

EIGHTEENTH EUROPEAN ROTORCRAFT FORUM

OUTSIDE VISION FROM A HELICOPTER  
CREW CABIN,  
APPROACHES TO ITS FORMING IN DESIGN  
PROCESS

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# OUTSIDE VISION FROM A HELICOPTER CREW CABIN, APPROACHES TO ITS FORMING IN DESIGN PROCESS

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## SUMMARY

The matters concerned with the formation of the field of view (FOV) from the cockpit crew stations at the early stage of designing a helicopter are discussed in the paper.

The provision of the adequate FOV is examined with consideration to the multilateral connections of this cockpit property both with the design and operational features of the helicopter being designed as well as with the ergonomic parameters of the crew station.

In order to work out a common approach, from the total cockpit FOV some zones were selected which are most informative from the point of designing the cockpit glazing for various types of helicopters.

Methods of simulating the FOV in various situations of the helicopter operation are examined and some particular results are presented.

## METHODOLOGY APPROACH

Designing all the piloted aircrafts is always unseparately connected with the necessity to solve the problem of an adequate FOV provision for the crew stations.

A special attention is paid to the problem when designing such multifunctional and multimode aircrafts as helicopters which mainly have to fulfil missions demanding nap-of-the-earth flying in a wide speed range.

The cockpit FOV is an operational feature and it is determined by the crew work in flight. So naturally the FOV parameters must be optimized for all the operational missions range assigned to the helicopter.

However to specify the operational mission types means to predict all the varying aspects of all possible flight situations which is difficult enough even in practice, to say nothing about earlier stages of the design process.

One of the ways to optimize the FOV parameters presented in the paper is the differentiation of the designed helicopter flight modes and the outside objects which must be visually observed by the crew, the pilot in particular, at such modes.

The purpose of the differentiation is to select from the total cockpit FOV some functional zones forming the critical branch of the cockpit glazing decision "tree" and directed, first of all, to the provision of the flight safety along its total profile and to effective fulfilment of the helicopter main mission functions. The latter gains even more importance because after the aircraft has been already designed the FOV becomes its static feature and in case of unadequacy it enters into a conflict with the operational capability of the helicopter.

The generalized structure of the proposed approach to forming the cockpit glazing design is presented at Fig.1

