



The first in the world joint flights of manned and unmanned aircraft in non-segregated airspace

St.-Petersburg, May 23-25, 2011

ICAO Circular 328 of 2011

Unmanned aircraft systems

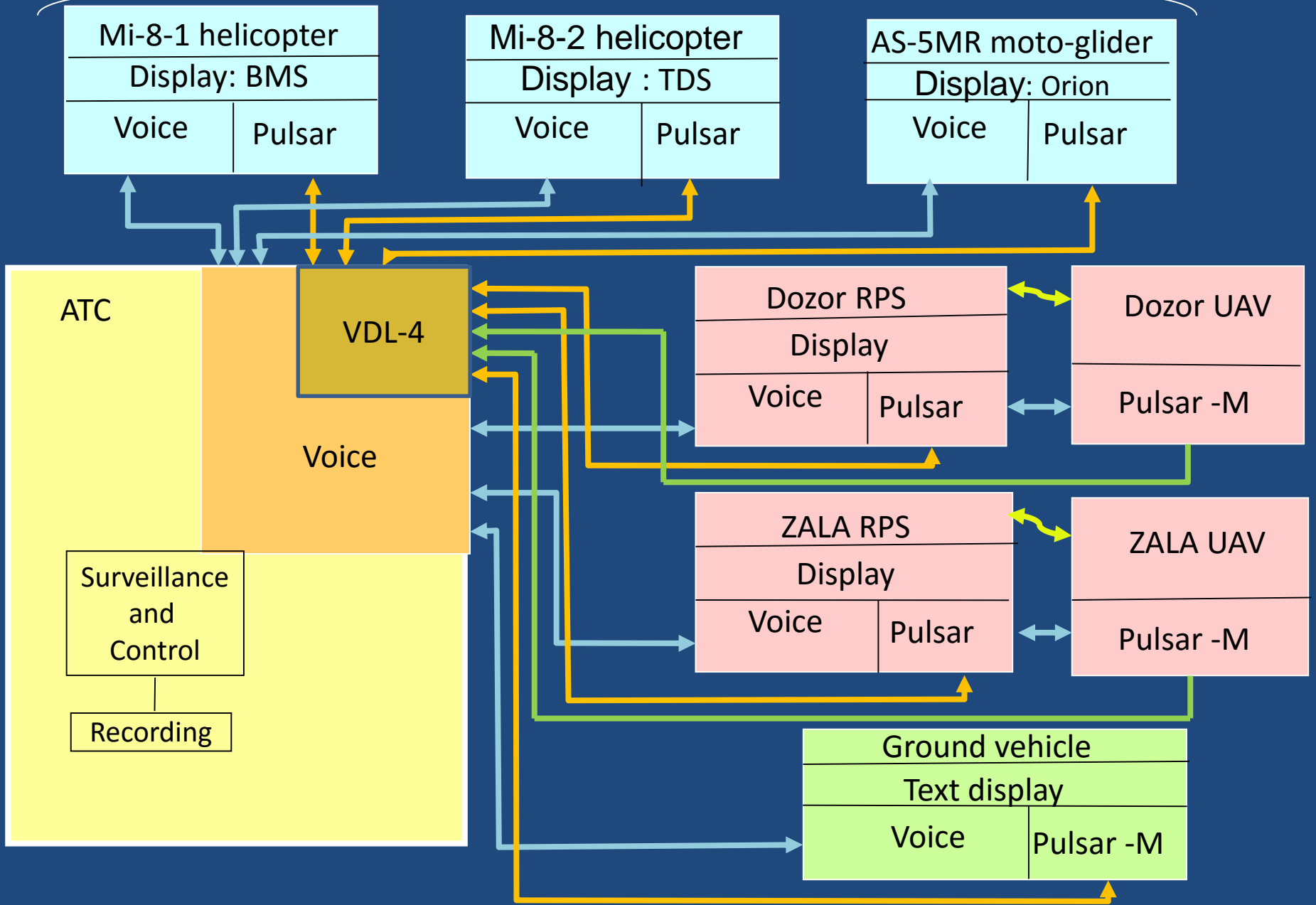
- “The safe integration of UAS into non-segregated airspace will be a long-term activity” which includes solving of many technical and procedure issues and development of a robust regulatory framework.
- At present joint flights of manned and unmanned aircraft are not being performed yet in any state in the world.

Background of flights on May 23-25, 2011

- Use of technical means made in conformance with approved regulatory documents of ICAO, EUROCAE, ETSI
- Flights were organized with the use of the automatic dependent surveillance – broadcast (ADS-B) and adjacent applications (TIS-B, FIS-B, etc.) based on VHF Mode 4 datalink (VDL-4).

Interaction of aircraft with ATC

Piloted aircraft



VDL-4 communications matrix in flights 23 – 25 May 2011

	ATC	Helicopt Mi-8-1	Helicopt Mi-8-2	Motoglid AS-5M	Dozor UAV	Dozor GS	ZALA UAV	ZALA GS	Car
ATC		↕	↕	↕	↓	↔	↓	↔	↔
Helicopt Mi-8-1	↕		↔	↔	↔	↓	↔	↓	↕
Helicopt Mi-8-2	↕	↔		↔	↔	↕	↔	↕	↕
Motoglid AS-5M	↕	↔	↔		↔	↓	↔	↓	↕
Dozor UAV	↓	↔	↔	↔		↓↕	Future	No	↓
Dozor GS	↔	↕	↕	↓	↓↕		No	Future	↔
ZALA UAV	↓	↔	↔	↔	Future	No		↓↕	↓
ZALA GS	↔	↕	↕	↓	No	Future	↓↕		↔
Car	↔	↕	↕	↕	↓	↔	↓	↔	

