced Arresting Gear System) Arresting Gear의 Wire에 성공적으로 걸리면 항공기는 착륙이 완료되고 속도가 완전히 정지되면 Hooker에 의해 Arresting Wire가 풀리고 Handler의 지시에 의해 이동하여 Ordnance의 지휘 하에 무장이 해제되거나 다중영무를 위해 재우장된다. 그리고 Aviation Fuel Officer의 지휘하에 연료재무장이 되어 다음 발진준비를 허가한다. 발진과 없을 시에는 엘리베이터를 통해 격납고로 이동하고 격납고에서는 Hanger Deck Officer의 지휘하에 최종 계류까지도 이동하면 발진과 종료된다.

항목	번호	이름	기능	위치	상태	비고
1	01000	항모	항모	항모	항모	항모
2	01001	항모	항모	항모	항모	항모
3	01002	항모	항모	항모	항모	항모
4	01003	항모	항모	항모	항모	항모
5	01004	항모	항모	항모	항모	항모
6	01005	항모	항모	항모	항모	항모
7	01006	항모	항모	항모	항모	항모
8	01007	항모	항모	항모	항모	항모
9	01008	항모	항모	항모	항모	항모
10	01009	항모	항모	항모	항모	항모
11	01010	항모	항모	항모	항모	항모
12	01011	항모	항모	항모	항모	항모
13	01012	항모	항모	항모	항모	항모
14	01013	항모	항모	항모	항모	항모
15	01014	항모	항모	항모	항모	항모
16	01015	항모	항모	항모	항모	항모
17	01016	항모	항모	항모	항모	항모
18	01017	항모	항모	항모	항모	항모
19	01018	항모	항모	항모	항모	항모
20	01019	항모	항모	항모	항모	항모
21	01020	항모	항모	항모	항모	항모
22	01021	항모	항모	항모	항모	항모
23	01022	항모	항모	항모	항모	항모
24	01023	항모	항모	항모	항모	항모
25	01024	항모	항모	항모	항모	항모
26	01025	항모	항모	항모	항모	항모
27	01026	항모	항모	항모	항모	항모
28	01027	항모	항모	항모	항모	항모
29	01028	항모	항모	항모	항모	항모
30	01029	항모	항모	항모	항모	항모
31	01030	항모	항모	항모	항모	항모
32	01031	항모	항모	항모	항모	항모
33	01032	항모	항모	항모	항모	항모
34	01033	항모	항모	항모	항모	항모
35	01034	항모	항모	항모	항모	항모
36	01035	항모	항모	항모	항모	항모
37	01036	항모	항모	항모	항모	항모
38	01037	항모	항모	항모	항모	항모
39	01038	항모	항모	항모	항모	항모
40	01039	항모	항모	항모	항모	항모
41	01040	항모	항모	항모	항모	항모
42	01041	항모	항모	항모	항모	항모
43	01042	항모	항모	항모	항모	항모
44	01043	항모	항모	항모	항모	항모
45	01044	항모	항모	항모	항모	항모
46	01045	항모	항모	항모	항모	항모
47	01046	항모	항모	항모	항모	항모
48	01047	항모	항모	항모	항모	항모
49	01048	항모	항모	항모	항모	항모
50	01049	항모	항모	항모	항모	항모
51	01050	항모	항모	항모	항모	항모
52	01051	항모	항모	항모	항모	항모
53	01052	항모	항모	항모	항모	항모
54	01053	항모	항모	항모	항모	항모
55	01054	항모	항모	항모	항모	항모
56	01055	항모	항모	항모	항모	항모
57	01056	항모	항모	항모	항모	항모
58	01057	항모	항모	항모	항모	항모
59	01058	항모	항모	항모	항모	항모
60	01059	항모	항모	항모	항모	항모
61	01060	항모	항모	항모	항모	항모
62	01061	항모	항모	항모	항모	항모
63	01062	항모	항모	항모	항모	항모
64	01063	항모	항모	항모	항모	항모
65	01064	항모	항모	항모	항모	항모
66	01065	항모	항모	항모	항모	항모
67	01066	항모	항모	항모	항모	항모
68	01067	항모	항모	항모	항모	항모
69	01068	항모	항모	항모	항모	항모
70	01069	항모	항모	항모	항모	항모
71	01070	항모	항모	항모	항모	항모
72	01071	항모	항모	항모	항모	항모
73	01072	항모	항모	항모	항모	항모
74	01073	항모	항모	항모	항모	항모
75	01074	항모	항모	항모	항모	항모
76	01075	항모	항모	항모	항모	항모
77	01076	항모	항모	항모	항모	항모
78	01077	항모	항모	항모	항모	항모
79	01078	항모	항모	항모	항모	항모
80	01079	항모	항모	항모	항모	항모
81	01080	항모	항모	항모	항모	항모
82	01081	항모	항모	항모	항모	항모
83	01082	항모	항모	항모	항모	항모
84	01083	항모	항모	항모	항모	항모
85	01084	항모	항모	항모	항모	항모
86	01085	항모	항모	항모	항모	항모
87	01086	항모	항모	항모	항모	항모
88	01087	항모	항모	항모	항모	항모
89	01088	항모	항모	항모	항모	항모
90	01089	항모	항모	항모	항모	항모
91	01090	항모	항모	항모	항모	항모
92	01091	항모	항모	항모	항모	항모
93	01092	항모	항모	항모	항모	항모
94	01093	항모	항모	항모	항모	항모
95	01094	항모	항모	항모	항모	항모
96	01095	항모	항모	항모	항모	항모
97	01096	항모	항모	항모	항모	항모
98	01097	항모	항모	항모	항모	항모
99	01098	항모	항모	항모	항모	항모
100	01099	항모	항모	항모	항모	항모

Fig. 6: Carrier aviation support operational scenario

explanation of standard views acquiring various systems views. This outputs are utilized for developing weapon systems acquisition document such as ICD (Initial Capability Document) and CDD (Capability Development Document). In the U.S. Acquisition Guidance, it makes a note of ICD containing OV-1 and CDD containing AV-1, OV-1, 2, 4, 5, 6c, SV-2, 4, 5, 6, TV-1.