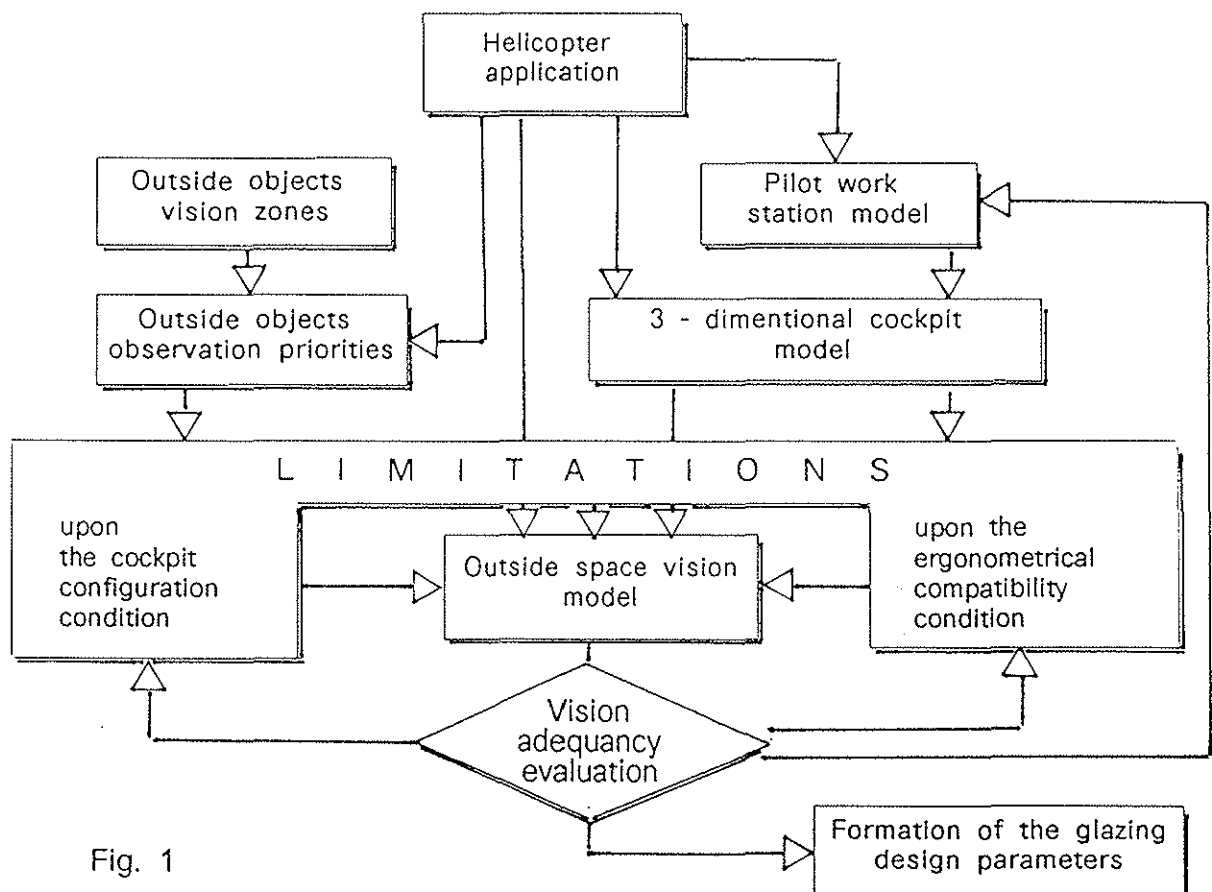


Fig. 1

## OUTSIDE VISION TYPICAL ZONES

For all the variety of helicopter types two vision zone levels being most informative from the design point may be sorted out as the critical branch of the cockpit glazing design decision "tree", namely:

- outside objects and helicopter components observation zones at take-off or landing modes;

- outside objects and helicopter components observation zones at mission flights.

In case of the first level zone it is not necessary to specify the outside objects as it is evident from the definition itself and the following parameters are accepted as the input data permitting in each specific case to formalize the task of the cockpit vision - glide path slope steepness and permissible dynamic change of the helicopter pitch angle at the deceleration stage prior to hovering. The specific nature of these factors lies in their fulfilling the functions of connecting links in the system "pilot-helicopter-environment" not only through the glazing parameters but also through such operational notions as stability, controllability.

The helicopter components typical for this level observation are landing gear structure elements.

This statement is based upon the practice of operating helicopters in severe geographical and climatic conditions. The possibility to observe one of the main landing gear supports from the pilot's seat is vital not so much from the point of ensuring a safe landing but from the point of ensuring the landing itself in a difficult terrain area when the landing site is not familiar or not prepared for landing.



Fig. 2.

A picture showing an example of such landing done in Russia extreme North area by a Ka-32 helicopter on a rocky site of a limited size is shown at Fig.2.

In its turn such ability opens new prospects of flying over more complicated routes for the helicopter.

The zones of the second observation level are formed on the condition of providing the pilot with the adequate visual orientation ability when fulfilling the mission especially when maneuvering in a low altitude flight. The specific object which must first of all stay within the pilots FOV are :

- traces of rotating main rotor blades;
- objects underslung externally to the helicopter;
- neighbouring helicopters or planes in case of a formation flight;
- horizon line in the forward hemisphere for the whole range of overloads permitted for the helicopter operation.

The necessity of adopting such an approach to the formation of outside cockpit vision is not connected with specific missions planned for the designed helicopter operation. The possibility to fulfil any such mission is embedded in the nature of a rotorcraft and only being applied for some definite purpose the helicopter gets its "colours".

#### BOUNDARY CONDITIONS

Formation of an outside cockpit FOV is examined for polar conditions of the pilot FOV organization, i.e.

- for the condition of monocular vision and fixed pilot's working position;
- for the condition of the pilot's binocular vision and possibility of his moving within the cockpit space.

It permits not only to correlate from the ergonomic point of view the pilot working position with the helicopter controls, its information boards, to mark the glazing boundaries but also to make an operational evaluation of the cockpit FOV qualities.

As a criteria boundary condition for a monocular FOV there was accepted a domain of the limiting angular parameters of the pilot's vision from the eye reference point (ERP) at a pilot's body position fixed and at natural limitations.