NITA ATC mobile station



NITA ATC mobile station



AS-5M moto-glider



AS-5M moto-glider



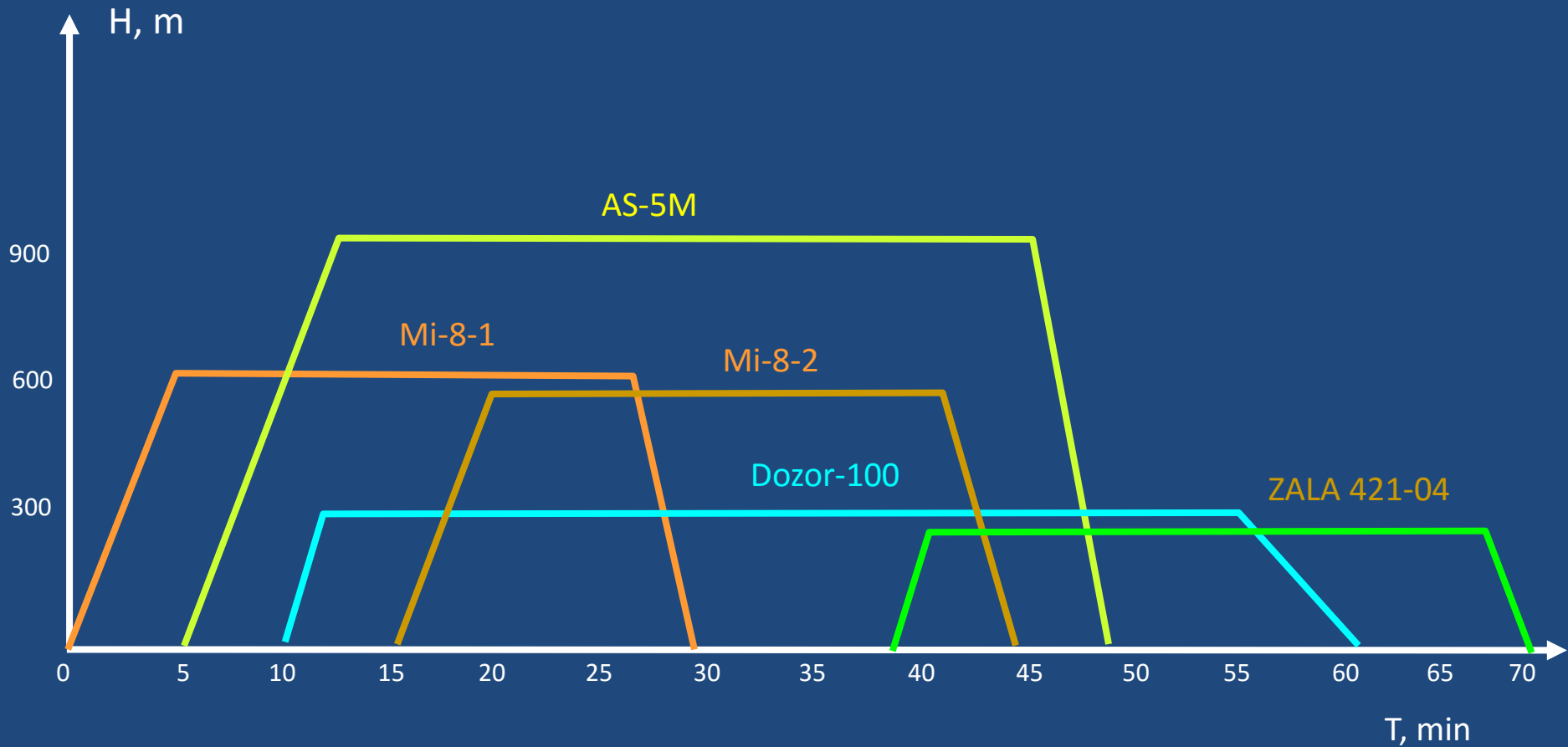
ZAO Tranzas Dozor unmanned aircraft system



