INTERNATIONAL CIVIL AVIATION ORGANIZATION
ASIA AND PACIFIC OFFICE

ICAO SPECIAL IMPLEMENTATION PROJECT (SIP)

WIND SHEAR SYSTEMS ACQUISITION WORKSHOP

SUMMARY OF DISCUSSIONS

1-3 December 2010
Bangkok, Thailand

Workshop Objective and Attributes **Page**

Summary of Discussions

Attachments

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1. Objective

1.1 The workshop was made possible as an ICAO Special Implementation Project (SIP) for the year 2010. The objective of the workshop is to provide States information on the different types of wind shear systems in order to assist States in the acquisition of wind shear systems that would satisfy Annex 3, Chapter 7 and Appendix 6.

2. Attendance

2.1 The workshop was attended by 41 experts from 14 States, IFATCA and ICAO. The List of Participants is provided in **Attachment 1** to this Report.

3. Opening of the Workshop

3.1 Mr. Christopher F. Keohan, Regional Officer Aeronautical Meteorology, ICAO Asia and Pacific Regional Office, opened the workshop and welcomed all participants to the ICAO Regional Office and emphasized the importance of exchanging information on wind shear systems in operation in the Region which would allow many States to make more informed decisions in selecting wind shear systems for their respective State. It was noted that this Region is prone to wind shear due to the high frequency of thunderstorms in the tropical zones, where there are many emerging States with significant increases in air travel. This combination increases the probability of wind shear related incidents and accidents. Therefore, it is no surprise that 11 of the 13 States attending are located or partly located between 30ºN and 30ºS latitudes.

3.2 Mr. Keohan thanked experts from Hong Kong, China, Japan, Australia and India who assisted in providing material necessary to meet the objective.

4. Facilitators of the Workshop

4.1 Mr. PW Chan of Hong Kong, China and Mr. Christopher Keohan, Regional Officer Aeronautical Meteorology, acted as facilitators of the workshop.

5. Organization and language of the Workshop

5.1 The workshop met as a single body. Working language was English including all presentations and this report. The workshop considered 6 presentations and various group discussions and break out sessions. List of presentations and papers are provided at **Attachment 2** to this Report.

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Workshop Programme

1.1 The Workshop Programme is as follows:

Discussion Topic 1: Brief introduction of wind shear, ICAO SARPs on wind shear, aircraft and pilot responses to wind shear

Discussion Topic 2: Wind shear detection systems as they relate to:

1) detection abilities for various wind shear types
   a) verification via air-reports and flight data
   b) continued improvement through user feedback forums

2) positive and negative attributes (e.g. maintainability, cost, life time)

3) air traffic management uses

4) user education

5) wind shear alert/warning phraseology - current standards (PANS-ATM, Chapter 12) and global considerations based on users and States

6) group to develop simple matrix of wind shear systems' performance as function of wind shear type

Discussion Topic 3: Wind shear detection systems acquisition process

1) steps taken by States in determining most useful wind shear system

2) group to develop consensus steps in acquisition process

Discussion Topic 4: Group to identify most suitable wind shear systems for their aerodromes

1) smaller sub-groups to discuss their unique wind shear situations (topography around aerodrome, wind shear types, etc…) at their aerodromes

2) using matrix in Topic 2 and acquisition steps developed in Topic 3, sub-groups develop list of suitable wind shear systems for their aerodromes by priority

3) members may present and discuss their findings to the whole group

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Discussion Topic 1: Brief introduction of wind shear, ICAO SARPs on wind shear, aircraft and pilot responses to wind shear

1.1 The workshop noted that approximately 1,500 fatalities occurred globally since 1943 in part from wind shear encounters and that wind shear detection systems are essential to safety as air traffic increases in tropical and mid-latitude zones susceptible to wind shear and in particular, emerging States.

1.2 ICAO Standards and Recommended Practices (SARPs) were reviewed and in particular requirements in Annex 3, Chapters 5, 7 and Appendices 3, 6 and 9 as well as Annex 11. The workshop noted the difference between wind shear warnings issued by the MET unit for typically longer duration wind shear associated with fronts or low-level jets or sometimes derived from air reports versus wind shear alerts which are generated from automated systems.

1.3 A brief definition of wind shear was followed by aircraft and pilot responses to wind shear. The three phases of the microburst: headwind, downdraft and tailwind, were noted by the group. The pilot response to the first phase (headwind) of a microburst is to reduce power and lower pitch to intercept the glide path. This configuration results in an enhanced negative aircraft performance when the downdraft is encountered because the loss of lift is greater when the angle of attack is lower.

1.4 Characteristics of a microburst were noted to have a rapid evolution in that the maximum strength generally occurs between 5 and 10 minutes after the onset of shear. Consequently, wind shear detection systems need frequent sampling and product updates below 300 meters above the aerodrome each minute. Wind shear is typically expressed in airspeed loss for easy pilot interpretation, but since ground systems mainly measure in the horizontal plane, the affect of the downdraft is not taken into consideration.

