Mode-S EHS derived observations

Siebren de Haan
5% improvement in wind direction by adding Mode-S EHS from a large domain over 18 to 24 hour forecast

- What is Mode-S EHS?
- Status and usage of Mode-S EHS
- Future of Mode-S EHS
- Final remarks
Origin/background

Request of Air Traffic Control the Netherlands (LVNL)

- Continuous Descent Approach (CDA)
- Environment
  - Fuel
  - Noise
- Efficiency
- Meteorological input for ATC system

Project Team under the umbrella of KDC:

**KNMI:**  Siebren de Haan – R&D  
  Ad Stoffelen – R&D  
  Jan Sondij – Stakeholder Management

**LVNL:**  Paul de Kraker – R&D  
  Ferdinand Dijkstra – R&D

**Boeing:**  Steven Glickman – Project Manager  
  Louis Bailey – R&D

Knowledge Development Center Schiphol (KDC)  
http://www.kdc-mainport.nl/
Within European **designated EHS airspace**: 

- All fixed wing aircraft, having a maximum take-off mass greater that 5,700 kg or a maximum cruising true airspeed in excess of 250 kts, intending to fly IFR (instrument flight regulation) general aviation traffic must be Mode-S EHS compliant.

- **Functionality**
  
  Aircraft compliant with Mode-S EHS provide basic functionality features plus the following eight downlinked aircraft parameters (DAPs):

  Source: EUROCONTROL website

Concerning this presentation:
- DAPs: not a broadcast but **interrogation**, 
- Most aircraft in Europe are EHS equipped, 
- ELS and EHS radar systems are identical, 
- LVNL uses ELS operationally, 
- LVNL uses EHS (TAR 1) non operational, 
- This presentation deals with the use of EHS.

<table>
<thead>
<tr>
<th>BDS Register</th>
<th>Basic DAP Set (if Track Angle Rate is available)</th>
<th>Alternative DAP Set (if Track Angle Rate is not available)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDS 4,0</td>
<td>Selected Altitude</td>
<td>Selected Altitude</td>
</tr>
<tr>
<td>BDS 5,0</td>
<td>Roll Angle</td>
<td>Roll Angle</td>
</tr>
<tr>
<td></td>
<td>Track Angle Rate</td>
<td>True Track Angle</td>
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<td></td>
<td>True Track Angle</td>
<td>Ground Speed</td>
</tr>
<tr>
<td>BDS 6,0</td>
<td>Magnetic Heading</td>
<td>Magnetic Heading</td>
</tr>
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<td></td>
<td>Indicated Airspeed (IAS) / Mach no. (Note: IAS and Mach no. are considered as 1 DAP (even if technically they are 2 separate ARINC labels). If the aircraft can provide both, it must do so.)</td>
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<td>Vertical Rate (Barometric rate of climb/descend or baro-inertial)</td>
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</tr>
<tr>
<td></td>
<td>True Airspeed (provided if Track Angle Rate is not available)</td>
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</tr>
</tbody>
</table>
Derived observations from Mode-S EHS

Wind:

Temperature:
Observed: Mach-number

\[ M = \frac{V_{\text{air}}}{V_{\text{sound}}} \]

Speed of Sound depends on Temperature

\[ c = \left(\frac{C}{\rho}\right)^{1/2}, \quad C = \text{constant} \quad \text{en} \quad \rho = \frac{p}{(R \cdot T)}, \quad R = \text{constant} \]

Thus: \[ V_{\text{air}} = K \cdot M \cdot T^{1/2} \text{ with } K \text{ constant} \]
Temperature observations improvements

Smoothing over 60 seconds for Temperature (15 obs.)

- Linear approximation of $T$ and $V_{true}$ over 60 sec
- Reduction of noise in $T$ and $V_{true}$
Wind improvements

Heading correction

- "Heading" correction
- "Magnetic" North versus "true"-North
  - Correction: 0 to 1 degree
- Landing calibration per aircraft
  - More than 10 landings
  - Correction: 1-2 degrees
  - Landing aircraft at Schiphol (1 yr)
- NWP calibration per aircraft
Wind improvements
Airspeed calibration

- Using NWP wind as truth estimate (ECMWF)
  - Heading correction
  - Airspeed calibration

- Dynamic lookup table for heading correction
- Static lookup table for airspeed calibration
Current coverage of Mode-S EHS observations available at KNMI

derived Wind and Temperature (quality controlled)

All Wind and Temperature observations (73,370) valid 2012/08/09 1000 1015 UTC

Wind and Temperature observations below FL100 (6,673) valid 2012/08/09 1000 1015 UTC

Example of 15 minutes of derived Wind and Temperature observations from Mode-S EHS data of a day in August 2012 over Western Europe, source MUAC, processed by KNMI
Impact of MUAC Mode-S EHS

HIRLAM v7.4 / 11km / hourly
- Rapid cycle (start HH:12)
  - Radar radial wind, GNSS ZTD (deHaan, 2013)
  - Mode-S EHS from LVNL (Netherlands)
    - reforecast (start HH+1:05)
  - AMSU/ASCAT/radiosonde data
  - MSG cloud initialization (Sibbo vd Veen)
    - FG for rapid cycle
    - ECMWF hourly boundaries

MUAC Mode-S EHS data:
- Thinning in 50kmx50kmx300m boxes
- AMDAR resolution in space/time
- All necessary corrections applied
Impact of Mode-S EHS

Compare assimilated Mode-S MUAC derived wind data with forecasts

Wind direction
Surface - 700hPa
2013/03/27 - 2013/04/14

Wind direction [deg]

std.dev.

bias

Wind speed
Surface - 700hPa
2013/03/27 - 2013/04/14

Wind speed [m/s]

std.dev.

bias

700hPa - 500hPa
2013/03/27 - 2013/04/14

700hPa - 500hPa
2013/03/27 - 2013/04/14

MUall.H11.bias
MUall.H11.stddev
MUall.H11MUAC.bias
MUall.H11MUAC.stddev

MUall.H11.bias
MUall.H11.stddev
MUall.H11MUAC.bias
MUall.H11MUAC.stddev
Conclusions

• High resolution models benefit from high resolution observations of good quality over a large area
  • Mode-S is such a data set

• Data usage can be optimized
  • HARMONIE: Cisco de Bruijn and Meteo France (SESAR WP 11.2)

• Mode-S data will be available Met-community
  • Starting July 2013
  • Delay 10 minutes
  • Every 15 minutes
  • BUFR/ASCII
  • ftp-server
Future

- More Mode-S EHS derived observations
  - Mode-S EHS radars in
    - France
      > Toulouse research EHS radar
      > Auch (30 km west of Toulouse, summer 2013)
    - UK
      > ?

- More other wind (and temperature observations)
  - Wind profilers/VAD winds
  - Radar radial winds/reflectivities: OPERA!
Acknowlegdement

- Jan Sondij
- LVNL
- EUROCONTROL

THE END ……
• Sharing observations is good for everybody
  • E-GVAP ZTD and its impact on NWP

• So .....  

WE SHOULD START SHARING
  - Especially high resolution (space/time) observations
Mode-S: technique

Automatic Dependent Surveillance Broadcast (ADS-B)
Aircraft broadcast position, altitude, speed etc

Secondary Surveillance Radar (SSR) Mode-S Surveillance
Altitude and identity data available

Mode-S Transponder
ICAO 24 bit Aircraft Address

Source: www.javiation.co.uk