ZAO Tranzas Dozor unmanned aircraft system



Distribution of aircraft on flight levels



ADS-B installation on board Mi-8-2

took 1 hour



ZALA AERO unmanned aircraft system

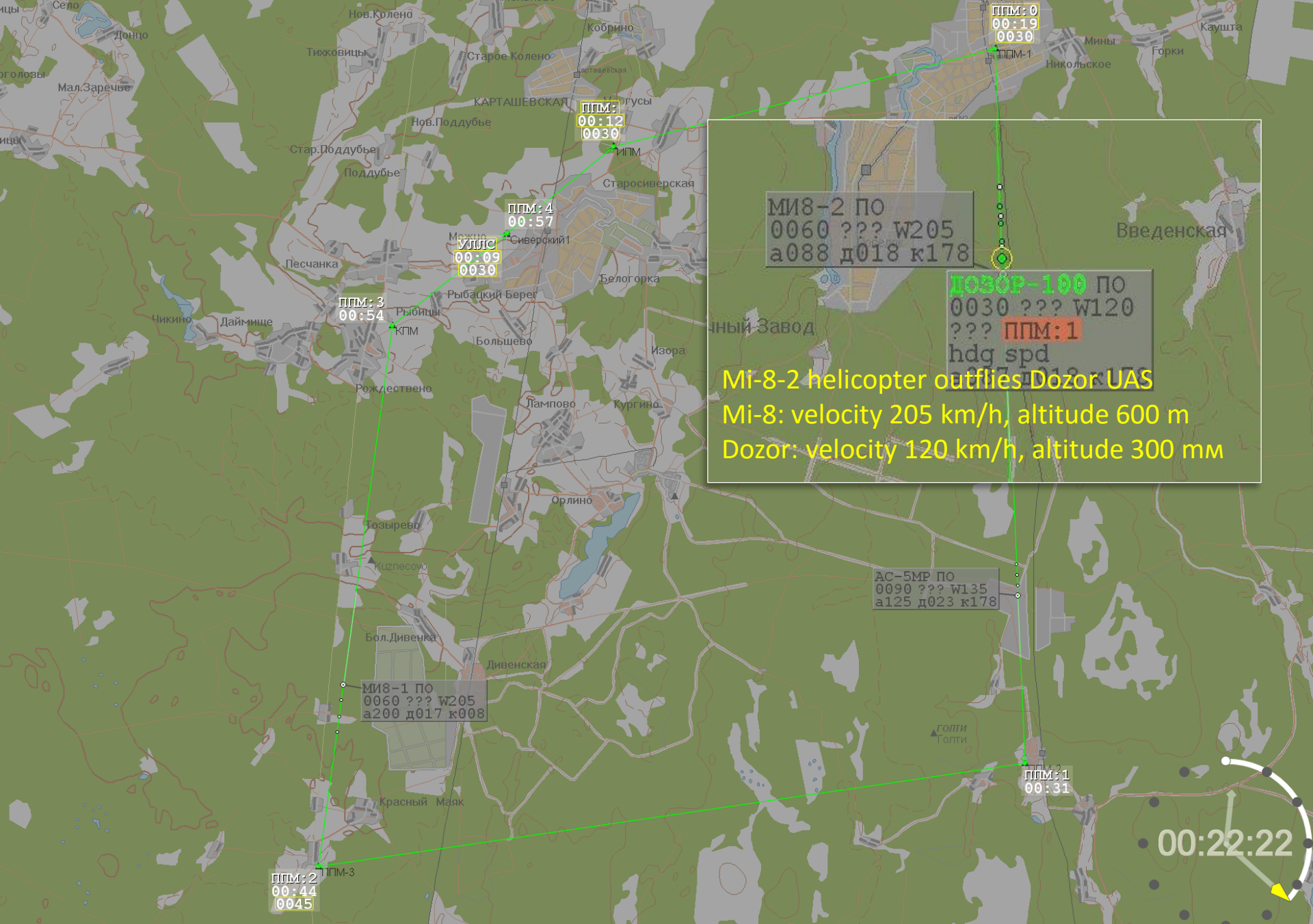


Ground station for ZAIA UAS



Scenario fragments/applications, performed in demo flights (Lessons Learned)

1. ATC survey all aircraft via VDL-4
2. Situation awareness for all the pilots
3. Remotely piloted and autonomous flights
4. Loss of communications: voice comms between ATC and RP; VDL-4 between RP and UAV
5. Conflicts: manned and unmanned aircraft; two UAS
6. Surface movement and incursion of a ground vehicle into the runway
7. Search and rescue with the help of UAS



Recording of the flights in Siviersky aerodrome area, 24.05.2011

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Situation awareness, the second helicopter is at Kuznetsovo parking place



Situation awareness via ADS-B

(hard-in-the-loop stand at GosNIIAS)



Data about each aircraft

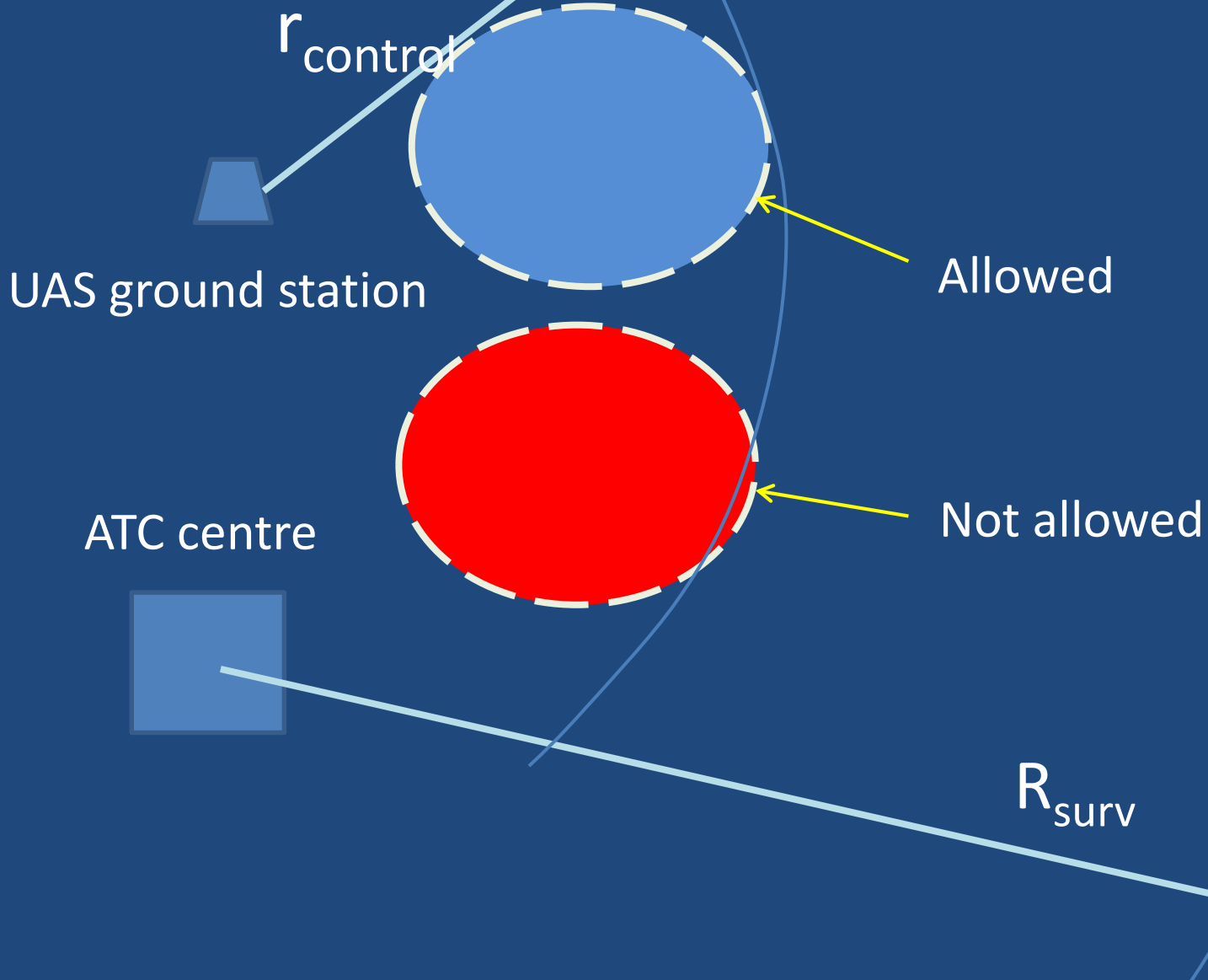


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Concerning autonomous flights

