1. **Introduction**

Weather that is potentially hazardous to en-route aviation includes significant convection, tropical cyclones, turbulence, airframe icing, high ice water content (HIWC), mountain wave and sand/duststorms. Other than impacting on the safety, hazardous weather also impacts on the efficiency and regularity. Under the current International Civil Aviation Organization (ICAO) system, Meteorological Watch Office (MWO) issues SIGMET, in the form of a text message, for its own Flight Information Region (FIR) to alert the airlines and pilots of the potential hazardous weather. The current system has a number of drawbacks such as the information issued by the neighbouring MWOs may not always be consistent or coherent; the output in text form is easily subject to error and is not easily useable by automated systems for further processing.

2. **Near-term solution**

To address the consistency of SIGMET issued by different MWOs on hazardous weather phenomenon that affects multiple FIRs, cross-FIR-boundary coordination for alignment of SIGMET information are undertaken operationally by Singapore, Malaysia and Indonesia after conducting a pilot under the auspices of WMO (WMO, 2017). Dedicated websites and coordination tools, developed by Japan and Hong Kong, China, were made available to the participating MWOs for common situation awareness and SIGMET coordination.
Figure 1 Web-based monitoring and SIGMET coordination platform provided by Hong Kong, China

Figure 2 Web-based tools and SATAID system provided by Japan

Other operational SIGMET coordination efforts include METAlliance SIGMET Coordination Project involving 6 member countries of METAlliance; the Russian Federation SIGMET Coordination Project involving Russia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan; the Balkans; (involving Bosnia-Herzegovina, Croatia, Serbia and Slovenia); DACH (involving Germany, Austria and Switzerland) and NAMCON (involving Denmark, Estonia, Finland, Iceland, Latvia and Norway).

3. Future Hazardous Weather Information

While there are currently much effort to improve the availability and consistency of SIGMETs through bilateral arrangements and regional coordination efforts, the users, which include the airline operators, flight crews and air traffic management, have expressed the need for a revamp of the whole system in line with the latest edition of the Global Air Navigation Plan (GANP) (ICAO DOC 9750, 2016) and the Aviation System Block Upgrades (ASBU) methodology by ICAO that guide complementary and sector wide development to enhance the safety and efficiency in the next 15+ years.

Based on the information from the users, some high level requirements have been obtained. In respect of the information needs, the users envisioned requirements in the following time horizons:

- Observed hazard - updated as required
- Immediate Forecast (30 mins) – updated every 30 mins or as required
- Near term forecast (3 hrs) – updated hourly or as required
- Medium Forecast (12 hours) – updated every 3 hours or as required
- Long term forecast (24 hrs) – updated every 6 hours or as required
- Extended forecast (TC) – updated every 6 hours or as required
The observation and shorter term forecasts will be used for tactical avoidance while the longer term forecasts will be useful for flight planning, tactical/strategic re-route and traffic flow management. However, it is reckoned that the requirements might be different for different phenomenon, e.g. convection is highly dynamic and would argue for shorter temporal responses than sand/duststorms.

While the long term and extended forecast are being addressed through the World Area Forecast System (WAFS), there is a need to address the user needs for the observed to near term forecast which is currently met by the provision of SIGMET and to be replaced by future hazardous weather information. The next generation of harmonized, phenomenon-based enroute hazardous weather information should also be integrated into the System-wide Information Management (SWIM) environment to allow for further processing and analysis by automated decision support tools. Apart from the need for a more timely, accurate, reliable service that is machine readable, the future service should be seamless across FIR boundaries.

In addition to traditional deterministic hazardous weather information, with the introduction of Safety Management System (SMS) by ICAO, some airline operators now based their operation on the assessed risk. One possibility to support risk analysis and decision making methodology is through the provision of ensemble probabilistic forecasts.

To meet the evolving needs of the aviation community, there needs to be a paradigm shift in the way such hazardous weather information is to be provided. The task to develop the next generation harmonized, phenomenon-based enroute hazardous weather information is being undertaken by the Regional Hazardous Weather Advisory Centre (RHWAC) workstream of Meteorological Information Service Development (MISD) Working Group under the Meteorological Panel of ICAO.

The users of hazardous weather information include operators (which includes Airline Operations Centres, Dispatchers and Flight Crew) and Air Traffic Management. Different users of enroute hazardous weather information may use the information in a different way with different emphasis. To better define the need for the hazardous weather information system, a user need analysis, a standard phase in commonly accepted system engineering practice, is being conducted via online survey. An example of the online survey is given in Appendix I.

It is important to garner robust user response through reaching out to as many end users as possible. On the other hand, considering that even for the same category of users, e.g. airline operators, their mode of operation may vary significantly and thus potential to receive a diversity in responses. Thus the survey results would generally first go back to the user representatives for consolidation before consideration by the workstream.

While the actual survey result is not yet available, a much higher service level requirement of the future en-route hazardous weather information is expected as revealed by the comments to the survey forms. For example, a comment on the option for the smallest convection that the user might want to know over continental airspace should be down to as small as 0.25 deg x 0.25 deg.