Architecture outputs: As DoDAF, architecture outputs was comprised of All View, Operational View, System View, Technical View in version 1.5 so far and added Capability View, Service View and so on, however, this study developed outputs AV-1, OV-1, 2, 4, 5, 6c. Before developing architecture outputs, making out operational concept detailed scenarios as a statement form and making out the scenarios as a template for identifying operational node activities. Figure 6 is the scenario a statement form and the scenario a template form being converted.

AV-1 overview and summary information: It identified carrier aviation support system and described a purpose and range of architecture making out a text form.

OV-1 high level operational concept graphic: It provided highest level operational views of systems provided in architecture.

OV-2 operational node connectivity description: Node, Architecture element generating, consuming and processing data, that is, it presented exchanging information among operational nodes performing mission or role.

OV-4 organizational relationships chart: It presented hierarchical organization relations.

OV-5 operational activity model: It classified total 44 activities from highest 0 to 3-level and presented IDEF0 and N2 Chart based on these activities.

OV-6c operational state transition description: It presented relations with aviation support system in steps performing mission and presented eFFBD.

Up to now, it makes out architectural outputs as text and diagram types required object/range and operational concept of system, relations among nodes identifying node, activity and relations from operational scenario.

CONCLUSION

The aircraft carrier is the warship operating aircraft as a main object, hence ship and aircraft unit on board should play an active role as single unit and large system so that they could display effective combat power without safety accident. For that reason, it needs to be set up carrier aviation support system for effective air operations on board. In this study, making up architecture of regular aircraft carrier but if modifying architectural outputs it could be apply to light carrier or helicopter carrier.

In this view, this study was made up operational scenario applying systems approach in concept level of carrier aviation support system and drew out operational requirements and presented architecture using DoDAF and CORE tool.

REFERENCES

- Angelyn, J., 1998. USS Nimitz and Carrier Airwing Nine Surge Demonstration. Center for Naval Analyses, Alexandria, Virginia, CRM 97-111.10/April 1998.
- Angelyn, J., 1999. Sortie Generation Capacity of Embarked. Center for Naval Analyses.
- Bonanne, K.H., 2014. A model-based approach to system-of-systems engineering via the systems modeling language. Thesis, Purdue University.
- David, L., 2011. Interdisciplinary and the Study of International Relations. In Aalto, P., V. Harle and S. Moisis (Eds.), *International Studies: Interdisciplinary Approaches*. Basingstoke, Palgrave, pp: 31-65.
- Defense Science Board Task Force, 2002. Future of the Aircraft Carrier. Office of the Secretary of Defense, Washington, D.C.
- Do, Q. and S. Cook, 2012. An MBSE Case Study and Research Challenges. INCOSE International Symposium, 22(1): 1531-1543.
- Erdem, A., 2003. CUVX design report unmanned combat air vehicle carrier. CUVX HI2 Option Ocean Engineering Design Project, Virginia Tech Aerospace and Ocean Engineering.
- Góngora, H.G.C., M. Ferrogali and C. Moreau, 2015. How to Boost Product Line Engineering with MBSE: A Case Study of a Rolling Stock Product Line. In: Boulanger, F. *et al.* (Eds.), *Complex Systems Design and Management*. Springer International Publishing Switzerland, pp: 239-256.
- Hermann, R.J., National Research Council (U.S.) and Naval Studies Board, 1991. *Future Aircraft Carrier Technology*. National Academy Press, Washington, D.C., pp: 35-36.
- Hong, H.B., 2009. *The Aircraft Carrier in the World*. Platoon, pp: 61-62.
- Jason, A., 2003. CUVX design report unmanned combat air vehicle carrier. CUVX HI3 Option Ocean Engineering Design Project AOE 4065/4066, Virginia Tech Aerospace and Ocean Engineering.
- Joseph, M. and L. James, 2002. *A Natural Approach to DoDAF: Systems Engineering and CORE*. Vitech Corporation, pp: 2, 8-9.
- Matar, M., H. Osman, M. Georgy, A. Abou-Zeid and M. El-Said, 2014. Evaluation of Civil Infrastructure Sustainability: A Model-based Systems Engineering (MBSE) Approach. In: Mahdavi, A., B. Martens and R. Scherer (Eds.), *eWork and eBusiness in Architecture, Engineering and Construction*. ECPPM 2014, Taylor and Francis Group, London, pp: 327-334.
- Miguel, R., W. Mark and H. Ashby, 2010. Total Ship Systems Engineering Employing Department of Defense Architecture Framework Approach. pp: 1-3. Retrieved from: <https://www.navalengineers.org/SiteCollectionDocuments/.../Rivera.pdf>.
- Sage, A.P. and C.L. Lynch, 1998. Systems integration and architecting: An overview of principles, practices and perspectives. *Syst. Eng.*, 1(3): 176-227.
- Sage, A.P. and W.B. Rouse, 2009. *Handbook of Systems Engineering and Management*. 2nd Edn., John Wiley and Sons.
- Scheeren, I. and C.E. Pereira, 2014. Combining model-based systems engineering, simulation and domain engineering in the development of industrial automation systems: Industrial case study. Proceeding of the IEEE 17th International Symposium on Object/Component/Service-oriented Real-time Distributed Computing (ISORC, 2014), pp: 40-47.