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Secure Networking Solutions
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Laser technologies to enhance helicopter safety when flying at low altitude in degraded visual environment

The Future Of Rotary Wing

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Degraded Visual Environment & Loss of Situational Awareness

- DVE is the condition that lead to a reduced visual acuity of varying degree with the consequence that situational awareness and aircraft control cannot be maintained as comprehensively as they are in normal visual meteorological conditions.
- Many different factors can lead to DVE
  - Light conditions
    - Night
    - Dusk
    - Dawn,
    - Sun
  - Meteorological conditions
    - Rain
    - Snow
    - Fog
    - Clouds
  - Environmental conditions
    - Sand and dust (brownout)
    - Snow (whiteout)
    - Smog
- Human visual acuity: there are obstacles like cables that cannot be seen even flying with clear sky

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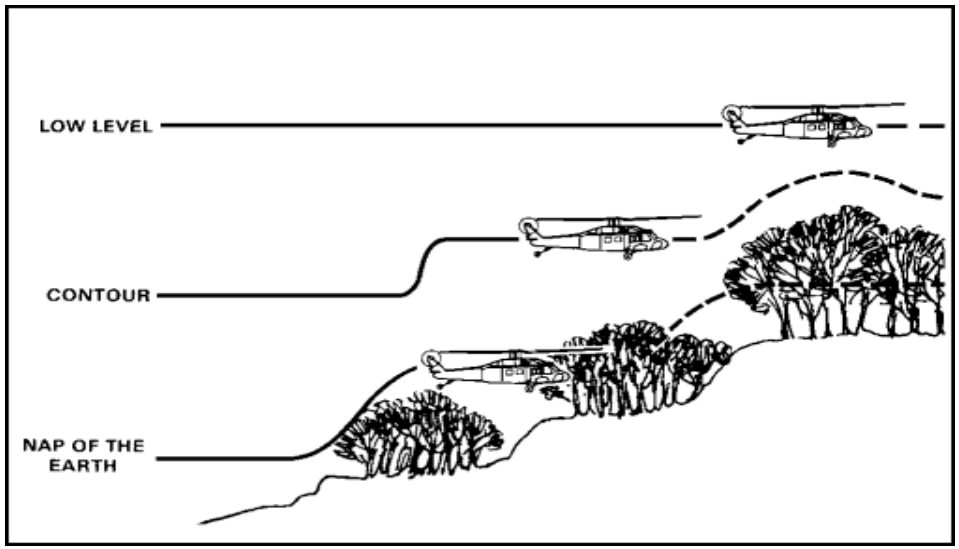
SELEX Elsag approach to DVE