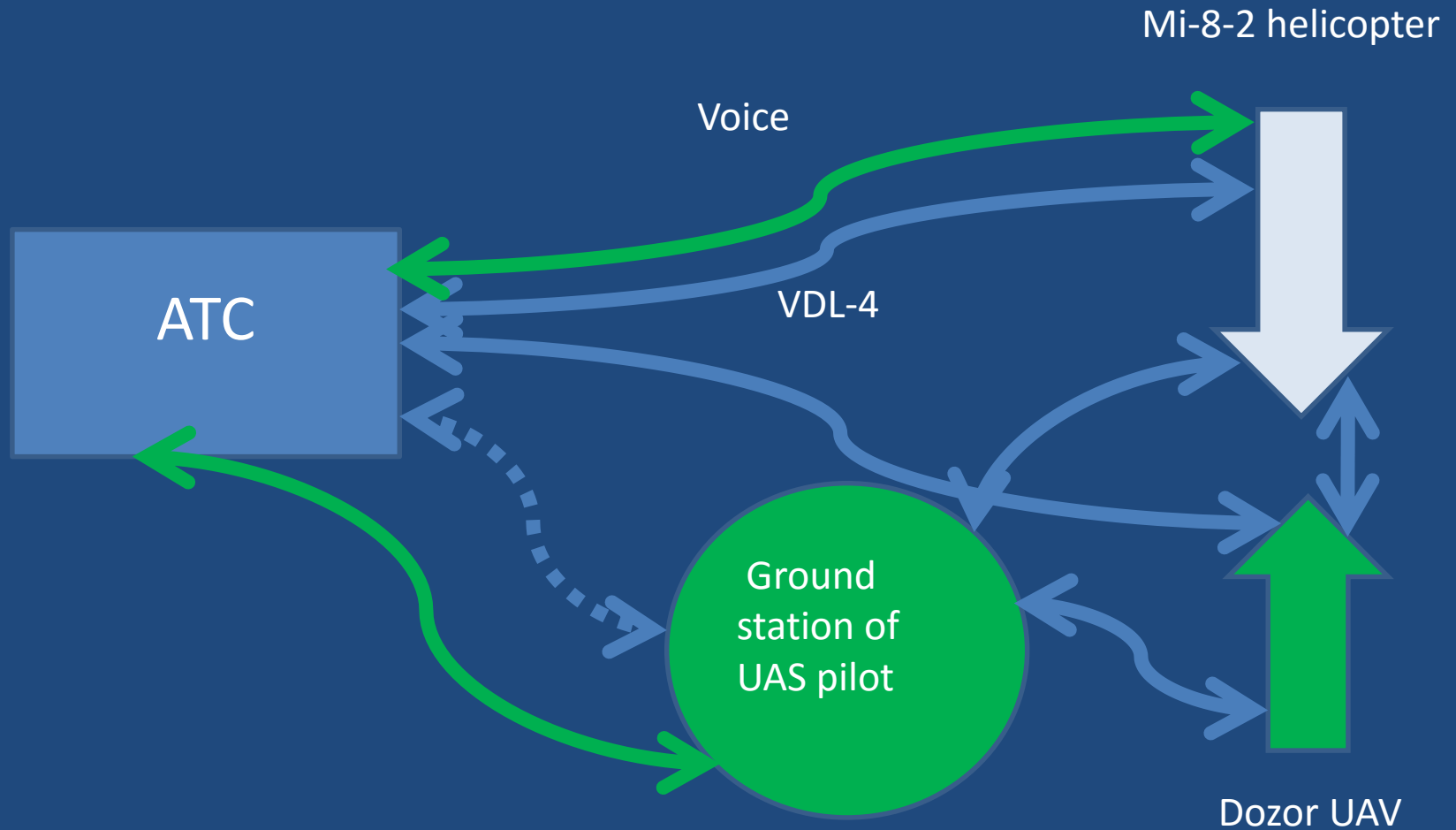
Circular 328 ICAO



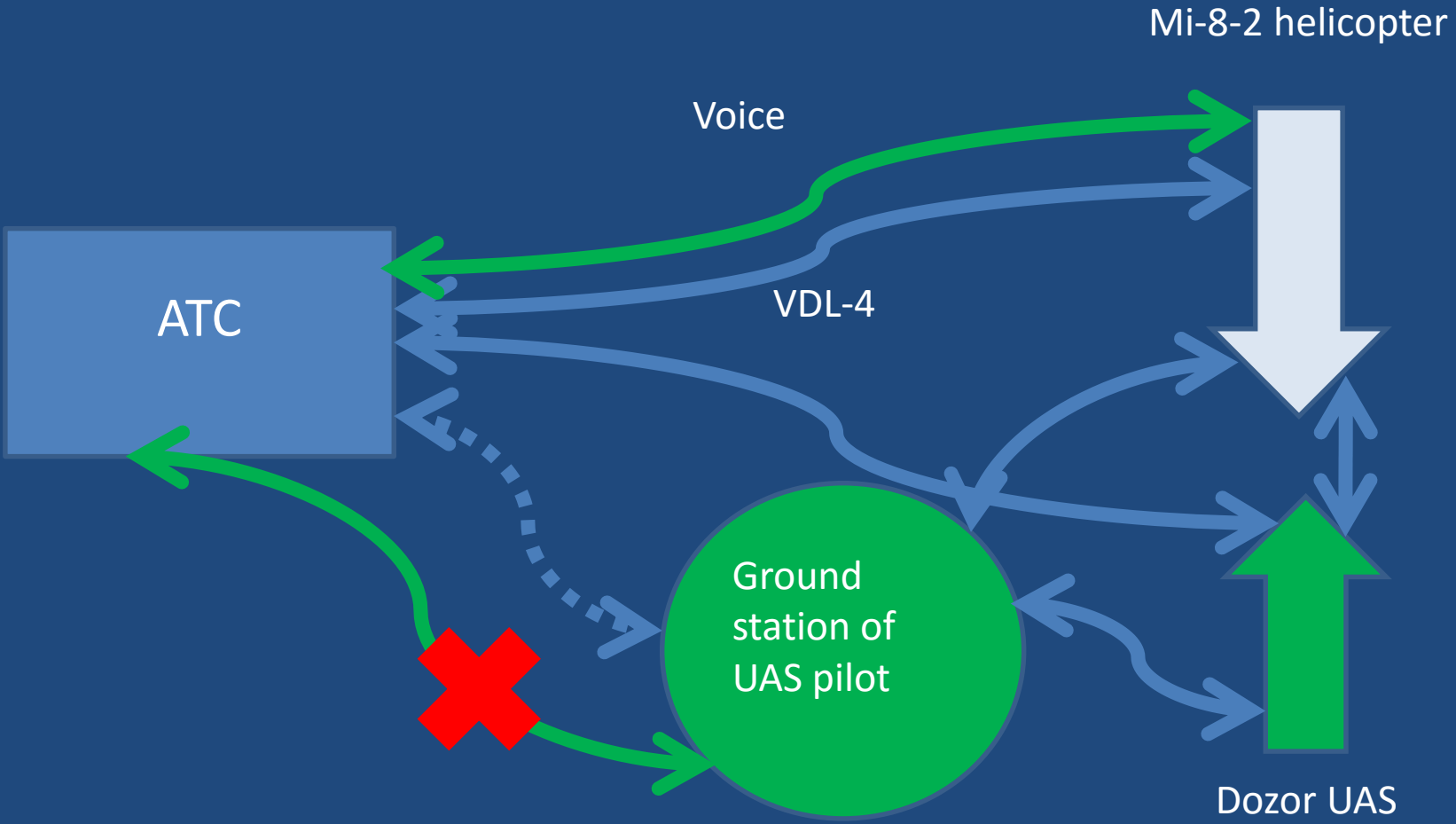