Considering the need for much higher granularity of the information, more advanced automatic identification of the phenomena using satellite/radar would be required, especially for service providers with a large area of responsibility. To well represent such smaller scale convections in the nowcasting timeframe would require improved blending of observations, radar/satellite-
based nowcasting products with high resolution NWP system. The development of ensemble probabilistic nowcasting products is another new area which would require more research.

4. Conclusion

The expected increase in aviation demands, economic pressure and attention to the environmental impact are relying ever more on accurate and timely information that ties in with the latest ICAO GANP and ASBU methodology and supports system wide interoperability. A large scale survey on the detail user requirement for future en-route hazardous weather information would be carried out. Initial feedback on the survey forms suggested a much higher service level requirement over the existing SIGMET provision which might require further research to improve on automatic identification of the hazardous weather phenomena, blending of observations, radar/satellite-based nowcasting products with high resolution NWP system and development of ensemble probabilistic nowcasting products.

References

ICAO, 2016: Global Air Navigation Plan 2013-2028 (DOC 9750)  

Appendix I

Significant Convection - Detailed requirement

Observation and Necessity

Note: The requirements should be based upon information needed to support realistic operational decisions. The figure is recommended for pilots with significant convection noted in its AOC. Vertical to the right are the different types of convection. The grid is 1-day x 1-day.

1. What is the CiCCN requirement for observation?
   [Note: calculated from the time when data is available, e.g. pilot report - from time when report received from ATC. This is the maximum allowed time for analysis and preparation, observation should be made by each available source (e.g.]
   - Yes
   - No
   - Other (please specify)

2. Do you use background information relating to convective OGC?
   - Yes
   - No

3. How many levels should the intensity of significant convection be expressed in?
   - 1
   - 2
   - 3
   - 4
   - More than 4
   - No requirement

4. How should significant convection intensity be expressed?
   - Hexadecimal, octal, decimal, hexadecimal, frequency
   - Hexadecimal/decimal [note: see the annex of the maximum for each, it would be derived from satellite]
   - Impact based on scale of 1, 2, 3, 4,...
   - Other (please specify)

5. Is your answer to the above question to impact based, please evaluate how you would define impact.

6. For convective air spaces, what would be the altitude range of the convective air you want to know?
   [Note: for very fine shapes, you may run into delineation method. So the requirement should be based on experience to maintain a balance between the significant convection]  
   - 50 km x 50 km
   - 100 km x 100 km
   - 200 km x 200 km
   - 300 km x 300 km
   - 400 km x 400 km
   - Other (please specify)

7. For convective air space, what would be the minimal separation distance between two convective systems which will not bring danger to your operation?
   [Note: for very fine shapes, you may run into delineation method. So the requirement should be based on experience and maintain a balance between the significance of convection]  
   - 50 km
   - 100 km
   - 200 km
   - 300 km
   - > 300 km
   - Other (please specify)
8. For convective systems, what would be the minimum size of the convective systems you want to know? (Note: For very few systems, you may not have information available. In that case, you should consider the minimum size of convective systems that will impact your operations. I.e., you may consider to go between these)
- 5 km x 5 km
- 10 km x 10 km
- 15 km x 15 km
- 20 km x 20 km
- Other (please specify)

9. For convective systems in air space, what would be the minimum separation distance between two convective systems which will not impact your operations, i.e., you may consider to go between these?
- 5 km
- 10 km
- 15 km
- 20 km
- Other (please specify)

10. Should the severity of the convective system convective systems be based on the number of convective lightning or lightning density (e.g., number of convective lightning strikes or lightning strike density)?
- Yes
- No

11. If your answer to Q8 is YES, what should be the minimum criteria?
- Less than 1 lightning strike in the past 10 minutes
- 1-5 lightning strikes in the past 10 minutes
- 6-15 lightning strikes in the past 10 minutes
- More than 15 lightning strikes in the past 10 minutes
- Other (please specify)

12. If your answer to Q9 is YES, what should be the minimum criteria?
- Less than 1 lightning strike in the past 10 minutes
- 1-5 lightning strikes in the past 10 minutes
- 6-15 lightning strikes in the past 10 minutes
- More than 15 lightning strikes in the past 10 minutes
- Other (please specify)

13. If your answer to Q9 is NO, what should be the basis of the criteria?

14. If your answer to Q10 is YES, what should be the minimum criteria?
- Less than 1 lightning strike in the past 10 minutes
- 1-5 lightning strikes in the past 10 minutes
- 6-15 lightning strikes in the past 10 minutes
- More than 15 lightning strikes in the past 10 minutes
- Other (please specify)

15. If your answer to Q10 is NO, what should be the basis of the criteria?

16. If your answer to the above question is YES, what cloud top information do you require?
- The minimum cloud top of the area
- The 90th percentile of the cloud top of the area, i.e., half of cloud top is higher than this height and the other half lower than this height
- The 5th percentile of the cloud top of the area, i.e., half of cloud top is higher than this height and the other half lower than this height
- The 90th percentile of the cloud top of the area, i.e., half of cloud top is higher than this height and the other half lower than this height
- The average cloud top of the area, i.e., the mean
- Other (please specify)

17. Do you require cloud top information?
- Yes
- No

18. Do you require cloud base information?
- Yes
- No

19. Your organization, name and job title, phone:
- Organization
- Name
- Position
- Phone

[Sign here]