At Fig.3 there is presented a particular kind of a parametric dependence having a form of  $\text{tg}\alpha_i = h_i/b_i \sin\psi_i$ ; of this boundary condition for the lower part of the forward hemisphere, where

- $h_i$  - ERP increase beyond the limitation;
- $b_i$  - width of limitation from the pilot work station symmetry plane.

The informativity of this dependence reflects the limiting level of the cockpit configuration visual comfortability.

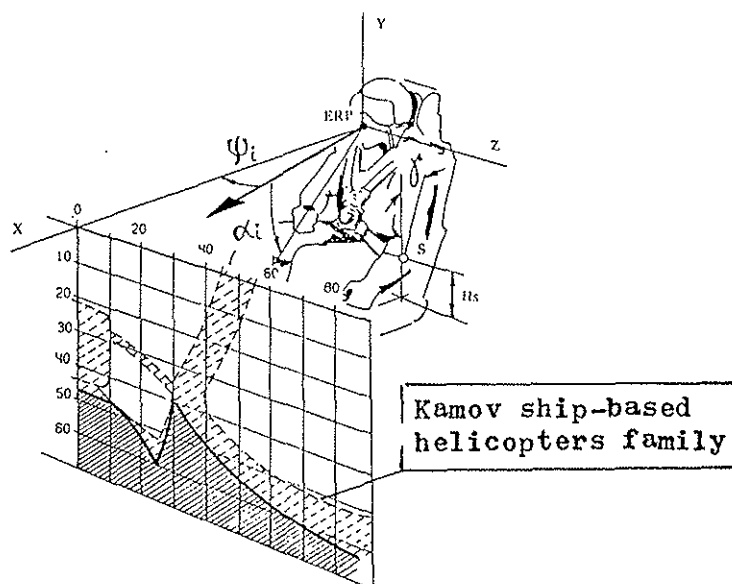


Fig.3 The limiting domain of the vision angles from the ERP for the lower part of the forward hemisphere from the pilot's work station (left side) for  $H_s=300\text{mm}$  and  $\Upsilon=18$  deg.

For real binocular outside FOV, which is constantly changed depending upon the complexity of the flight profile, the dynamics of its fulfilment and the individual motion activity of the pilot permitted, two cases may be considered typical :

- 1 - real outside FOV in conditions of a stabilized flight;
- 2 - real outside FOV in conditions of a maneuvering flight.

From the point of selecting a cockpit configuration based on the FOV adequacy the first case presents lesser interest since a possible zone of the pilot's eyes motion at this mode of flight may occupy relatively large portion of the cockpit space and sometimes even stretch beyond its boundaries (due to the glazing of cockpit doors).

As decisive in the way of selecting the cockpit configuration and the glazing design in particular there may be considered the task of forming the outside FOV in conditions of transient flight modes which demand "subtle", coordinated movements of the controls on the part of the pilot. From the ergonomic point of view, motion activity of the pilot at his work station with the purpose to increase the real FOV is not rational since it is connected with a possible nonvoluntary effect upon the dynamics of the control handles movement due to a disruption of inner interconnected couplings in the body.

This is the reason why it is recommended to select the glazing areas and to evaluate their adequacy at the designing stage on condition of limiting the pilot's eyes motion by the volume of his head possible motion volume.

This limitation is based upon the results of processing the statistical data on the work of pilots on Mi-8, Mi-24, Ka-32 and Ka-50 helicopters.

The limiting boundary of the pilot's eyes motion obtained on the basis of the ergonomic investigations done is approximated by a conditional hemisphere surface of 150 mm radius within the boundary of the head tilt of  $\pm 30$  degrees and the head turn of  $\pm 60$  degrees.

### FOV SIMULATION

Simulation of the FOV from the pilot's work station as the main part of the general helicopter cockpit design methodology is based upon the methods of 2-dimensional representation of the object space in a bi-central cylindrical projection [3].

The simulation procedure is carried out according to the scheme "space - sphere - surface/intermediary - plane" (Fig.4) and depending upon the design purposes permits to make a representation of a spatial original in various projections with the preset representation conditions and the main sighting course orientation in aspect to the basic coordinate system.