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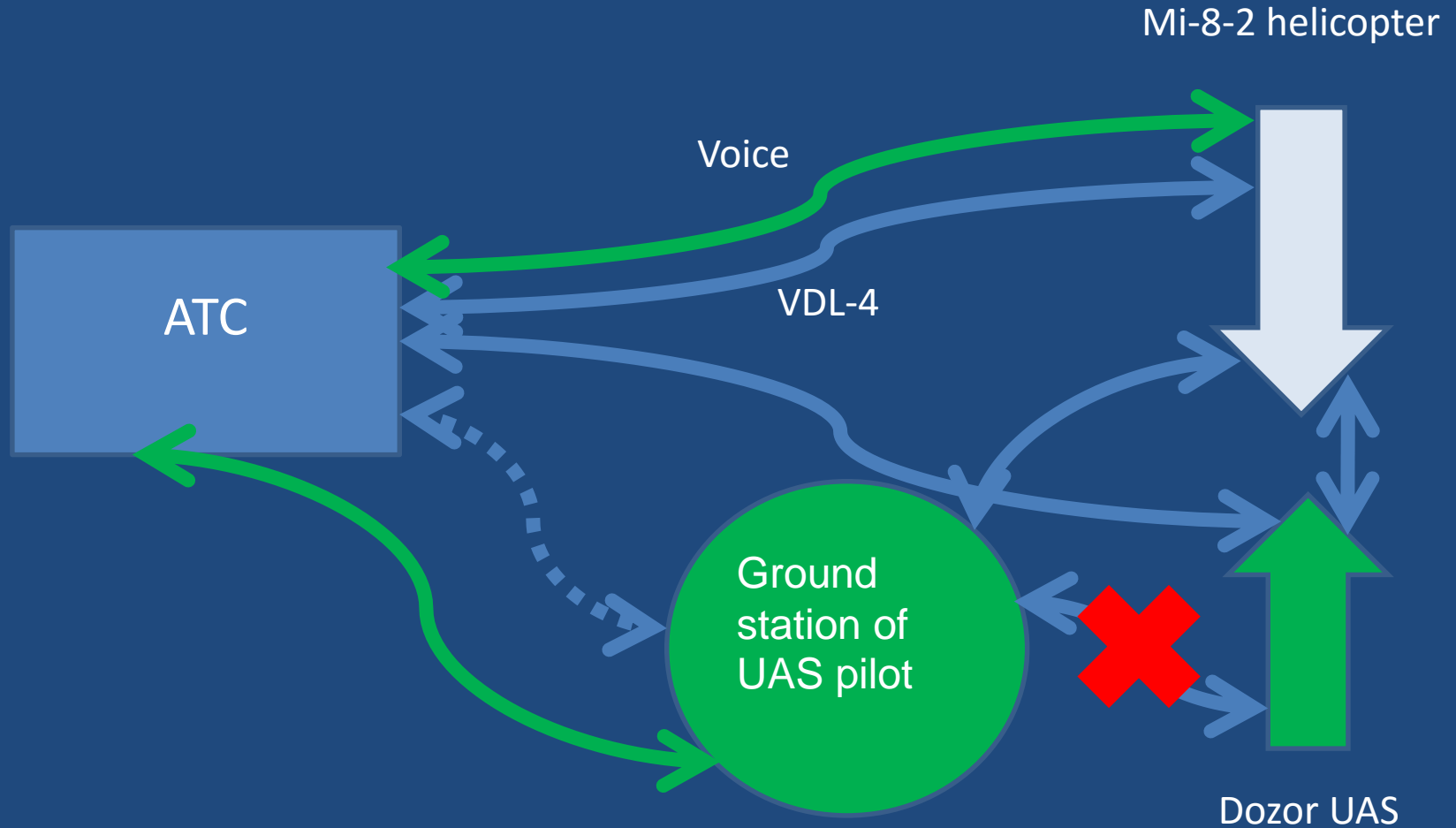
Comms via voice and datalink