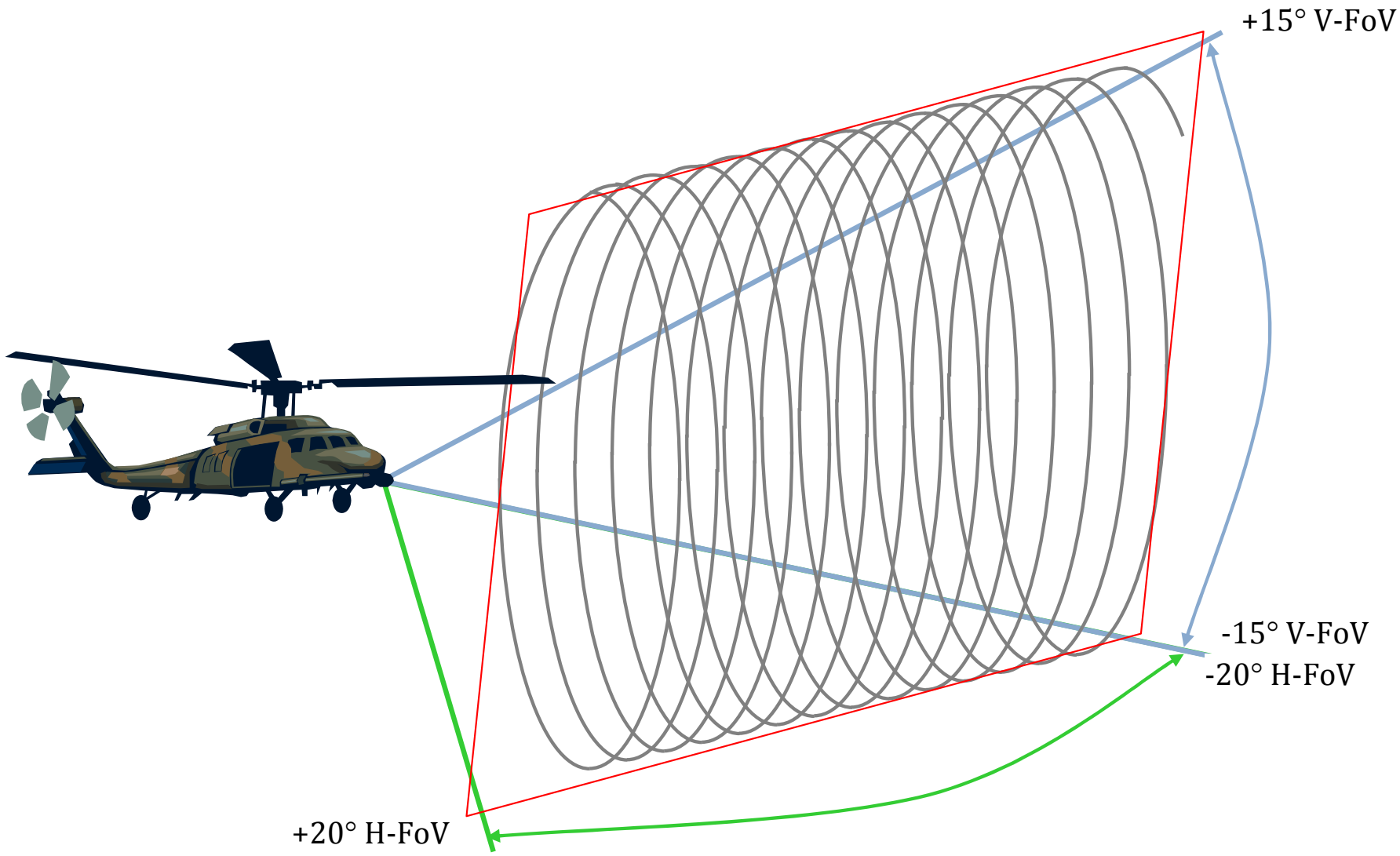
- DVE problem encompass such a wide range of different conditions that can be faced during the various flight phases that a single technology is not capable to address all of them.
- SELEX Elsag started to work on the usage of laser technology to be used to enhance safety of flight for helicopters since the early ’90s
- From the very beginning the R&D activities were aimed at developing a Laser based Obstacle Warning System (LOAM)
  - Obstacle detection and classification
  - Impact Warning generation
  - Visual cues
- Optics (laser) vs. radiofrequency (millimetric waves)
  - incidence angle: the angle between the wire and the flight trajectory
  - Detection range for laser systems is almost constant for a much wider incidence angle range
  - Millimetric waves systems shows a higher detection range for obstacles that are at about 90 degrees

LOAM – Purpose of the system

The LOAM is primarily intended to provide the crew with obstacle warnings to enhance their situational awareness and as such the safety of flight during low level flight missions under VMC. It is in fact in these conditions, when the pilot attention is mostly focused on the mission target, that the presence of masts, wires and other obstacles is expected to pose the major threat to the flight safety.

