DEVELOPMENT OF A FRAMEWORK OF THE KOREA AIRPORT PAVEMENT MANAGEMENT SYSTEM

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Abstract: Korea Airport Authority (KAA) has 16 commercial airports, which have relatively old pavements, many of which are more than 20 years old. Although rehabilitation costs have increased, KAA does not have a systematic decision supporting system for maintenance strategies yet. In order to provide a means to facilitate the efficient management of the pavement maintenance budget, KAA decided to develop the airport pavement management system (KAPMS, Korea Airport Pavement Management System) in May 2000. During the first year, the project team developed a framework of the airport pavement management system. The project team adopted Micro PAVER 4.2, developed by US Corps of Engineers as a basic subprogram of the system and will develop other additional components of the system such as the program for calculating allowable gross load and so on. This paper deals with customization of the Micro PAVER for the Korean airports, development planning of pavement deterioration prediction model, establishment of rehabilitation strategies, graphic display of various database items, development of the evaluation guideline of pavement condition, development of the allowable gross load using NDT (Nondestructive Testing), operation guidelines of the automated pavement condition survey equipments, and establishment of the PMS Database.

Key Words: PMS, Micro PAVER, Pavement, Allowable gross load, PCI

1. INTRODUCTION

There exist 16 commercial airports in Korea, most of which are more than 20 years old. An increase in demand for international airports caused by international exchanges and a rise in domestic air traffic as a result of continued economic growth, add to the expansion of airport pavements and thus, the increased cost for maintenance. As a result, the Korea Airport Authority (KAA) pays more attention to the pavement management since the 90s. Each airport conducts pavement evaluations and decides the maintenance method of the pavements based on its results. However, a lack of systematic keeping and utilization of data related to pavement evaluations often make it impossible to find the construction history on old pavements. To provide its solution and the efficient management of the maintenance, KAA launched the development of Korea Airport Pavement Management System (KAPMS) in 2000.

In Korea this study is the first try to develop a PMS for airports. Therefore, in order to reduce trial and error in developing the pavement management system, the research has been conducted with close attention to the experiences of other nations committed to support the operation environment of Korea airport pavement.

The Korea Institute of Construction Technology and Hanyang University has planned to jointly develop KAMPS for a total of three years from 2000 to 2002 and has proceeded in its first stage now. This paper proposes the future direction and basic plan by item for the development of the KAMPS.

2. DEVELOPMENT STRATEIES FOR KAPMS

To establish the development strategies for KAPMS, research has been carried out on the review of foreign airport PMS development and the result is committed to support the domestic situation. <Figure 1> shows the approach procedures of development strategies.