1.5 Gust front characteristics (headwind) were noted by the group and in particular the danger to aircraft in that the touch down point is further down the runway and differential lift can occur when the front intercepts the aircraft at an angle resulting in a roll to the side of the aircraft the gust front has not yet impacted (very short duration). It was also noted that gust front detection can assist forecasters in future convective development.

Discussion Topic 2: Wind shear detection systems

2.1 Detection abilities for various wind shear types and resulting matrix

2.1.1 Detection abilities for various wind shear types was formulated by the group after being briefed on the various systems being used at Hong Kong, China, Japan and the United States and their strengths and weaknesses. The group agreed that advantages and disadvantages were associated with each system (i.e. Doppler radar reliable in detecting wind shear in low clutter environment and with the presence of rain but problematic in high clutter environments with little or no rain associated with the wind shear). Therefore, depending on the wind shear types at an aerodrome, complementing systems may be necessary. Integration of systems in alerting is preferred by Air Traffic Service (ATS) and pilots. It was noted that general logic in integrating systems places emphasis on airspeed loss and system confidence (Hong Kong, China uses a hierarchy of TDWR, anemometers and LIDAR; the United States generally uses averaging with system confidence logic applied to weaker wind shear). The group also noted consistency amongst displays (e.g. Microburst denoted in red) and alerts (runway, wind shear type, strength, location, and boundary wind) which was designed to satisfy human factors and training issues.

2.1.2 The use of buoy anemometers in the Anemometer based windshear Alerting Rules – Enhanced (AWARE) system in Hong Kong, China was an interest to the group in that many aerodromes boarder a body of water resulting in expensive platforms if wind sensors are considered for wind shear detection. The group learned that a 10 second average is used for the wind estimate to dampen the impact from wave action and it was noted that the fetch of wind where the buoys are located is minimal.

2.1.3 The group noted that the scan strategy of the LIDAR can be catered to the flight path of interest such as the approach glide slope. The elevation and azimuthal motors can be synchronized to adequately measure conditions along the glide path. The use of LIDAR for obstacle wind shear was demonstrated in both Hong Kong, China (in addition to the terrain induced shear which represents 70% of all shear in Hong Kong, China) and Tokyo, Japan. The former uses high resolution sensing.

2.1.4 In terms of wind shear alerting range, the group noted that historically wind shear alerts are provided for 3 miles final to the runway for approach and the runway to 2 miles departure for departure for two reasons: 1) aircraft may not have sufficient altitude to recover from a wind shear encounter and 2) microburst strength is typically greatest below 300 m above the ground.

2.1.5 The use of wind profiler for detection of low-level jets was noted and that this system was not designed for detecting horizontal type wind shear.

2.1.6 New developments and systems were discussed such as the Radar Data Acquisition of the TDWR for improved wind shear detection particularly in dry environments in the western United States. Furthermore, microwave radiometer and shear/temperature relationship are being investigated by Hong Kong, China. Upgrade to computer processors are planned every 7 years in Japan for the TDWR (new signal processor replaced) and replacement systems at the end of the life span of approximately 15 years is being considered in Japan.

2.2 Positive and negative attributes

2.2.1 Positive and negative attributes of various systems were discussed and summarized such as maintainability, cost, lifetime, optimal siting, real-estate issues, and ownership as it relates to liability and engineering. As each aerodrome would present its own unique situation with respect to these attributes, generalizations were not formulated except that these issues be addressed by each State.

2.3 Air traffic management (ATM) applications

2.3.1 The group noted ATM applications of wind shear detection systems which have derivative products such as the wind shift prediction issued for runway configuration changes which assists in saving time and fuel by finding a gap in traffic upstream which optimizes the time of configuration change. In addition, an accurate configuration change time allows aircraft to taxi to the other end of the runway in anticipation of the change.

2.3.2 Ten and twenty-minute prediction of moderate precipitation (level 3) allows ATM to estimate the time of reduced airport capacity and adjust upstream traffic accordingly and coordinate with approach and enroute when necessary. Arrival gate impacts can be dealt with by using other arrival gates when necessary. At times, significant approach/aerodrome impacts may warrant ground stops which are less expensive than delays in the air. Furthermore, timing the increase in capacity at the end of an event assists in reducing unnecessary delays. The Integrated Terminal Weather System (ITWS) Terminal Convective Weather Forecast (TCWF) provides moderate/high probability of moderate precipitation (level 3) up to 1 hour in advance which allows for broader planning between tower, approach and enroute and at times the national coordination centre. Use of alternate aerodromes and airline strategies such as aircraft placement are sometimes warranted.

2.3.3 The ITWS Terminal Winds product uses wind information in the terminal area (numerical models, Doppler, sensors, aircraft reports) to provide wind estimates at various altitudes for select air traffic locations such as arrival gates and outer markers. Anomalies in wind at arrival gates allow ATM to optimize flow by utilizing other arrival gates. Furthermore, knowing the wind at various altitudes in the presence of a low-level jet allows for proactive planning in spacing aircraft upstream to maintain spacing on final where spacing compression occurs from downwind to base and base to final.