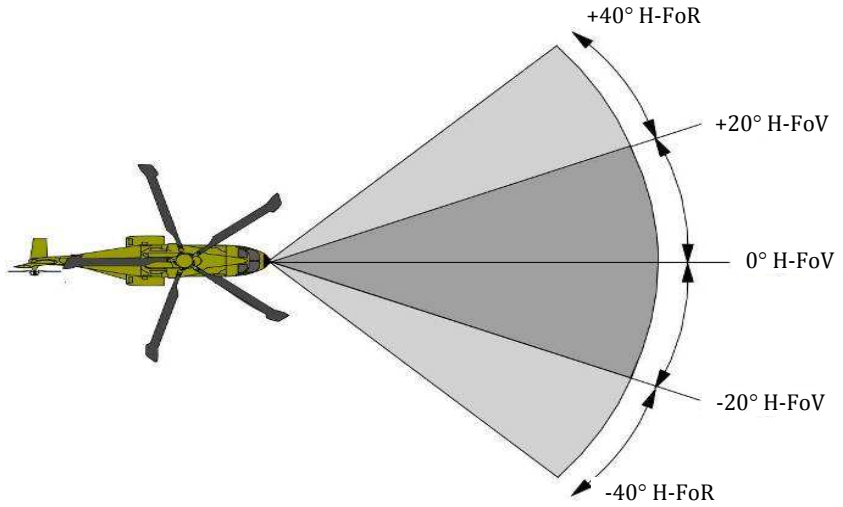


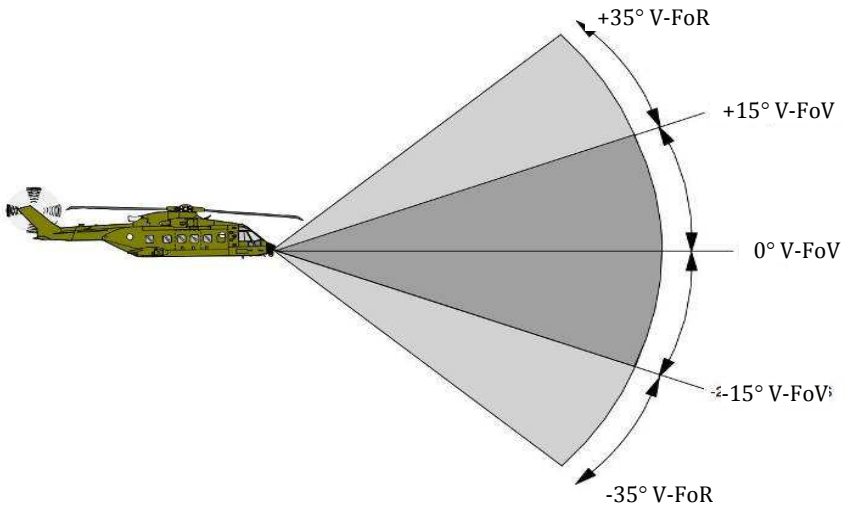
Principle of Operations



Scanning Characteristics

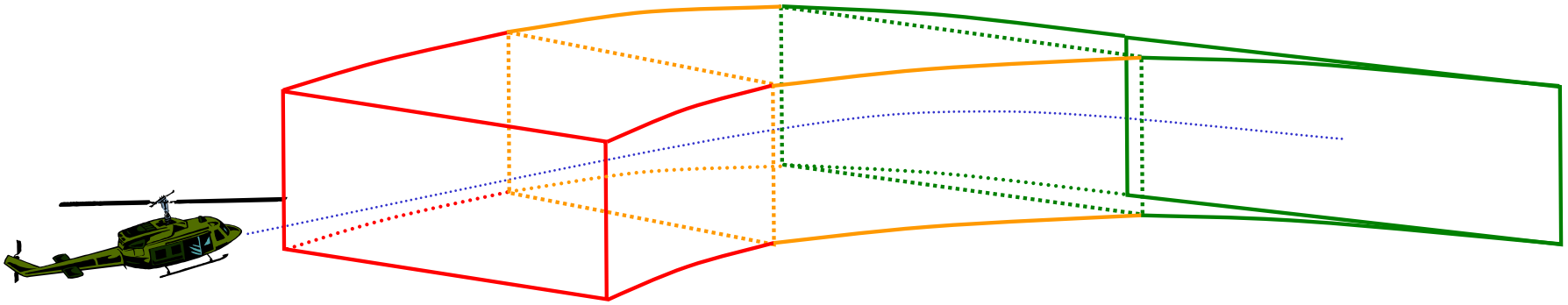
- Eye-safe (class 1 laser system)
- Wide Field of Regard
  - to be able to look into turn
  - to provide better coverage during landing
- Field of View steering capability can provide warning anticipation from 3 to 7+ seconds