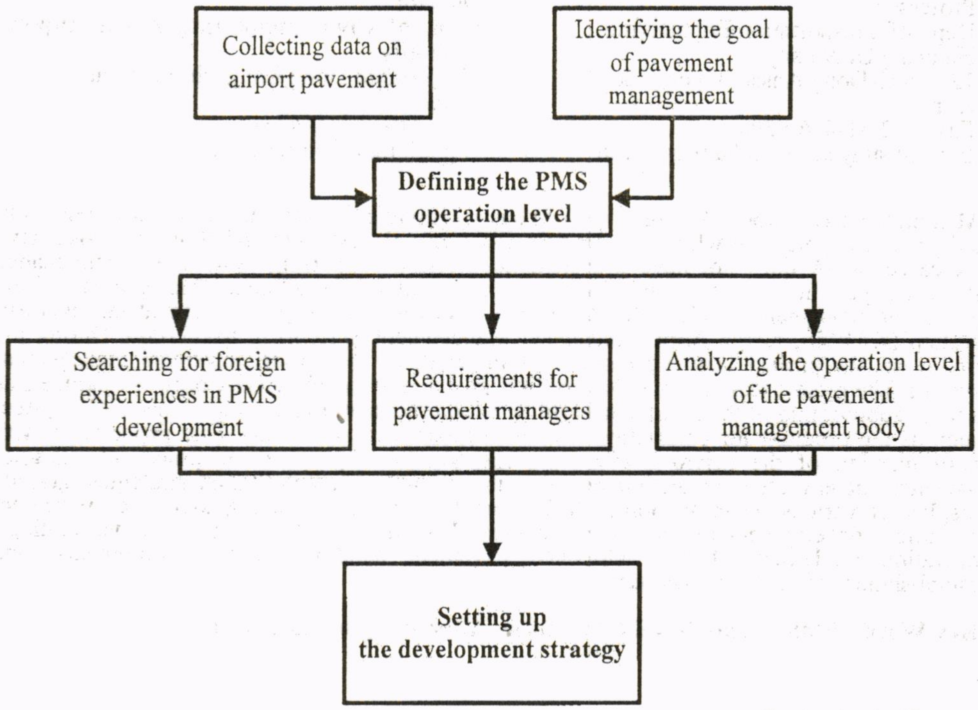

Figure 1. PMS Development strategy set up procedures

2.1 Determining the PMS operation level

The normal PMS operation level can be classified into three levels: Network level, Project level and Research level. The network level predicts an overall picture of the current and future state of airport at low cost, with the purpose of checking the pavement state, selecting repairing measure, and formulating mid- to long-term plans as a manager. The project level, on the other hand, conducts research and analysis in a great detail since it involves selecting the best and detailed repair method and implementing preliminary design. Therefore, a detailed repair method and the repair time are proposed based upon the analysis of a lot of data. The research level conducts research on the pavement design and pavement materials by using of the DB in the PMS.

PMS with all the three levels will be optimal, but it is difficult to be realized at the development stage. Therefore, it was planned that the KAPMS is focusing on the network level. <Table 1> shows the status of the current pavement management in Korea.

Table 1. Current airport pavement management in Korea (1990s)

Classif-ication	Pavement related data available in Korea	Development environment
Content	- Evaluation by PCI from 1994 (1～2 survey data available for each airport) - Pavement evaluation method yet to be established - Difficulty in collecting data on construction and repair details	- Lack of pavement management specialist - Lack of mind expecting long term benefit

The network level is employed to the KAPMS in following reasons.

- Project level PMS requires considerable amount of data to be surveyed.
- Network level PMS is sufficient to understand the general condition of the pavement at the manager's level. In addition, it is possible to estimate the maintenance budget plan.

However, the operation level could be changed to both network level and project level in the future.

2.2 Basic strategy of development

It inevitably contains trials and errors that all the functions mentioned earlier are adopted and developed from the beginning of the development stage. In addition, the existing data regarding airport pavements has not been collected systematically so far. Therefore, it was decided to use commercially available PMS program as a subroutine of the whole KAPMS. <Table 2> shows the comparison of the various development alternatives.

Table 2. Comparison of the development alternatives

Alternatives	Advantages	Disadvantages
Alt. 1 Using foreign PMS	- Only minor adjustments required to establish PMS - Lowers development cost - Reduces development period	- Unable to reflect domestic conditions Program cannot be modified without source code. - Extra time needed to fully understand the program
Alt. 2 Fully new-development	- Development of programs that meet the specific requirements of domestic airports	- Possibility of going through trial and errors already experienced abroad Possibility of extending the development period
Alt. 3 New-development + Foreign PMS	- Includes the contents required for the domestic airport management - Reduces unnecessary trial and errors by adopting foreign programs already in active use	- Compatibility required between foreign program and domestic program

Table 3. Comparison of foreign airport PMS programs(*Papaleo,1998*)

Name	Micro PAVER	IAPMS	Others (AIRPAV, DSS)
Developer	• Corps of Engineers (COE)	• Gibb Consulting, Inc.	•AIRPAV: Eckrose & Greem, Inc. •DSS: ERES, Inc.
Advantages	•Well-known world-wide •Developed by COE with huge amount of budget and has already experienced much trial and error. •Public program (low cost) •Continued upgrading •Developed on ample DB	•Includes logic of calculating allowable gross load and the remaining life	• PMS developed to suit the corresponding airport
Disadvantages	•No logic for calculating allowable load (plans to include LEEP)	• Directly operated by the program developer • Need to require the developer for customizing	• A separate verification needed • Not widely-used
Usage	•1,017 US airports •Chicago, O'hare, Midway, and Hong Kong airport	•JF Kennedy, Heathrow (London), Miami, and Bahrain airport	•AIRPAV: 393 US airports •DSS: 193 US airports

The appropriate foreign PMS program is required for establishing the KAPMS that meets the objectives of the selected development strategy. Based on literature review, the advantages and disadvantages of various PMS programs were compared as described in <Table 3>. Micro PAVER is the most widely-used program, developed jointly by the US Air Force, Army, Federal Highway Administration, Federal Aviation Administration and still receiving active R&D.(*Shahin et al, 1999*) With these advantages, Micro PAVER was selected as a subroutine of the KAPMS.

