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Mission planning systems: cubic multipliers

R.P. de Moel and F.J. Heerema

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ABSTRACT
The National Aerospace Laboratory NLR, in The Netherlands, has a long time experience in development and production of military aircraft mission planning systems.
With respect to objectives, operating and technology mission planning systems can be considered as multipliers. This paper discusses some topics related to these multipliers: the cubic multipliers.
The most prominent multiplier is directly related to the mission objectives: improved mission execution.
The second multiplier is the capability of mission planning systems to play a role in the training of military pilots with respect to the execution of real missions.
The third multiplier is: mission planning systems are driving the technology.
The cubic multiplier statement is discussed only for ground based mission planning systems. The significance of mission planning systems is demonstrated at the most, if the tasked mission is complicated and has to be executed in a complex and relatively unknown area.

Contents

(9 pages in total)

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MISSION PLANNING SYSTEMS: CUBIC MULTIPLIERS

by
R.P. de Moel, F.J. Heerema
National Aerospace Laboratory NLR,
PO Box 90502 1006 BM Amsterdam, The Netherlands

1 Introduction

AGARD Advisory Report No. 296, published May 1991, contains the definition of a planning system for aircraft missions: "A system that allows all the available and pertinent information to be used to plan a mission to achieve certain objectives in an optimum and near-optimum way, and also data that describes the mission to be loaded into the aircraft. With respect to objectives, operating and technology mission planning systems can be considered as multipliers." This paper discusses some topics related to these multipliers.

The National Aerospace Laboratory NLR, in The Netherlands, has a long time experience in development and production of military aircraft mission planning systems (figures 1 and 2). In 1975 already NLR studied the feasibility of "rear-port tube" graphic display systems for mission planning purposes. This type of display system provided the capability to project map information via a rear-port on the innerside of the display screen, so the screen itself could be applied to compose and show an overlay on the projected map. However, inadequate positioning accuracy of the overlay on the map with respect to navigation requirements made this rear-port tube graphics technology unfeasible for military aircraft mission planning systems. NLR's assessment of technology improvements is part of the section on technology (section 4).

The most prominent multiplier is directly related to the mission objectives. Awareness of the actual battle theatre and several types of advices (weapon - to - mission objectives suitability, minimum risk route, attack manoeuvring etc.) are improving principally and practically the chances on mission success. Section 2 of this paper highlights two ingredients of this multiplier:
- in the framework of interoperability the standardization of data exchange;
- in the framework of user friendliness a user definable electronic continuous map area.

The second multiplier is the capability of mission planning systems to play a role in the training of military pilots with respect to the execution of real missions. To make this multiplier effective three conditions have to be fulfilled:
- the mission planning system supports all mission types due to be exercised;
- a metric system is available to assess the planned and sometimes also executed missions in detail;
- fake realistic battle theatres are composed in such a way that progress in training can be determined.

This second multiplier will be discussed in section 3.

Mission planning systems are driving the technology: the third multiplier. Routing systems need always geographic/topographical/reconnaissance information and this information mass is e.g. driving storage capabilities, data compression techniques, and remote sensing derivatives. This subject will be discussed in section 4.

2. The first multiplier: improved mission execution

An electronic information system consists of three components: hardware, software and information. These three components are all essential: the quality of information defines for the major part the value of the multiplier. A large part of this information is either unchanging or very slowly changing, so that update of this is rarely necessary and in no way critical. However, some of the information - e.g. the geographical position of both friendly and enemy assets - could be changed frequently to correspond to rapidly changing real world situations.

2.1 NATO standards for data exchange

The mobility of military forces - needed because of an essential task of NATO: embanking of local conflicts - and the improved mobility of enemy threats hamper obtaining correct and up-to-date information. Of course it is an option to prepare a mission without using this information: in that case a judicious risk analysis is recommended. The NATO approach to facilitate the transfer of information is to define "exchange standards": standard information formats.

What NATO data exchange standards are available to load this pertinent information (see table 1) into the mission planning data base? This investigation is limited to the information sets in the scenario cluster, because of the rapidly changing character of most of these information sets. The first column of table 2 contains the name of the information subset involved, the second column the number and the edition of the NATO Standard Agreement (STANAG), the third column the designation and covering of the related standard.

Table 2 shows that only for geographical information data exchange STANAGs have been defined. The important intelligence data STANAG is a concept version; for meteo only a communication STANAG is available. For navigation data a STANAG for obstacles is available. In the framework of data exchange standards for command and control still a lot of work has to be done.