Obstacles Recognition & Classification

- The received echoes are collected and processed in real-time
- Obstacles are identified and classified in three categories
  - Wires (long and “thin” mainly horizontal structures)
  - Poles (tall and mainly vertical structures)
  - Isolated (large bidimensional structures)
- The system do not provide 3D synthetic images based on the received data
- Obstacles are ranked based on the level of threat they pose to the safety of flight: two distances are used
  - From the helicopter current position to the obstacle
  - From the obstacle to the flight trajectory



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Impact Warning

- Warning are generated if and only if there is at least one obstacle in close proximity (inside the “tunnel”) to the projected flight path
- Warnings shall be timely raised
  - Range filtering
  - Obstacle type filtering
- Nuisance alarms shall be avoided
  - Terrain is not considered as an obstacle: it would generated too many warnings preventing the system from alerting against actual obstacles

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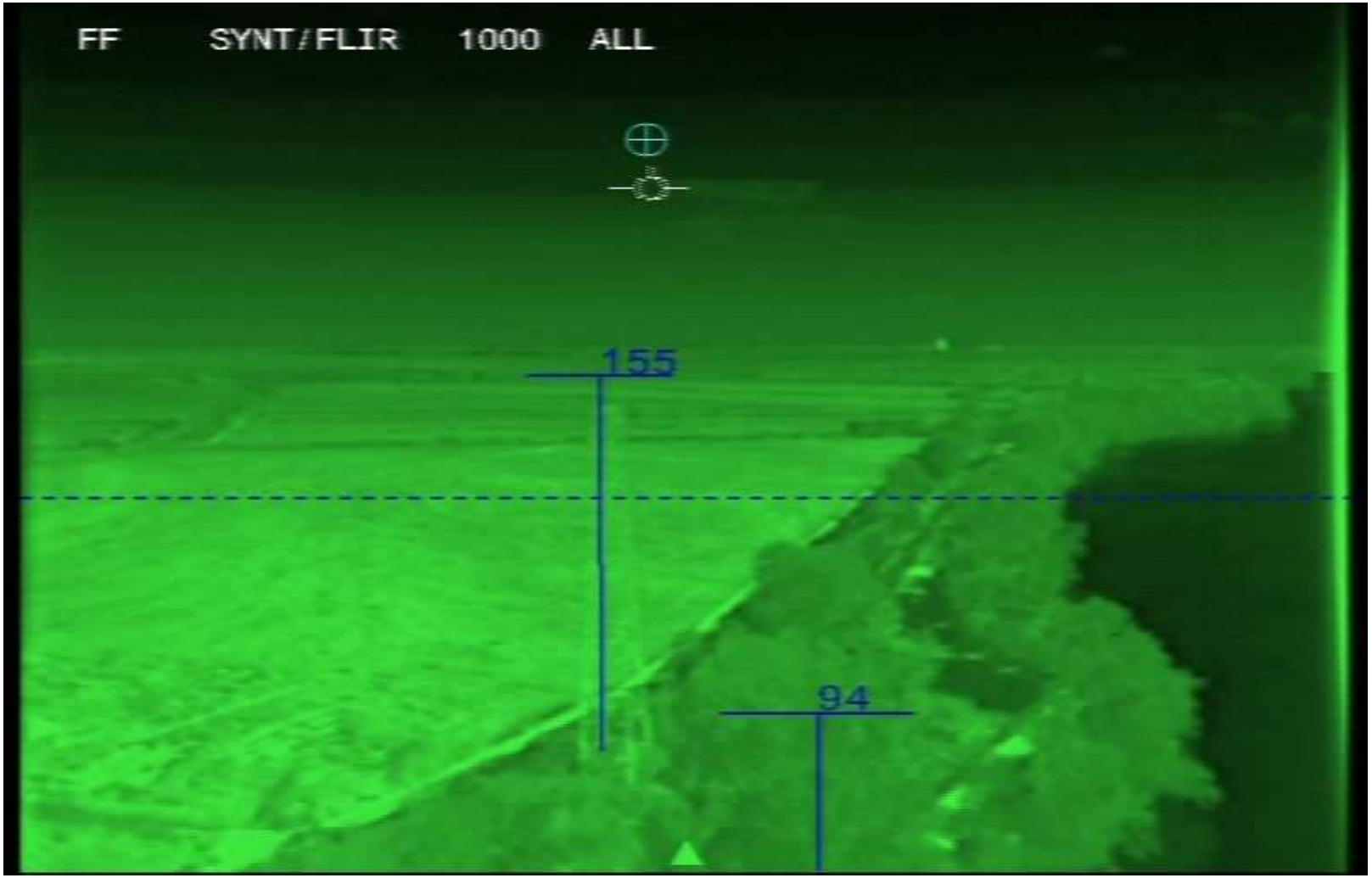
Output Options