3. DEVELOPMENT OF KAPMS COMPUTER SYSTEM

3.1 Introduction

In designing a computer system for the airport PMS, Micro PAVER was used as a module while VISUAL BASIC was used to develop programs that Micro PAVER cannot cover, such as module for calculating allowable gross load. To minimize the problem of compatibility with the self-developed program in terms of data storage, MS ACCESS DB found in Micro PAVER was used for common database. The concept of KAPMS is shown in <Figure 2>.

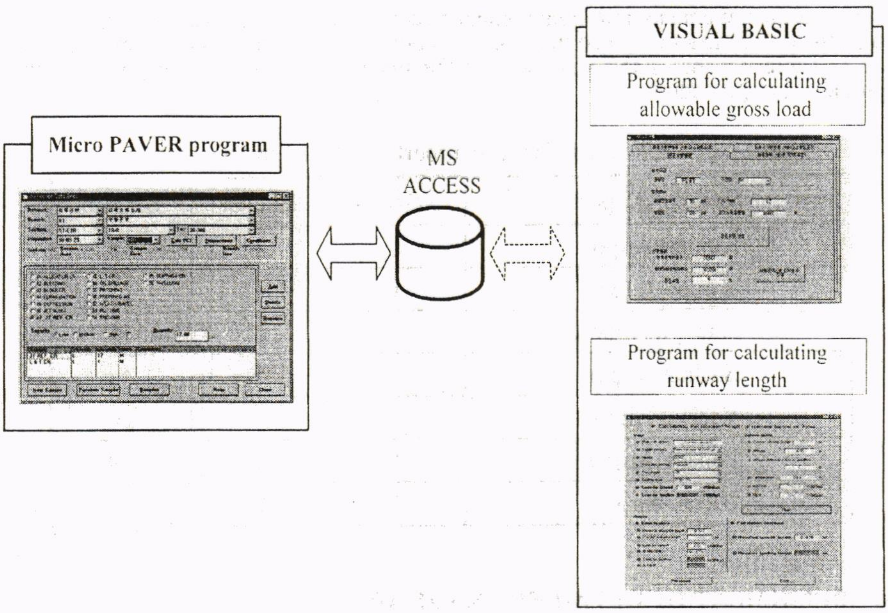

Figure 2. Overview of KAPMS

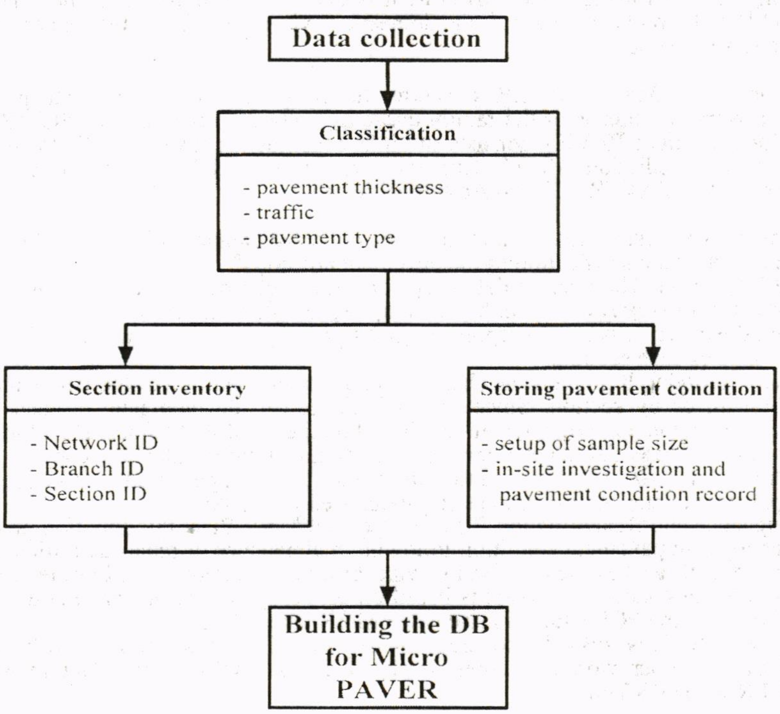

Figure 3. Steps for building the DB for Micro PAVER

In classifying the pavements into homogeneous sections, the ID protocol was built in such a way to fit the domestic situation so that it can become the standard in the future establishment of PMS. <Table 4> shows the summary of the inventory for several airports constructed through the above procedure.

