INTRODUCTION TO THE 4DWxCube

UFO Dissemination Workshop, NLR, 23 April 2015

Jean-Louis Brenguier, Météo-France, Manager WP11.2.2, on behalf of Eumetnet
Enhanced MET Services to Aviation

- SESAR1 WP11.2
- Management of MET Forecast Uncertainty
- 4DWeatherxCube Architecture
- MET Integration in ATM Systems

UFO Dissemination Workshop, NLR, 23 April 2015
MET Impacts on Aviation

Adverse weather conditions! (in flight)
Adverse weather conditions are responsible for 13.5% of in-flight delays
Adverse weather conditions! (at airport)

Adverse weather conditions are responsible for 64.4% of delays at airports in winter (35% in summer)
MET Impacts on Aviation

Adverse weather typology at airport (CDG)

ATFM delays attributed to weather: Europe, 2010 (OSED)
MET Services to Aviation aim at

- Improving performance and reducing impact (optimum trajectory).
- Improving safety and comfort (adverse weather avoidance procedures).
- Anticipating capacity reduction and setting up mitigation actions (aircraft deicing at airport, aircraft separation).
MET Support to Aviation from Planning to Execution

Climatology

Seasonal forecast

Short range forecast

Medium range forecast

Nowcasting

Real Time Observation

YEARS
Long Term

6 MONTHS
Mid/Short Term

DAYS

HOURS

MINUTES
Execution

Reference business trajectory
Airspace users and ATM expectations
Nominal / Adverse Weather Conditions

Nominal MET conditions
Pressure, Temperature, Humidity, wind

- Performance,  
- Capacity,  
- Environmental Impact

Adverse MET conditions
MET hazards: Convection, Wind Shear, Icing, CAT, Visibility, Winter conditions

- Safety,  
- Capacity,  
- Performance

YEARS 6 MONTHS DAYS HOURS MINUTES
Long Term Mid/Short Term Execution
Airspace users and ATM expectations
Two contrasting approaches

- In nominal conditions (99,9..% of the time), minor gain (70 kg/h of fuel for 10 km/h gain in tail wind), times a huge number of flight hours (50 M FH)

- In adverse weather (0.01...% of the time), Real time information in support to tactical decision, huge gain in term of safety and confort in a very small number of cases. Forecast of capacity reduction, significant gain for management and operation costs of airports and airspace users in adverse weather conditions
Basics of Meteorology (fast track)
Basics of Meteorology (tedious approach)
Enhanced MET Services to Aviation

SESAR1 WP11.2

Management of MET Forecast Uncertainty

4DWeatherCube Architecture

MET Integration in ATM Systems

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WP11.2 Contributions in SESAR1

Consistent (in space and time) MET services in EU

Digital MET Information: interoperability & Integration

Focus on short term: Observation – Nowcasting T0-T+3h

Dynamic assessment of MET uncertainty: non-nominal

Priority to Integration of MET information in impact assessment and decision support tools
Consolidation (Observation)

Radar composite for 3D convection

200 radars in EU with diverse spécifications (frequency, Doppler, dual polar).

OPERA/ODYSSEY aims at harmonizing radar data processing and interpretation (severity levels)
Consolidation (Forecast)

Super-ensemble forecast of convection

Three convection resolving forecast models (more in the near future) initialized from different parent global models.

Intercalibration of ensemble forecast PDFs aims at providing ATM users with seamless probabilistic forecast of convection.
Translation (Observation)
All actors share the same information
MET translation in Aviation usable Information:
Satellite imagery + NWP to identify convective cells and measure cloud top.
Observations merged with short term forecast (+2 h).
Contour of convection 3km resolution, 15 min refresh rate
Management of MET Uncertainty: Ensemble MET Forecast

Ensemble MET 18 h Forecast

Radar Observation of Echo-Top
Spatialization of convection probabilities

- Raw point-based prob of event

- Verifying Zmax obs

- Prob of event everywhere: P<20% everywhere!

- Even worse...

- Prob of event in neighborhood

- Orange: p>30% = no-fly zones.
Management of MET Uncertainty

Ensemble forecast can be used in two ways:
Probabilistic MET for Impact Assessment

Ensemble Impact Prediction

DIA Deterministic Impact Assessment (as usual)
Probabilistic MET Forecast

CPS Forecast valid from: 7-Feb 6:00

Inbound Capacity Forecast Schiphol
Valid from: 07 Feb 2004, 06:00 UTC

Inbound ATC Slot Delay Forecast Schiphol
Valid From: 07 Feb 2004, 06:00 UTC

KNMI Prob Forecast, issued at: 7-Feb 0:00

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Ensemble Impact Assessment
Steiner et al., 2010

(a) Probabilistic MET

Weather hazard

Forecast #1  Forecast #2  Forecast #3

averaging weather ensembles

How many air lanes may fit?
Impact of MET Uncertainty on the 4DTraj
Enhanced MET Services to Aviation

MET Services to Aviation

SESAR1 WP11.2

Management of MET Forecast Uncertainty

4DWxxCube Architecture

MET Integration in ATM Systems

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The European Context

The consumers are diverse, hence are the services in terms of content, domain, spatial and time resolution, latency, etc.... but....

the MET services shall provide a unique and consistent vision of the present state of the atmosphere and of its future evolution

REQ-11.02-DOD-6100.0001

The MET information shall be consistent in time and across the different Operational User Environments.
P1: NMSs provide the 4DWxCube with diverse pieces of MET Information, observation and forecast, for either consolidation, translation, or direct dissemination to consumers via the MET-GATE.