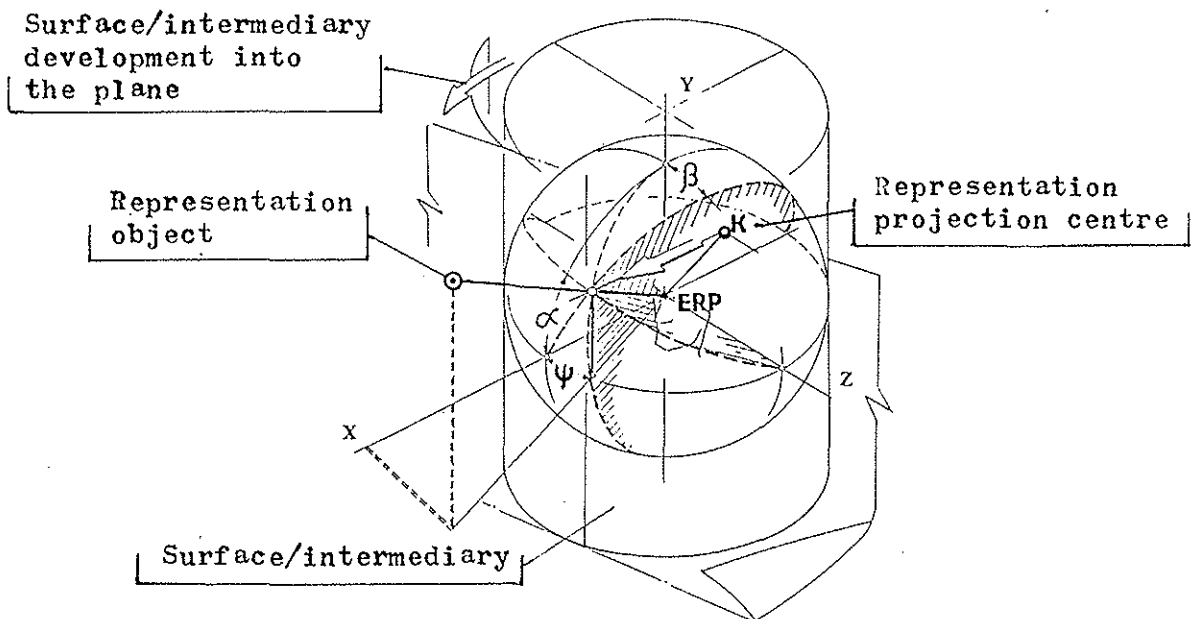


Fig. 4 Spatial object simulation in a bi-central cylindrical projection.

$\alpha, \beta, \psi$  - angular parameters of the main sighting face.



The spatial object representation may be obtained both in a projection with the largest adequacy to the image and in a projection with preset conditions of equality, of dimensional representation equidistancy or conformity of its elements which in combination permits to solve a more wide range of problems than a simple visual observation, for example:

- dimensional representation of the terrain surface observed through a limited vision window and its change with the change of flight altitude and speed;
- coordination to vertically moving objects as in case of landing on to a rocking ship deck etc.

The functional interconnection of all planes in the simulation process ensures the analytical solution of the problem and by the use of computational facilities, ensures an operational control over the process of organizing the visual comfortability for the pilot in an interactive mode.

The visual space simulation algorithm include the following:

- determination of the eye reference point (ERP) location or the domain of its motion;
- determination of the image projection type and a field of vision key according to the nature of the visual situation objects array and depending upon the purpose of simulation;
- formation of a digital model for the helicopter structural elements representation;
- determination of the spatial location of the visual perception media objects and formation of their protoimage representation digital models;
- sorting out shadowed objects;
- determination of means providing the visual information on the environmental objects and formation of such means ( for example, cockpit glazing configuration, location, size, orientation and shape of the back view mirrors surfaces etc);
- formation of the scenery representing the external object images.

The modular structure of the simulation system makes it open and permits to easily modify it to suit various design purposes. When the pilot tracks terrain objects in a low altitude flight, it is worth-while to note the evaluation of the FOV in condition of the so called "blind zone" formation at a specific combination of parameters: vision evaluation angle ( $\alpha\psi$ ), flying speed (  $V$  ), flight altitude (  $H$  ).

Take into account the large psychological pressure born by the pilot in such flights and connected with the necessity to simultaneously control a continuously varying outside situation and instruments readings [1,2], it is desirable to optimize the observation zones lying within the boundaries of the best human visual perception ( $\pm 30$  degrees) on the condition of the maximal compatibility of the typical flight profile dynamics and the maximal dynamic eyesight sharpness depending upon the angular speed of tracking (10 deg/s).