Table 1 MSS/P DATABASE

information	breakdown	remarks
Scenario cluster		
Geographical info.		
Digital Landmass SYSTEM	terrain elevation and feature data	
1:50/100/250,000 electr. maps	continuous areas	UTM projection
1:500,000 electronic map	scontinuous areas (TPC, LFC)	Lambert projection
1:2,000,000 electronic maps	map sheets	Lambert projection
Schematic maps (WVS)		DMA product
Intelligence Info.		
Threats*	AOB, EOB, GOB, MOB, Events, Latent threat	point co-ordinates
Planning lines*	including FLOT, FSCL, EFSCL, RIPL	split up in line parts
Nuclear incidents*		for presentation only
Meteorological info.		
Airfield weather*	actual and forecast	
Significant weather chart*	lines, symbols and text	
Aircraft performance weather*	grid position, wind speed/direction, temperature, QNH	mainly for Ferry a/c performance calc.
Navigation info.		
Airspace management*	routes, zones, lines, boundaries, traverse levels	validity periods
Low flying restrictions	lines, areas, circles	validity periods
Obstacles	Elevations in AGL and MSL	limited availability for low level flights
Friendly airfields	status of ATC, runway, weather, X-serv.	necessary for diversion
Airfield ICAO codes	position and capabilities	
Standard waypoints		to support fast planning
Flight information regions	region identifiers + latitudes/longitudes	for air traffic control in peace time
Magnetic corrections		predicted for 5 years
Aircraft and weapon cluster		
Aircraft performance		implemented as software library
Aircraft configuration	tailnumber specific and generic	
Weapon Stores config.	aircraft/station/stores standard, pilot selectable	standard configurations can be predefined
Tactics cluster		
Tactical scenario	altitude bands, risk levels, EW conditions, threat type	threat presentation and risk calculation
Weapon effectiveness	predefined by NATO, local adaptations possible	
Manoeuvres	run-in, attack, delivery	fuse arming/safe escape/ fragmentation
Route (Preplanned)	air-to-ground missions, air defence sectors, CAP-pos.	
Communications	including IFF/SIF codes	
Default and control parameters		
Defaults		to speed up standard planning sessions
Control parameters	ID. of info. source, map scale/type and symbols	user friendliness

* also obtainable from other CCIS systems

Table 2 NATO DATA EXCHANGE STANDARDS

Information subset	STANAG	Remarks
Geographical		
- terrain elevation	3809 (ed. 3, 1995)	MIL-D-89020
- feature analysis	-	MIL-D-89006
- electronic maps NATO	4387 (concept)	ASRP
DOD	-	MIL-A-89009 ADRG
- digital maps	7074 (ed. 1, 1995)	DIGEST
Intelligence	2433 (concept)	AIntP3
Meteo	6014 (ed. 2, 1995)	AWP3(A), only communications
Navigation		
- airspace management	-	ATP 40 (A), 1989
- low flying restriction	-	CALF, AFCENT
- obstacles	2123 (ed. 3, 1988)	obstacle folder
- friendly airfield	-	ICAO
- airfield ICAO codes	-	ICAO
- standard waypoints	-	-
- flight info regions	-	ICAO Doc. 8400/3
- magnetic corrections	-	British Geological Survey

2.2 NATO standards for geographical data exchanges and userfriendliness

The geographical STANAGs mentioned in table 2 are used mainly for data exchange. What effort has to be spent to make this exchange data ready for use? The three geographical subsets under consideration will be discussed separately.

2.2.1 Digital Terrain Elevation Data (DTED)

Each terrain elevation is compressed into two 36-bits words, the file size is a 1-degree by 1-degree geographical cell. The conversion effort is defined by the collection of the required cells and the decompression into usable items. It is recommendable to spend this effort once prior to the use of the information in the application.

2.2.2 Electronic maps

Table 2 shows two exchange standards for electronic (raster) maps. The first one is the DMA exchange standard, adopted by the USA DOD specifications under MIL-A-89007. NATO has not copied this standard completely but defined STANAG 4387. A significant difference between both standards is the defined raster resolution (MIL-A-9007: 250 pixels/inch, STANAG 4387: more flexible, nominal 250 pixels/inch, variations allowed).