P5: NMSs collect MET Information derived from aircraft observation after quality control, for assimilation.
Aircraft provide the 4DWxCube with in flight observations, via:

**P3 (Step 1)**: existing channels such as E-AMDAR

**P4c (Step 2)**: the SWIM Purple Profile via the MET-GATE
TAD Ed. 00.03.00 External Interfaces
ATM-dedicated Aerodrome Infrastructure

**P2**: ATM-dedicated Aerodrome MET Infrastructure provide the 4D-WxCube with local observations.

Local MET observations from the ATM-dedicated Aerodrome MET Infrastructure are consolidated with regional scale observations, merged with MET forecast and translated into Aerodrome dedicated MET products for the MET-GATE to provide local MET services.

Very short latency MET alerts are passed to consumers (TWR) via a direct link (**P6** in step 1, **P4** Blue Profile in Step 2.)
Sec. 2 Architecture of the System
2.1 Functional View

2.1.1 Functional breakdown

- C01: Radar Composite
- C02: Aircraft Information Processing & QC
- C03: VST Forecast
- C04: Inter-calibration of HR/ST/LA Ensemble Forecast
- C05: Super-ensemble MR/MT Global Forecast

Consolidation

performs

- T01: ICAO Annex 3 Regulatory MET Information
- T02: Local MET Information & Alerts
- T03: Convection Warnings
- T04: Sub-regional Scale Diagnostics of Icing Conditions
- T05: Sub-regional Scale Diagnostics of CAT
- T06: Global Scale Diagnostics of Icing Conditions
- T07: Global Scale Diagnostics of CAT
- T08: Global Probabilistic MET Forecast

Translation
From Generic MET information to C&T MET Products

- WAFC
  - Radar Obs
  - FORECAST
- MSP1
  - Radar Obs
  - FORECAST
- MSP2
  - Radar Obs
  - FORECAST
- MSP3
  - Radar Obs
  - FORECAST

METGATE

Reflectivity

OPERA

CAT

ICING

CONVECTION

CAT

ICING

CONV
From C&T MET Products to MET Services

- WAFS
- Reduce Resolution
- MET GATE
- Domain Sub-Setting
- CAT
- ICING
- CONV
- HR MET Hazards T0-+3h
- MET SERVICES
- NETWORK
- MR MET Hazards +3-+24h
- FMP
Impact assessment is not a MET responsibility, although MET Services shall be tailored to facilitate integration of MET information in impact assessment tools.

- Weather Impact at Airports

**FMP**: Time horizon T0 - +3h

- Sub-Regional Weather Hazards
Consistent MET Information and Single Access Point to the Met Services

MET Services are collections of MET products that shall be consistent in time and across the different Operational User Environments (MET-DOD), hence shall be Consolidated and Translated in the 4DWxCube before the MET-GATE constitutes the Services.
Enhanced MET Services to Aviation

MET Services to Aviation

SESAR1 WP11.2

Management of MET Forecast Uncertainty

4DWxxCube Architecture

MET Integration in ATM Systems

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MET & ATM Roles and Responsibilities

MET DOMAIN

MET PRODUCTION

MET TRANSLATION

ATM DOMAIN

SWIM

IMPACT

DECISION
Level Ø – no integration

Level 1 – MET integrated in the controller display

Level 2 – MET translated in constraints

Level 3 – Impacts

Level 4 – Decision Support
SESAR-2020 : Priority to MET Integration
Integration of Weather into Traffic Flow Management

- Weather Information
- Weather Translation
- Impact Estimation
- Ensemble Weather Forecasts
- Flight Plans and Amendments
- Demand Projection Model
- TFM Initiative Execution Model
- Planning Time = t
- t = t + Δt
- En Route Weather Translation Models
- Terminal Weather Translation Models
- National Flow Planning Delay and Rerouting Decision Model
- TFM Initiatives at Time t
- Response Scenarios
Contact Details

Jean-Louis Brenguier
Météo-France
Tel: +33 5 6107 9321
Fax: +33 5 6107 9848
Mob: +33 6 8530 7082
Email: jlb@meteo.fr
Web: www.meteofrance.com/

GIE EUMETNET Secretariat
c/o L’Institut Royal Météorologique
de Belgique
Avenue Circulaire 3
1180 Bruxelles, Belgique

Tel: +32 (0)2 373 05 18
Fax: +32 (0)2 890 98 58
Email: info@eumetnet.eu
Web: www.eumetnet.eu