Such correlation of the cockpit glazing design with the instrumentation equipment (Fig.5) is most typical for combat helicopter cockpits (Fig.6) where the tasks of vision adequacy often come into conflict with combat survivability requirements.

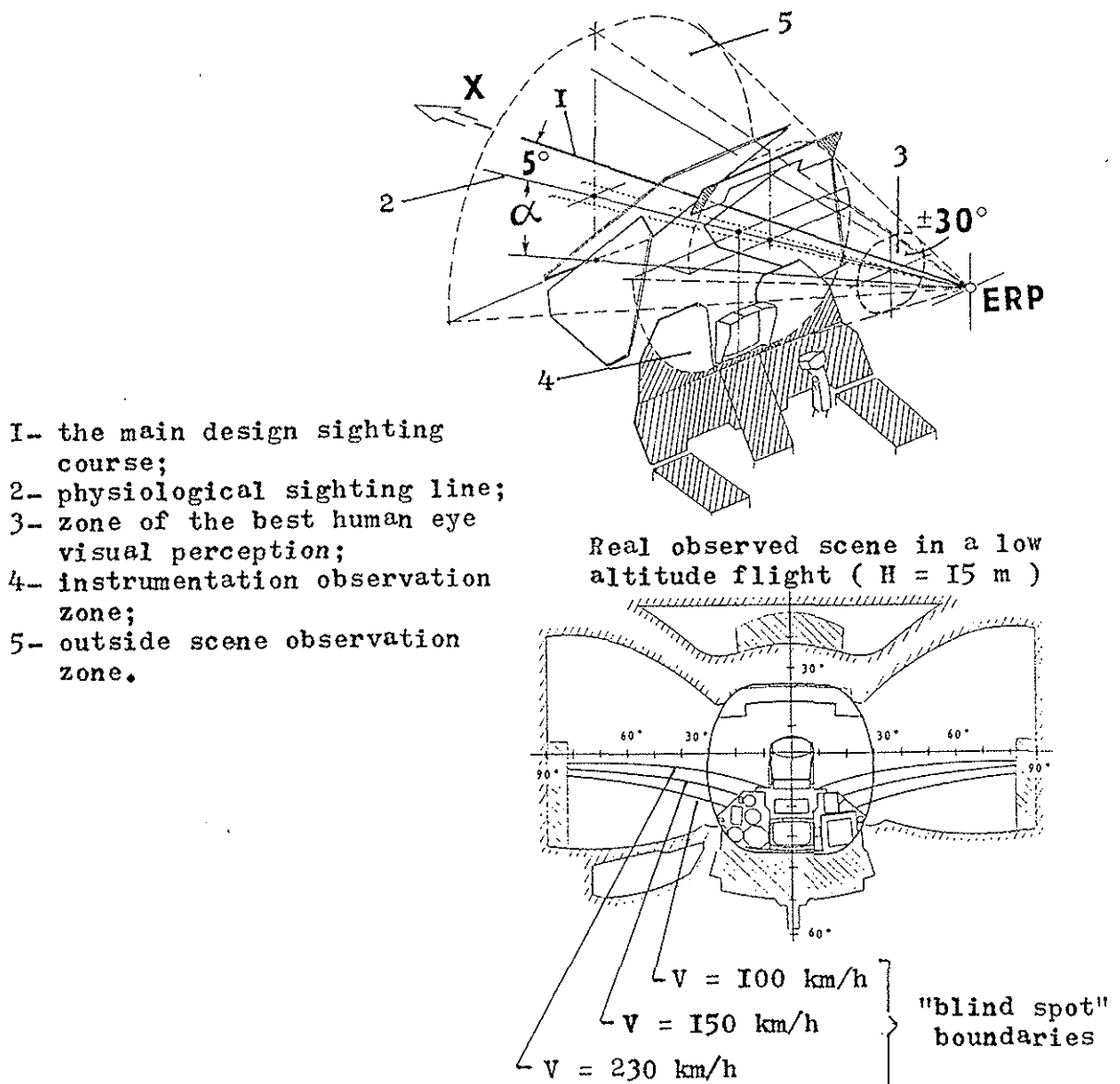


Fig. 5 Configuration aimed at provision of the visual comfortability to the pilot in conditions of combining zones of the outside scene and instrumentation observation.