Loss of voice communications between Dozor pilot and air controller



Loss of surveillance by UAS pilot



ADS-B in full swing (Out&In) forms a networked (Internet-Like) robust infrastructure – S&A basis

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Unplanned conflict: separation of ZALA UAV and M-8-2 in the landing zone (ZALA UAV started 2 min. later that it was planned)

ZALA421-4 ПО
0030 ??? W80
a231 д002 к231

МИ8-2 ПО
0060 ??? W205
a231 д001 к051

АС-5МР ПО
0090 ??? W135
a208 д011 к008

ДОЗОР-100 ПО
0045 ??? W125
a184 д022 к262

00:42:24

Recording of the flights in Siversky aerodrome area, 24.05.2011

Planned conflict.
Separation of ZALA UAV and Dozor UAV

ZALA421-4 ПО
0030 ??? W80
a204 д012 к185

ДОЗОР-100 ПО
0045 ??? W125
a205 д012 к008

00:50:45

Recording of the flights in Siversky aerodrome area, 24.05.2011

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Incursion of a car equipped with ADS-B
on the runway.

Operator of Dozor UAV sees the object
on the runway and commands the UAV
a go-around.

АВТО ПО
0000 ??? W15
a032 д000 к032

ДОЗОР-100 ПО
0045 ??? W125
a231 д004 к051

ZALA421-4 ПО
0030 ??? W80
a179 д011 к078



Recording of the flights in Siversky aerodrome area, 24.05.2011

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Search and rescue
ATC controller transmits to ZALA
pilot the coordinates of Mi-8-2
emergency landing in TIS-B mode.
UAS pilot directs the UAV onto
transmitted coordinates and
photographs the object.

ZALA421-4 ПО
0030 ??? W80
a150 д011 к078

ZALA421-4 ПО
0030 ??? W80
a150 д011 к078

00:59:16

Recording of the flights in Siviersky aerodrome area, 24.05.2011

ZALA UAS goes to SOS sign and takes a photo



Applications/functions worked out at the hard-in-the-loop stand in GosNIIAS and in flights of Dan UAS

1. TIS-B and situation awareness
2. Air navigation information management D-AIM (operative setting of prohibited zones , etc.)
3. Operative weather awareness
4. Provision of vortex safety
5. ADS-B and ADS-C integration
6. VDL-4 as a backup for UAS control

Hard-in-the-loop stand (semi-nature modeling)



ATC system in hard-in-the-loop simulations





Recording Dan UAS flight



Точка посадки (фактическая)

Старт (фактический)