Table 4. DB for each airport developed so far

Name of Airport	Network	Branch	Section
Kimhae Airport	1	4	41
Kimpo Airport	1	4	25
Chungju Airport	1	5	16
Sachun Airport	1	5	44
Yechun Airport	1	2	20
Pohang Airport	1	3	29
Ulsan Airport	1	2	11

4. ESTABLISHMENT OF DETAILED PMS MODULE

4.1 Customization of Micro PAVER

In developing KAPMS using Micro PAVER, it is necessary to understand the functions of Micro PAVER and modify them to suit the domestic environment. Thus, this paper will focus on those matters in the below.

The main logic of Micro PAVER concerns deciding on the budget and prioritizing rehabilitation works by means of the family curve by section on the basis of PCI (Pavement Condition Index). Micro PAVER consists of eight constituents: Inventory, Field Inspection, Standard Report, Prediction Model, Condition Analysis, M&R Plan (Maintenance and Rehabilitation Plan), PAVER GIS and Additional Menu.

- Inventory: The basic constituent in inputting collected data into Micro PAVER. Various data on classification of the pavement are stored.
- Field Inspection: The distress data necessary in calculating the PCI are stored here in the form of survey date, number of samples, sample number etc.
- Standard Report: A type of a report, it allows printing out stored data as well as the PCI value of each section.
- Prediction Model: It predicts the changes in pavement condition of the whole airport, by branch, or by section. Since Micro PAVER can develop new models, it is possible to come up with a new model based on the input PCI values. Developing a new model is essential to developing a prediction method suitable for Korea.
- Condition Analysis: It is designed to analyze the change in pavement condition, with the pavement deterioration prediction model used for analysis.
- Maintenance and Rehabilitation Plan: Also called M&R Plan, this function predicts the changes in pavement condition following maintenance or repair activities when the pavement reaches the pre-fixed serviceability or a certain limit. In other words, the pavement condition forecast is based on the results of maintenance and repair. Accordingly, the PCI value will rise when M&R takes place.
- PAVER GIS: This links the coverage made using CAD and Arc/Info with Micro PAVER. In other words, it connects the analysis results of the data in Micro PAVER with GIS Tool.

4.2 Allowable gross load calculation module

There are two ways to calculate allowable load. One is backcalculating using the design chart and the other is conducting a nondestructive test to obtain the modulus of elasticity consequently load carrying capacity. KAPMS adopted the latter method as shown in < Figure 4>.

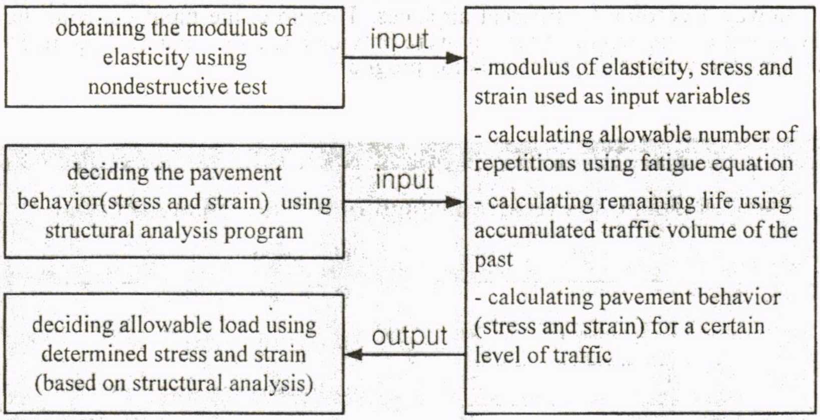

Figure 4. Allowable gross load calculation

4.3 Pavement condition survey

Pavement condition survey is the most important step in pavement management system. Since the results of the survey differ greatly depending on the investigators, equipment used and the time of investigation, it is essential to have a set standard for survey. Pavement condition, in general, can be classified into three: structure, function and safety. Structural function includes surface defect and structural bearing capacity. Functional function includes surface defect and roughness. And, safety includes skid resistance.