Fig. 6 The Ka-50 combat helicopter

In the way of general correlation of the cockpit glazing design with the cockpit interior and outside objects as the most productive there may be considered the projection of the maximal adequacy to the image permitting to give the designer the "effect of presence" in the cockpit. An example of such vision scenery from the pilot's station is presented at Fig.7.

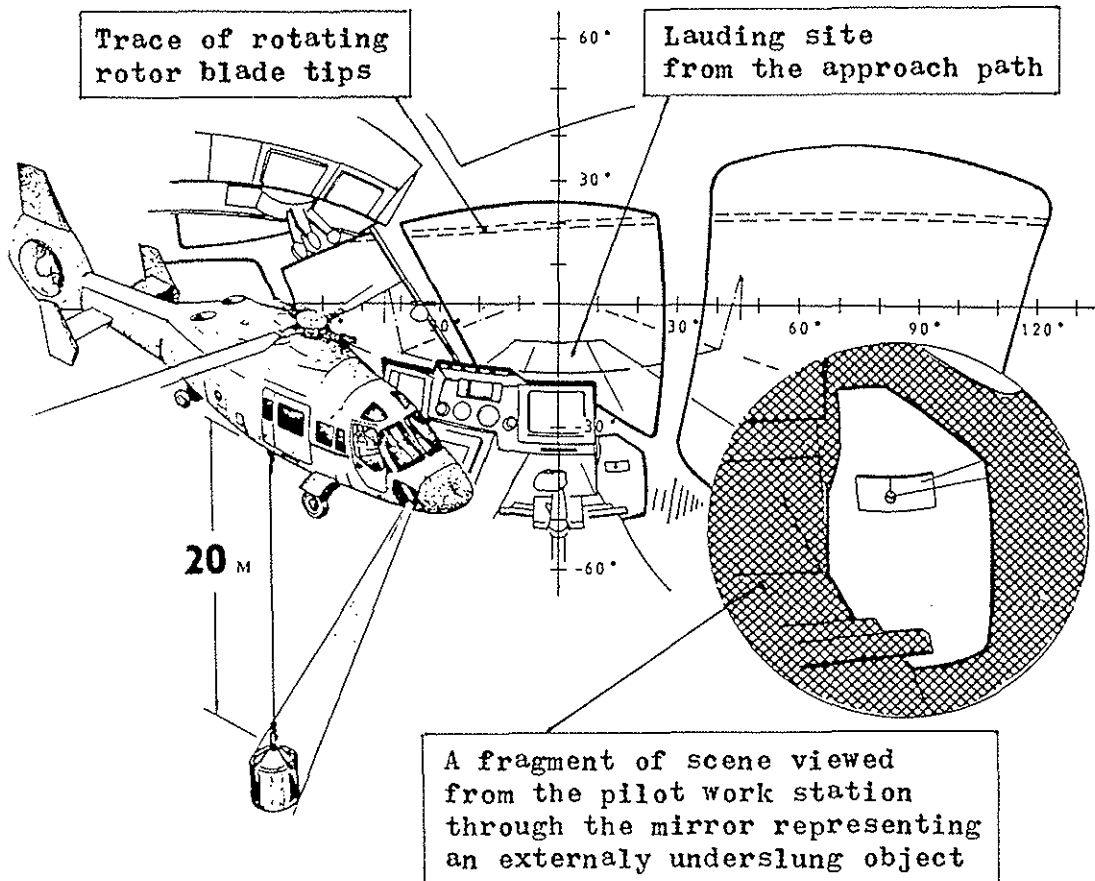


Fig. 7 The cockpit interior and outside scene representation as viewed from the pilot work station.