Elton

Saykhin

Verkhniy Baskunchak

Nizhniy Baskunchak

18.8 km

Pointer lat 48.245134° lon 46.492314° elev 25 m

Image © 2007 TerraMetrics
© 2007 Europa Technologies
Image © 2007 DigitalGlobe

Streaming 100%

© 2007 Google™

Eye alt 57.77 km

Situation awareness via TIS-B, including SOS



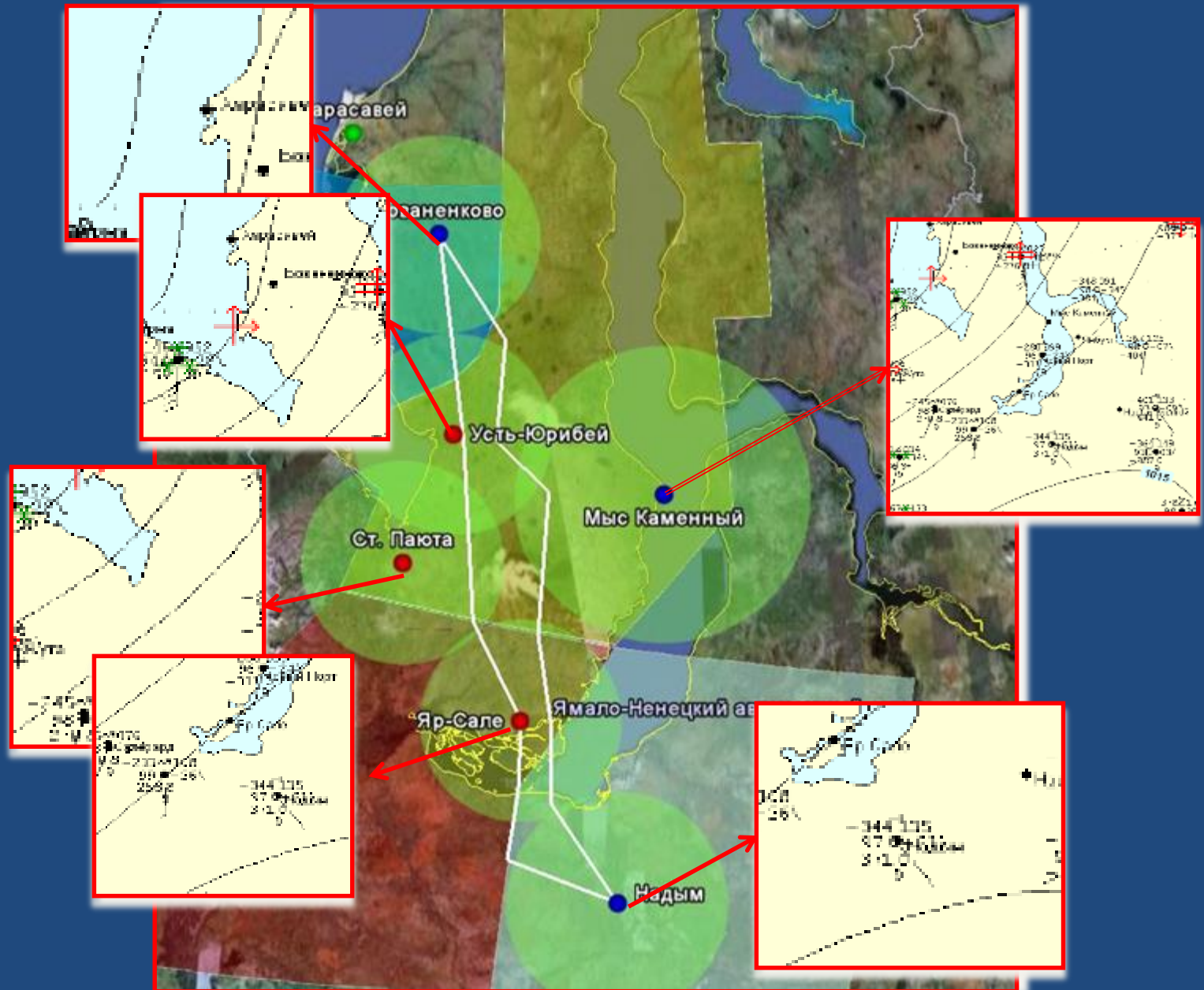
FIS-B: D-AIM



Digital NOTAM



Decomposition of a weather map in ADS-B ground network

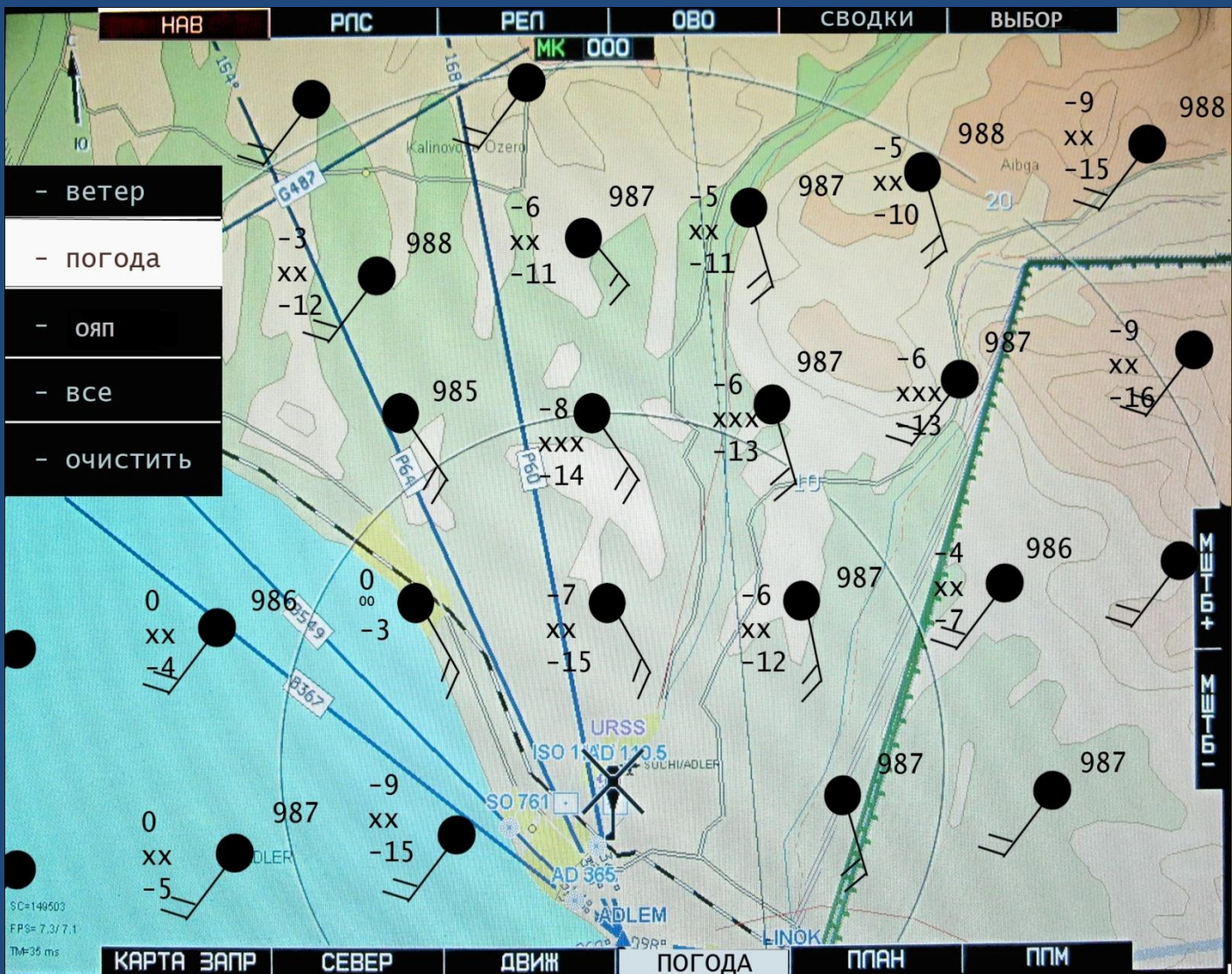


FIS-B (text)