Both standards for arc raster products data exchange are dealing with the conversion of paper map sheets into electronic map sheets in a non-equidistant projection system. If the user requirements for the mission planning system are satisfied by separate non-equidistant electronic map sheets, there is no effort needed any more. In case the user requirements for the mission planning system are requesting scrolling over a continuous area (a number of electronic map sheets defined by the operational user), a considerable effort is necessary.

The above mentioned scrolling requirement is most of time due to combined tactical objectives: overview of (attack) scenario and a high level of detail for mission success. Especially if 1:50,000; or 1:100,000 scale maps are needed for the level of detail; map sheets have to be glued together for overview purposes.

The effort to glue maps together is considerable due to:
- the required navigation accuracy in attack manoeuvring;
- variations in map sheet sizes and in colour definitions caused by the traditions of the national geographical/topographical services;
- deviations (e.g bulges exceeding the defined map sheet size) and defects of paper map sheets (e.g smaller than the specified area, or folded).

The NLR Electronic Map Area Production System (EMAPS) copes with these problems (figure 3).

2.2.3 Digital Maps

STANAG 7074 provides the rules for the transfer formats of geographical information consisting of coordinates and attributes for each map item. Already a long time the user community is waiting for this digital map information with a high expectation level. It cannot be avoided that these users will be disappointed.

This disappointment is caused mainly by the lack of real user requirements. The national topographical/ geographical services contributed to the STANAG in such a way, that the digital geographical information may be used to reconstruct the original map sheet. The topographical/geographical services will have the full profit of the much better update possibility.

If the user needs with respect to geographical information are satisfied by separate sheets, there is no effort needed any more, just the same as for electronic maps. The advantage for the user will be that the map producer is able to provide updates faster and at lower cost. If the user needs are requesting continuous map areas, the effort to realize these areas can not yet be estimated due to the lack of experience. It is not impossible that electronic maps will be used for a longer period than previously expected.

3. The second multiplier: uniform training in mission execution

After the pilot has obtained his flying certificate, he needs an additional training in order to become a competent mission executor. The employment of a mission planning system in this training for mission execution has several advantages:
- uniformity in training is improved;
- uniformity in presentation of battle theatre is assured;
- exercises can be repeated easily, also after completion of the training.

In the introduction of this paper three conditions have been mentioned. The mission planning system needs to support all mission types that have to be trained and exercised; this includes of course the airforce specific tactics in mission execution. The way to consider the other two conditions (metrics and fake scenario) is to take them together. Fake realistic scenarios have to be built in increasing difficulty level and an appreciation figure is attached in case the mission execution problem has been solved properly.

4. The third multiplier: technology driver

The second paragraph of the introduction tells the story of the rear-port tube graphic systems, being at that time the only possibility to present multicolor maps to the user. Disapproval - due to the required navigation accuracy - postponed the presentation of multicolor maps for mission planning for several years. Table 3 shows the evolution of the peripherals/workstations for the mission planning systems developed by NLR.

Table 3: EVOLUTION OF MISSION PLANNING WORKSTATIONS

MOT&E System (1979 - 1981)	Phase 1 + Pilot System (1981 - 1995)	S.O. CAMPAL System (1985 - 1988)	MSS/CAMPAL (1991 - 1994)	MSS/PANDORA (1996 -)
· a-N display	· a-N display	· a-N display		
· printer	· printer	· graphics printer		
	· colour graphics	· 2D colour image	· 3D colour graphics	· 3D colour graphics
	display	display (1024x1024 pixels)	display (1280x1024 pixels)	display (1280x1024 pixels)
	· digitizer	· digitizer	(1x1.4 m)	(1x1.4 m)
		· colour hard copy	· colour hard copy	· colour hard
	copy	unit (A3)	unit (A3)	unit (A4/A3)

Also the technology progress of foreground/background memory and computer speed played a significant role. Some examples:

- **MSS/Campal has a 1 Gigabyte harddisk and a 1-Gigabyte optical disk; MSS/Pandora has an 8-Gigabyte harddisk and no optical disk any more; response time for geographical information has been decreased from some minutes to some seconds;**
- **the current computing speed enables scrolling of geographical information at a speed of 8Hz.**

"Computer based mission planning is a technology driver" is the statement. For the time being this statement remains valid. Mission planners want to have a overview over the entire (mission) area of interest. To the opinion of some operational users scrolling is only a poor replacement for this overview. The requested screen size is about 1 meter by 1 meter. More computer speed is needed because of 3D terrain presentations and verification of terrain coverage during low flying (fixed wing and rotorwing aircraft).