- Video
  - Obstacles symbols over a background image
  - Obstacles symbols over 3D synthetic image representing the terrain
  - 2D false colour image (terrain and obstacles)
- Audio
  - 3 audio tones
- Digital
  - Obstacle positions
    - 3D georeferenced
    - Range and bearing

Video over background image



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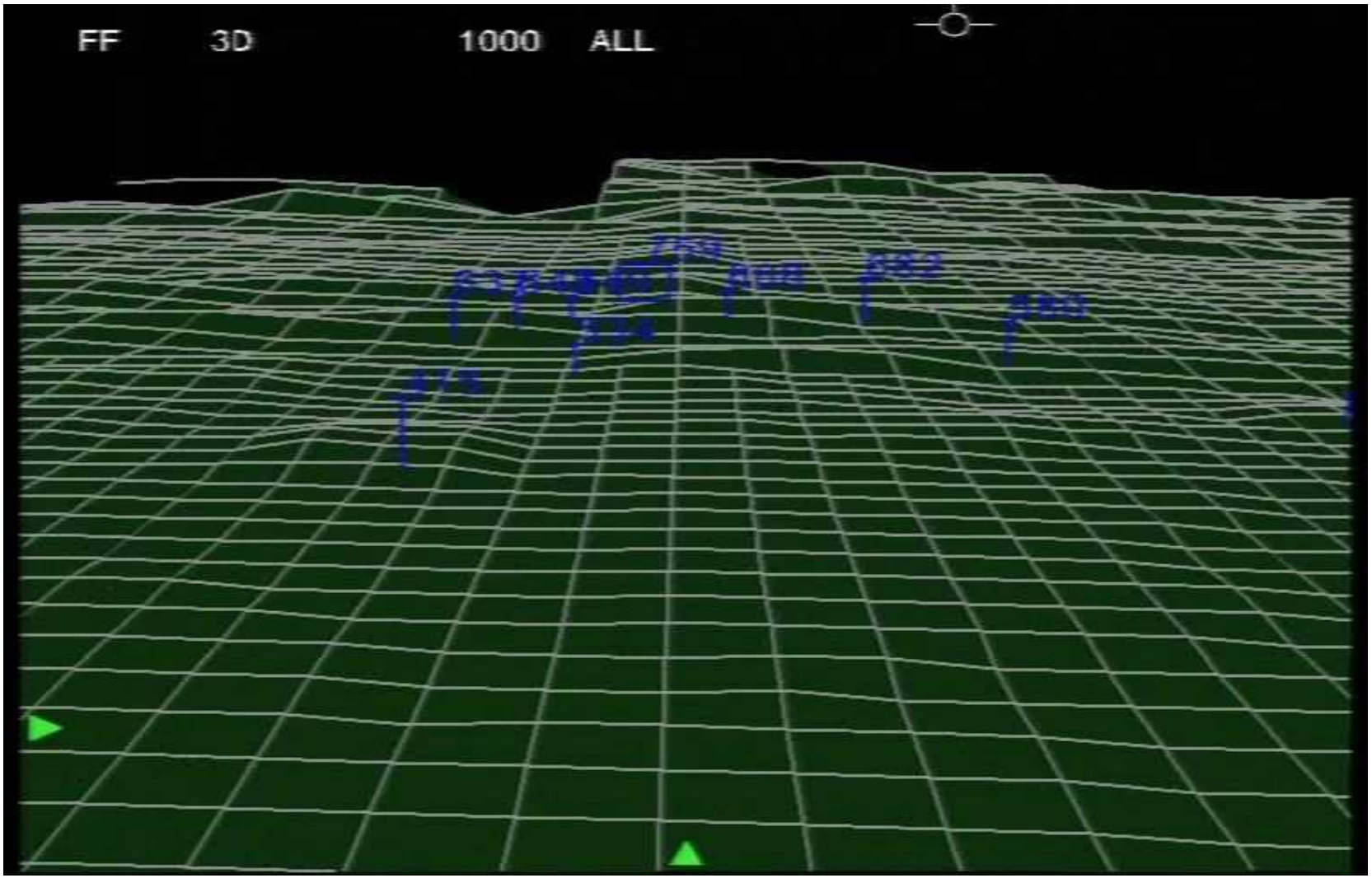
Video over 3D synthetic terrain image