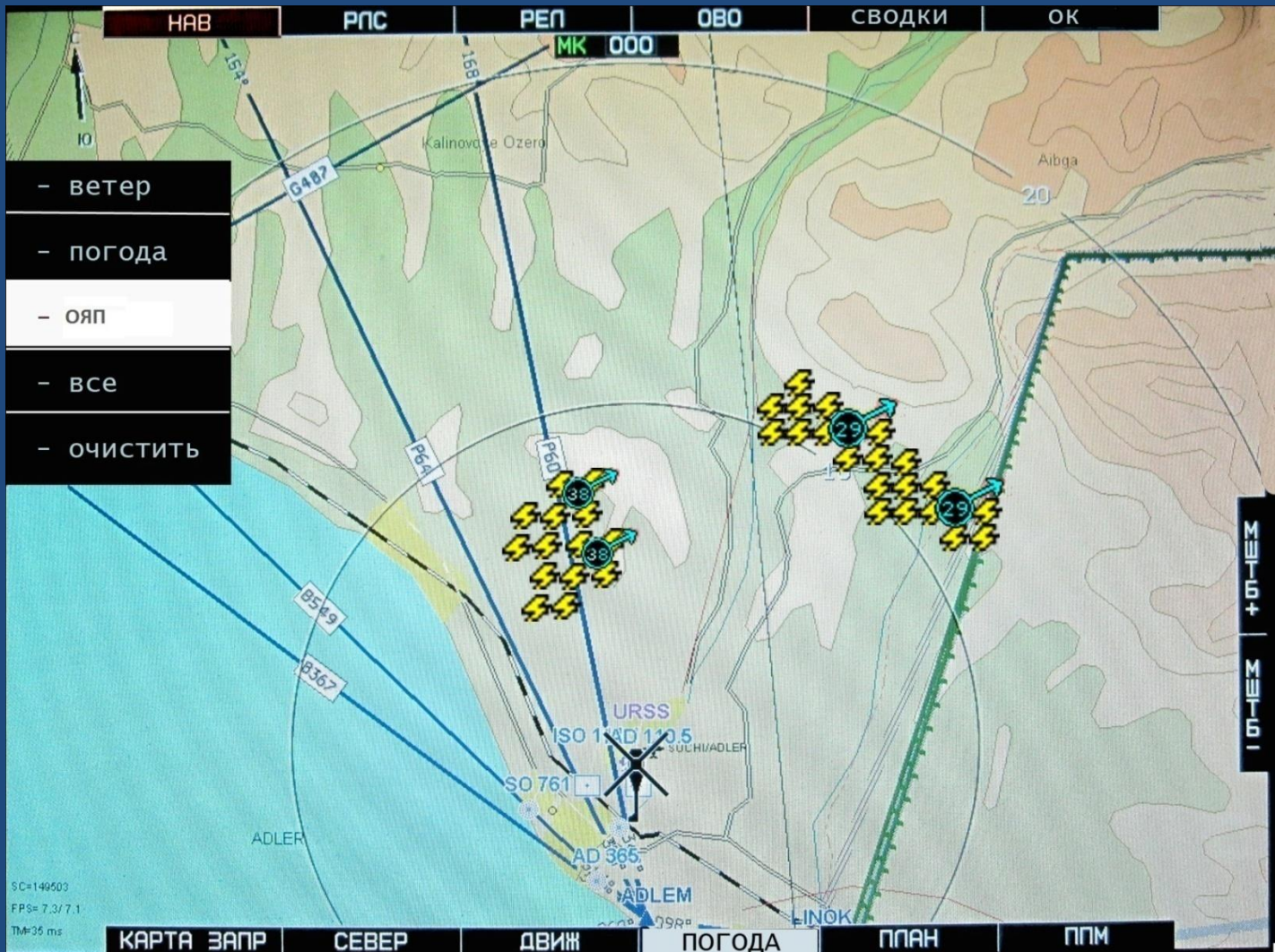


Weather data on a movable map via FIS-B





Operative weather data on the movable map



Hazardous weather on the movable map

VDL-4 transponder used for UAS



- Frequency range , MHzГц 136,0 – 136,975
- Bandwidth, kHz 25
- Power of transmitter, Wt 4
- Capacity, kbit/s 19,2
- Dimensions, mm 110x110x70
- Mass, kg 0.8

VDL-4 patch

In any controlled airspace (without VDL-4) it is supposed to apply a VDL-4 patch including:

- UAS complexes (UAV + RPS);
- ADS-B ground station within ATC .

All VDL-4 patch elements contain VDL-4 transponders.

Regardless of air navigation services rendered in ATC the VDL-4 patch will provide UAS implanting into non-segregated airspace.

Alternatives: what to do if in the airspace of some states VHF Mode 4 datalinks are not used now and will never be used in future:

1. Continue to ignore VDL Mode 4 and look for other possibilities. Until then not to use UAS in non-segregated airspace.
2. Implement the ground and airborne segments of VDL-4 only to manage UAS flights in civil airspace. Inclusion of the ground UAS block into existing ATC ground infrastructures will not create technical challenges.

Airborne block of UAS will apply ADS-B, TIS-B, FIS-B, A-SMGCS, DGNSS, in future TSAA and, possibly, CPDLC as a backup for command/control link.

Full information about UAS will be input in ATC system.

Conclusion (1)

1. ADS-B is a powerful and transparent instrument providing for UAS surveillance in civil airspace
2. VHF Mode 4 datalink is a powerful communications line providing for both ADS-B operation (Out and In) and other functions in the broadcast mode like FIS-B, TIS-B, A-SMGCS, DGNSS as well as situation awareness (TSAA), and point-to-point communication which can be used as a stand-by communications link for the control
3. Flight tests of Dan UAS, investigations at the hard-in-the-loop stand in GosNIIAS and demo flights performed near St.-Petersburg on May 23-25, 2011 have proved the ability of VHF Mode 4 datalink and based on its functions/applications to control UAS flights in civil airspace in robust manner.

Conclusion (2)

4. In conformance with ICAO Circular 328 it is necessary to work out issues of licensing pilots and their medical certification, problems of detection and warning systems, provision of separation, use of the RF spectrum (including its protection from unintentional or unlawful interference), development of airworthiness norms, etc, as well as the development of the regulatory base.
5. However performed works showed that the use of legal from ICAO point of view technical methods and means will promote implementation of UAS in non-segregated airspace.