PCI(*Shahin,1994*) was used as the criteria for investigating surface distress, FWD for structural bearing capacity and IRI for roughness. The measuring criteria for these values will be fixed in the next stage of the study.

4.4 Runway length calculation module

Although not directly related to the management of pavements, the runway length calculation module was developed according to airport administrators' request. The length of runway was calculated based on the calculation logic of Federal Aviation Administration(*FAA, 1990*), with the following variables taken into account:

- Name of airport: insert the name of a selected airport,
- Target runway: Select the runway depending on the selected airport(For example new runway, old runway, etc.),
- Type of airplane: select the airplane type to be analyzed,
- Takeoff/Landing: select whether it is the takeoff or landing,
- Flap angle: select the flap angle according to the selection of Takeoff/Landing,
- Type of engine: select the engine installed in the airplane,
- Load applied during takeoff: When analyzing the runway length for take off, put in the load to be applied during takeoff (unit:1,000kg),
- Load applied during landing: When analyzing the runway length for landing, put in the load to be applied during landing (unit:1,000kg),
- Current length of runway: the current length of the selected runway(a fixed value),
- Altitude: the altitude of the selected airport(a fixed value),
- Altitude difference due to gradient: input the altitude difference due to gradient,

- Temperature: the temperature of the selected airport(a fixed value),
- MSTOW: Maximum structural takeoff weight(a fixed value , unit:1,000kg),
- MLW: Maximum landing weight(a fixed value , unit:1,000kg).

This program was developed to help airport administrators in determining the appropriate length of runway according to different airplanes. Therefore, the input variables having negligible impact on the length of runway were provided as fixed values. <Figure 5> is a screen showing the runway length calculation program.