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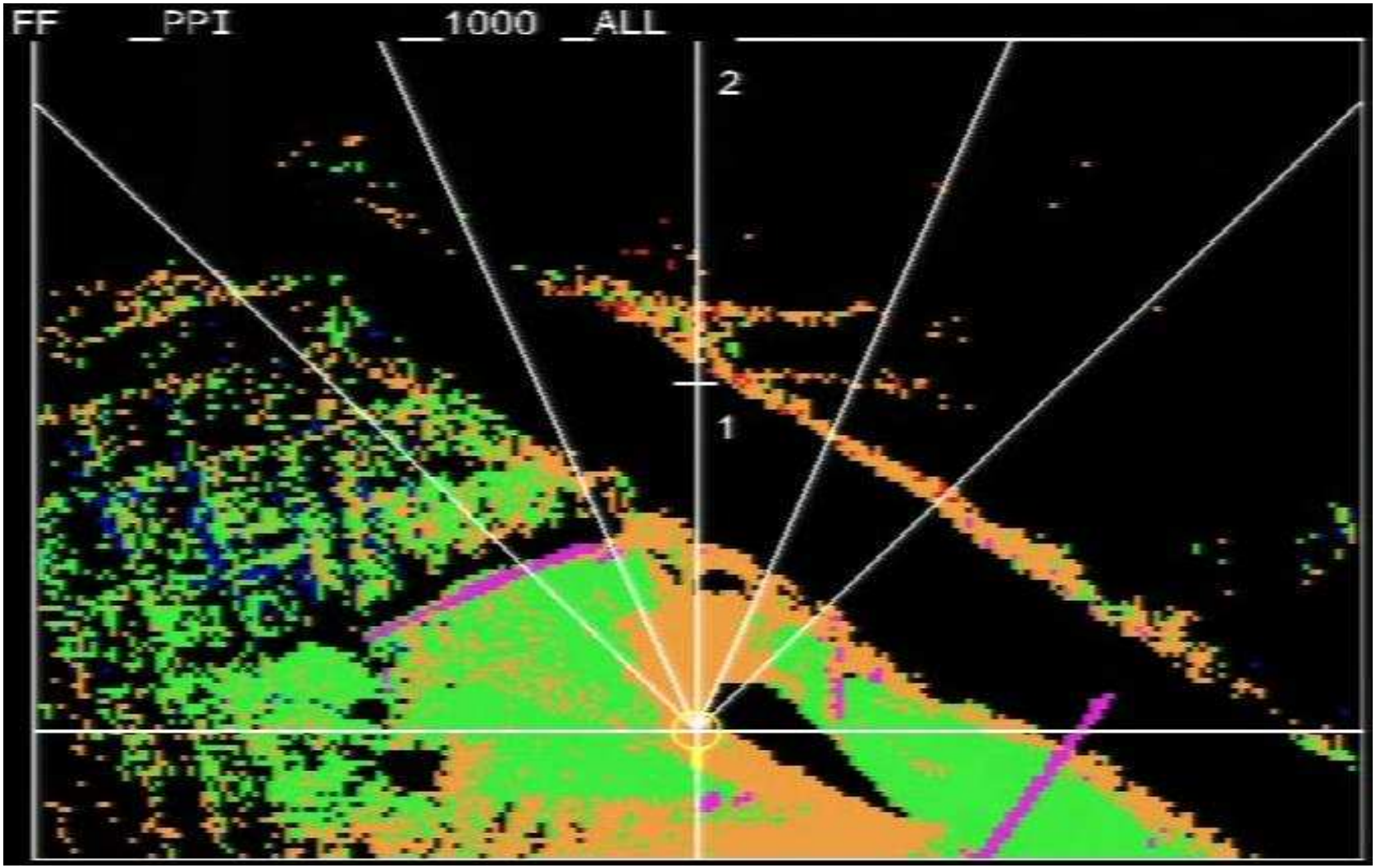
2D False color image