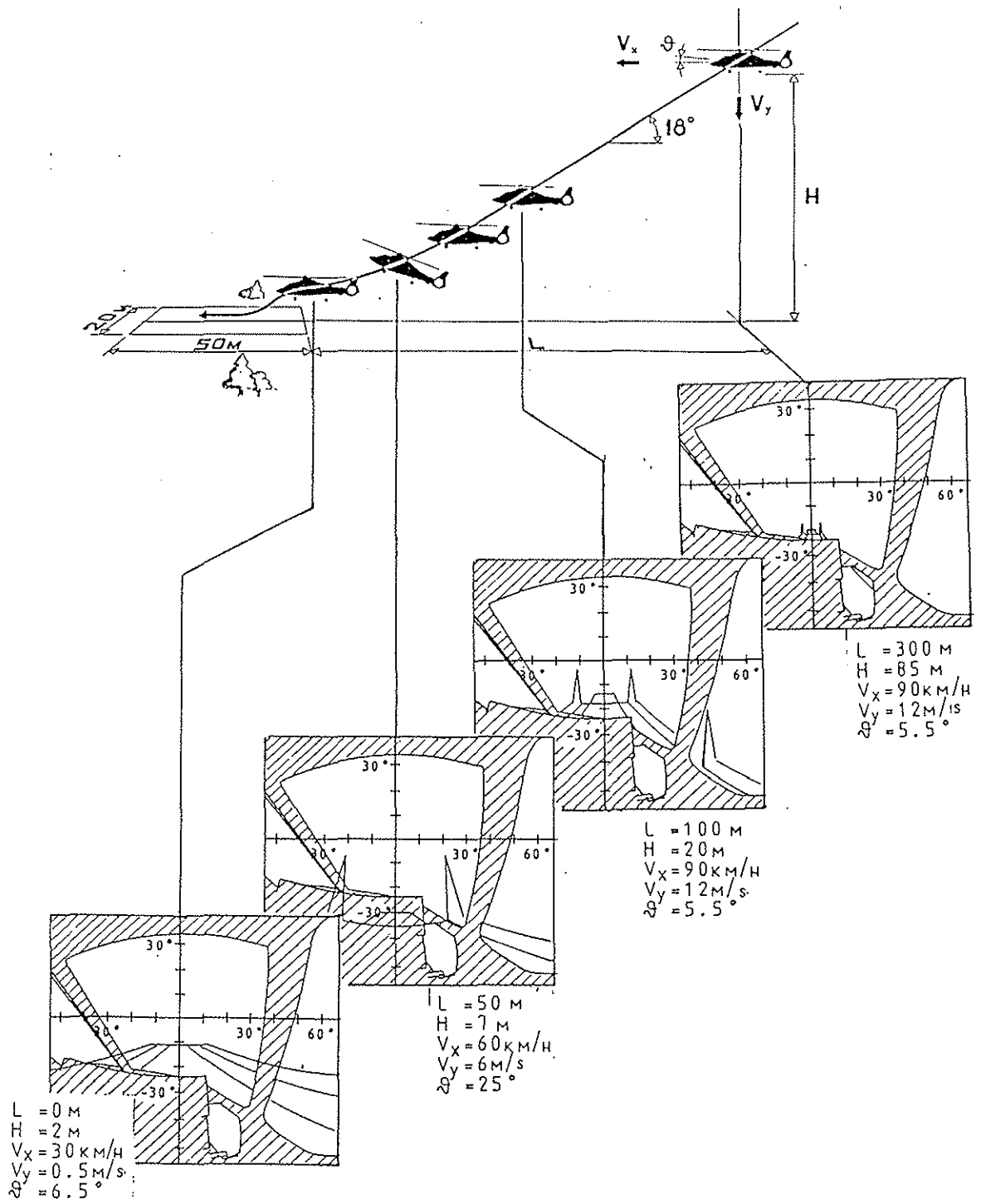


Fig. 8 Situational FOV model from the pilot work station at helicopter landing.

In such projections one can not only form observation zones but also analyse some situational models of visual scenery and evaluate them in the real time dynamics.

A typical example of such situational model is the scene outside the cockpit at helicopter landing. At Fig.8 there are presented some still frames showing the situational model where the dynamics of the pilot observation angle change is reflected when the pilot watches over the landing site starting from the glide path and up to the moment of hover.

## CONCLUSION

The presented approach to forming observation zones from the helicopter cockpit does not embrace the whole range of problems connected with the visual activity of the pilot in flight but permits to analyse the most common operational situations at the design stage.

The method productivity depends to a larger extent upon the level of the operational tasks formalization and to a lesser extent upon the actual types of the task.

The method examines the task of providing the crew with a visual comfortability in correlation with general cockpit design tasks, offeres some trade-offs and thus helps to find some interesting design configurations.

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