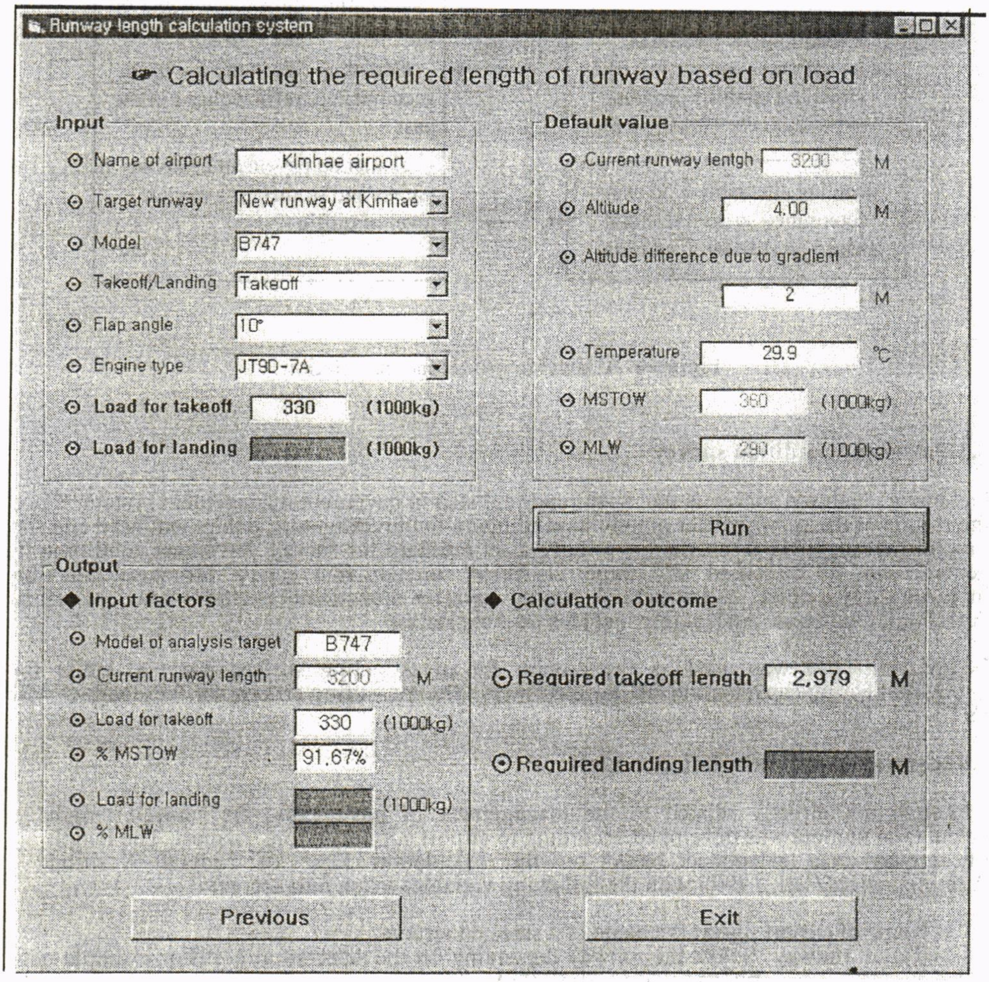

Figure 5. Runway length calculation system

5. FUTURE PLANS

5.1 Improving presentation using GIS

For a successful usage of PMS, it is necessary to be able to present the PMS DB to the users in an efficient manner. To this end, the information on pavement condition should be displayed graphically. Micro PAVER has PAVERGIS module, which can embrace these functions. Until now, the apr. file of Arcview designed and distributed by the US COE was used. However, the new Micro PAVER ver. 5.0 to be released in the near future is expected to allow an easier representation of information using MapObject.

5.2 Developing details of each module

A successful implementation of PMS should be accompanied by clear definition of various modules related to PMS. The development of logic which currently stands at an initial stage will be further developed and concretized. The logics to be implemented are as follows.

- Allowable gross load calculation: In order to assess the structural capacity of the pavement through nondestructive testing, it is necessary to firmly establish standard ways to estimate the modulus of elasticity and the allowable number of load repetitions.

- Determining M&R priority: The current prioritization of repair is based on Micro PAVER, which only takes surface distress index into account. In the future, roughness, structural bearing and friction will also be taken into consideration.

5.3 System Integration

Until now, we have focused on the development of each module. However, all these modules need to be integrated into one system so that the users can easily use the system. System integration is expected to become a major research item in the next step of this study. The current integration plan is as shown in <Figure 6>.

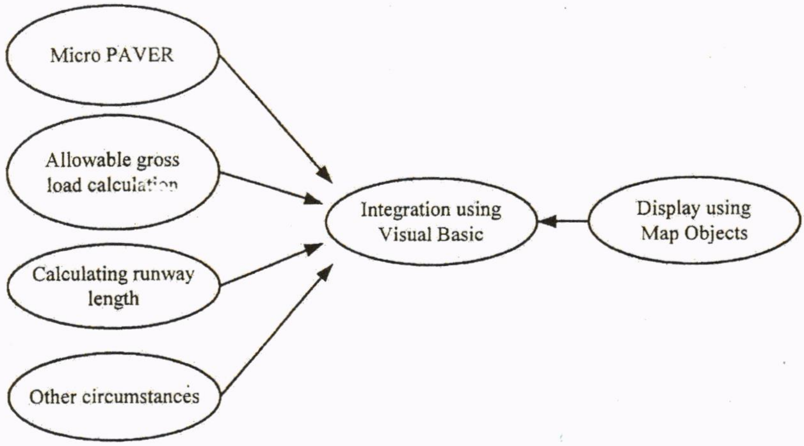

Figure 6. Concept of system integration

6. SUMMURY

In order to reduce the risk of trial and error for establishing a PMS for Korean airports, a variety of literature review and contacting PMS developers of other countries were carried out . As a result, Micro PAVER ver. 4.2, the most widely used program, was adopted as one of the modules, with additional functions being developed when the need arose. During the process, it was decided by the Korea Airport Authority and on-site managers to include runway length calculation, reflecting the needs of on-site administrators. Below is the summarized procedure.

- Network level was chosen as the operation level of PMS in consideration of the available data and domestic situation.
- The widely-used Micro PAVER ver. 4.2 was adopted, as one of the modules and additional modules will be developed additionally.
- Modules, to be developed include structural bearing capacity (allowable gross load calculation) and runway length calculation, both of which are not included in Micro

PAVER ver. 4.2.

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