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Performances Factors

- Many factors influence the performances in terms of detection range
  - Visibility
  - Background Radiation
  - Obstacle
    - Dimensions
    - Material (reflectivity)
- Visibility (due to humidity) – detection of a 5 mm Ø wire
  - 600 m @ 2 Km
  - 450 m @ 1 Km
- Background Radiation
  - The best condition: flying during a night without moon ⇨ 600 m
  - The worst condition: flying in the direction of the sun ⇨ 500 m
- Material
  - Reflectivity varies with ageing and surface finishing
    - Typical powerline cables: 40%
    - Brand new stranded aluminium cables: 80%

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Detection Range & Time To Impact

- Visibility: 10 Km
- Cable
  - Diameter: 10 mm
  - Reflectivity: 40%
- Background Radiation: 50 W/m^2 (average clear day)

Detection Range = 700 m

- When flying at 100 Kts the above detection range translates into

Time To Impact = 13 seconds

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Impact of other visibility limiting factors

- There are conditions other than humidity that can lead to a reduction of visibility:
  - rain, snow dust, sand and smog
- Performances are affected in different ways by the above conditions because their effect on the light propagation is different:
  - Absorption
  - Reflection
- When absorption is the most relevant effect the impact is a reduction of the detection range
- When reflection is the most relevant effect the result is a sort of wall that could be thick enough to prevent the laser beam to be able to cross it back and forth and the detection range could be eventually reduced down to zero

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Everyday usage of an Obstacle Warning System

- Previous awareness of the presence of obstacle along the intended flight trajectory is not sufficient to prevent the accident
- Real time alerting is an important feature
- Laser based obstacle warning system can effectively and timely detect obstacles that could pose a serious threat to the safety of flight of helicopter flying at low altitude especially during en-route or transfer phase of flight
- Different mission profiles ask for different level of detail and different way in which the outputs of the active sensors have to be made available to the pilots
  - Human Machine Interface
  - Integration with other systems

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Usage of the video

- Video is the most intuitive and effective way to provide an enhanced view of the scenario
- LOAM has been already integrated with
  - Forward Looking Infra Red sensors
  - Cameras
  - Enhanced vision systems
- Issues
  - Different Field of View dimensions
  - Fields of View dynamic alignment

  } processing
  - Installation on the helicopter ⇨ single turret
- Video is a head down feature ⇨ other ways to be pursued
  - Head up displays
  - Helmet mounted displays

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Integration with other systems

- The capability of transferring obstacles position is the key for the integration with other systems
  - Head up displays
  - Helmet mounted displays
  - Helicopter Terrain Awareness Systems (HTAWS)
  - Terrain followers
- HTAWS and terrain followers are maps and database based systems, their performances are bound to:
  - Data availability
  - Level of detail
  - Update rate
- They can alert only for what is actually in the data they have ⇨ integration with active sensor is the way to be pursued to provide a more comprehensive coverage
  - Technical issues are mainly related to database management but can be solved

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Other laser based experiences

- Obstacle Warning systems are not the only ones to have adopted laser as the base technology for developing products and solutions that can play a role in addressing DVE related issues
- Other companies, mainly in the USA are developing laser based sensors
  - to overcome limitations in brownout conditions
  - to measure altitude and speed during landing phase
- They are at different maturity stages and in general should not be considered as alternative to OWS but rather as collaborative sensors

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Conclusions

- Laser Obstacle Warning System are mature and flight certified
  - Can be installed today on helicopters and effectively used to enhance the situational awareness during en-route and approach phase
  - Are open to integration with many different types of systems to address a wider range of DVE related issues
- The future evolution is to move toward integration and installation of multi sensor solutions
- SWaP-C issues have to be properly addressed to make these solutions affordable and the technology evolution is already helping