5. Concluding remarks

The cubic multiplier statement is discussed only for ground based mission planning systems. In the case the mission planning task is split over a ground based component and an aircraft component the statement is not changing essentially.

The significance of mission planning systems is demonstrated at the most, if the tasked mission is complicated and has to be executed in a complex and relatively unknown area. To experience the multiplier in extreme circumstances, training in more simple circumstances is highly recommended.

6. Acronyms

ADRG	**Arc Digital Raster Graphics**
AFCENT	**Allied Air Forces Central Europe**
AGARD	**Advisory Group for Aerospace Research and Development**
AGL	**Above Ground Level**
AIntP	**Allied Intelligence Publications**
AOB	**Air Order of Battle**
ASRP	**Arc Standard Raster Product**
ATC	**Air Traffic Control**
ATP	**Allied Tactical Publication**
AWP	**Allied Weather Publication**
CALF	**Chart Amendment Low Flying**
CAMPAL	**Computer Aided Mission Preparation at Airbase level**
CAP	**Combat Air Patrol**
CCIS	**Command and Control Info. System**
DIGEST	**Digital Geographical Standard**
DMA	**Defense Mapping Agency**
DOD	**Department of Defense**
DTED	**Digital Terrain Elevation Data**
EFSCL	**Emergency Fire Support Coordination Line**
EMAPS	**Electronic Map Area Production System**
EOB	**Electronic Order of Battle**
EW	**Electronic Warfare**
FLOT	**Forward Line Own Troops**
FSCL	**Fire Support Coordination Line**
GOB	**Ground Order of Battle**
ICAO	**International Civil Aviation Organization**
IFF	**Identification Friend of Foe**
LFC	**Low Flying Chart**
MOB	**Missile Order of Battle**
MSL	**Mean Sea Level**
MSS	**Mission Support System**
MSS/C	**MSS/CAMPAL**
MSS/P	**MSS/PANDORA**
NATO	**North Atlantic Treaty Organization**
NLR	**National Aerospace Laboratory NLR**
PANDORA	**Planning of Aircraft Navigation for Defensive, Offensive and Reconnaissance Airtasks**
QNH	**Airpressure (milibar) above MSL**
RIPL	**Reconnaisance and Interdiction Planning Line**
SIF	**Selective Identification Feature**
S.O. CAMPAL	**Semi-operational CAMPAL**
STANAG	**Standard NATO Agreement**
TPC	**Tactical Pilotage Chart**
UTM	**Universal Transverse Mercator**
WVS	**World Vector Shore Line**

Fig. 1 - MSS/C at Volkel Airbase (courtesy Volkel)

Fig. 2 - Pandora mission support system

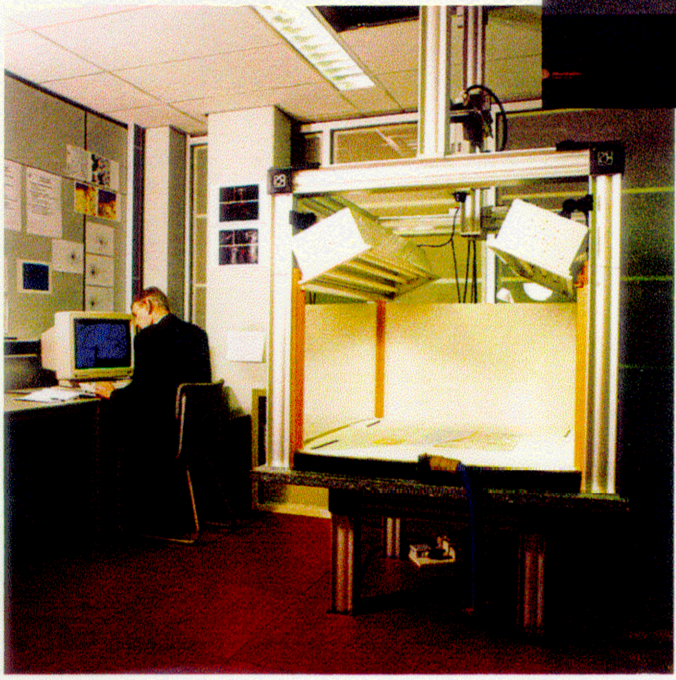

Fig. 3 - NLR Electronic Map Area Production System

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