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MIKLÓS ZRÍNYI
NATIONAL DEFENCE UNIVERSITY
Doctoral Board

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Technical support issues of stability and controlability of MISTRAL 2 air defence missile system

(PhD) thesis of the author's review and
formal critiques

Budapest

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Supervisor:

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1. THE FORMULATION OF THE SCIENTIFIC PROBLEM:

The MISTRAL-2 air defence missile approaches the target with the method of proportional navigation. In case of the method of proportional navigation the air defence missile loses its stability because in the vicinity of the target the angular velocity of the line connecting the missile and the target (q2,r2) suddenly increases. Although the causes, in general, are known, it is impossible to determine them due to the lack of factory data and range experience. As a consequence, I consider the following to be scientific problems:

1. The determination of the phase margin of the feedback control system of the MISTRAL 2 missile in the first and second stages of its flight.
2. The determination of the moment in time when stable and controllable movement becomes unstable, and the determination of the distance of the target plotted against the movement parameters of the target regarding the MISTRAL 2 missile.
3. The determination of the position in space plotted against the target parameters (H_c,v_c) of those meeting points where there is maximum probability of target destruction with the MISTRAL 2 missile, and the determination of when it has to be launched at a target moving at a given speed in case of target acquisition at 7000 meters.

2. RESEARCH OBJECTIVES:

I have defined the following research objective: the stability analysis of the feedback control system of homing missiles, the target spotting, guidance and control system of the MISTRAL 2 air defence missile in particular, plotted against the movement parameters of the target after the missile has entered free-flight.

3. RESEARCH METHODS:

In order to achieve my research objectives I used a combination of general and specific methods during my research. Out of the general research methods I used **induction**, **deduction** and **synthesis**.

In order to fulfil the objectives of my research, I:

- **studied** the Hungarian and foreign specialized literature in connection with the subject, paying special attention to the results of the most recent international research and development of the MEADS air defence and missile defence system
- **systematized** the acquired information
- **attended scientific conferences** and used what I had heard there in my thesis
- **prepared MATLAB® files** for carrying out the analyses
- **carried out stability analyses** regarding the feedback control system of the MISTRAL 2 missile, and also in the time and frequency range.

4. A BRIEF DESCRIPTION OF THE ANALYSIS I MADE BY CHAPTERS:

In **Chapter 1** I systematized the mathematical model describing the special movement of air defence missiles, the methods of the control technology analysis of air defence missiles, described the analysis of controls and the methods of control system analysis.
In **Chapter 2** I summarized the guidance methods of guided air defence missiles, the structure of the feedback control system of homing air defence missiles and the correlations determining the stability of the feedback control system.
In **Chapter 3** I determined the factors affecting the target destruction zone boundaries of the MISTRAL 2 passive homing air defence missile. I carried out the analysis of the feedback control system of the MISTRAL 2 passive homing short-range air defence missile. I determined the phase margin of the feedback control system of the missile plotted against the target parameters, as well as the time and distance characteristics (its time and distance) of the moment when the air defence missile feedback control system enters the unstable state.

5. THE SUMMARY OF CONCLUSIONS:

I carried out the stability analysis of the MISTRAL 2 air defence missile feedback control system. I established that in the final stage of free flight there is weak correlation between the target altitude and the stability of the missile feedback control system and that there is strong correlation between target velocity and the stability of the missile feedback control system in the final phase of free flight. There is also strong correlation between the position of the meeting point and the moment of entering the unstable state.

6. NEW SCIENTIFIC ACHIEVEMENTS:

I worked out the deterministic analysis of the guidance system of homing air defence missiles and the exact analysis of the missile feedback control system taking into account the target parameters.
I determined the relationship between the phase margin of the MISTRAL 2 homing air defence missile feedback control system and the target parameters (v_c, H_c), including the time and distance interval of the transition from the air defence missile feedback control system stable state into unstable state.
I defined the coordinates of the homing air defence missile dependant on the target parameters (v_c, H_c) and the position of the meeting point.
I determined the optimal moment for launching the MISTRAL 2 homing air defence missile plotted against the target parameters (v_c, H_c).

7. THE PRACTICAL USE OF THE RESEARCH ACHIEVEMENTS:

The results can be used for the determination of the optimal moment for missile launch during the training of air defence missile subunits.