2.3.4 The group also noted that PANS-ATM requirements for operations in wind shear conditions such as the suspension of simultaneous approaches for closely spaced parallel runways and selection of runways for noise abatement, the former resulting in capacity reduction. Wind prediction can also assist in satisfying PANS-ATM requirements in reporting significant changes in mean surface wind (change of 10kt, 2kt and 5kt for head, tail and cross wind) at start of final approach and of suspending noise abatement selection when crosswind and tailwind components exceed thresholds of 15kt and 5kt, respectively.

2.3.5 ATM stressed the need for situational awareness and in particular the need for pilots to have the same information as ATM and controllers. It was noted that the Terminal Weather Information for Pilots (TWIP) uplinks TDWR and ITWS wind shear information in text form to pilots for some airlines.

2.4 User education

2.4.1 The group acknowledged the importance of consulting the user in the acquisition process in order to establish requirements and meet user needs. Furthermore, Hong Kong, China demonstrated user interaction with reference to wind shear detection systems and their improvements for the last 10 years by meeting with the user group (consists of but not exclusive to: MET service, ATC, Airport Standards, Flight Standards, airlines, and pilots) twice per year to obtain user feedback on these systems. Also noted was the importance of two way communications in explaining the various wind shear phenomena that exists and their scales, which explains in part the discrepancies sometimes observed between wind shear detection and aircraft reports of wind shear. It was also noted that aircraft reports by pilots are subjective and do not represent a completely accurate truth dataset, but are nevertheless important to the overall analysis that uses aircraft reports as well as other wind sensors. Continued education through wind shear posters, booklets and briefings was noted by the group to be essential in maintaining user confidence and important in obtaining funding for wind shear detection systems and continued improvements.

2.5 Validation

2.5.1 The group noted that validation of wind shear detection systems include pilot reports and use of other weather systems in the terminal area. Since microbursts are not typically sampled by aircraft (avoidance policy), many cases need to be validated by an analyst that considers all available data in formulating the truth. Thai Airways noted that pilot reports are typically given when ATC requests them.

2.5.2 India informed the group that only .03% of aircraft report wind shear resulting in approximately 200 wind shear reports over a several year period in Chennai. This was attributed to possible oversight or routine phenomenon that pilots are used to and therefore do not report (adjustments to trim, power and configuration is typically more gradual and not as noticeable in a vertical wind shear event and may not warranting a wind shear report). Hong Kong, China reported a .14% rate of wind shear reports. Therefore, the group suggested the use of automated reports (AMDAR) as a contributor to the validation process. Other wind sensors in the area can be used to develop a best guess of the truth noting that aircraft reports by the pilot are subjective.

2.6 Wind shear alert/warning phraseology – current standards and global considerations

2.6.1 The group noted the efforts underway by the ICAO Meteorological Warnings Study Group (METWSG) in formulating an agreed upon wind shear phraseology for inclusion in PANS-ATM. Discrepancies between States (such as first encounter, maximum shear intensity reporting versus generic terms of approach and departure) and possible use of terms forecast and reported are being addressed by the METWSG. IFATCA expressed interest in involving ATS in that they are the medium of conveying wind shear information to pilots and information should not be complicated or conflicting. The group noted that this issue will be raised by the METWSG to the users and States which involves a risk assessment and training impacts associated with the proposed changes.

2.7 Group to develop simple matrix of wind shear systems' performance as function of wind shear type

2.7.1 Given the above discussions, the group developed a draft matrix of wind shear systems' performance as a function of wind shear type for further examination by their State.

Discussion Topic 3: Wind shear detection systems acquisition process

3.1 Steps taken by States in determining most useful wind shear system

3.1.1 The group noted the process of determining the most suitable wind shear system by recent events presented by Australia. This followed a B747 wind shear incident that occurred 15 April 2007 on short final to 16R at Sydney International Airport where a 28 knot loss resulted in hard bounces on 16R before a successful go-around occurred (some damage occurred to the aircraft such as fallen ceiling tiles). The dry microburst was captured by the wind sensors at the aerodrome on northern end of 16R.

3.1.2 This incident resulted in a detailed study on options for an automated wind shear alert system, including: technology options, procurement-implementation issues, integration issues, stakeholders, climatology, sensor siting issues and functional requirements. The location of the Airport in an urban environment and on the shore of Botany Bay makes it a very challenging site. Acquisition of sufficient LLWAS anemometer sites to provide full protection for the airport will be very challenging. The existing Doppler weather radar is well placed to provide coverage for the main north-south runways although it is not optimal for events at 3 MF on the north approach or events on the east-west runway. Ground clutter in the radar signal arising from the urban environment, the Harbour area and the central business district will be challenging to overcome, particularly for the detection of dry microburst events. A general estimate of system performance noted that most systems may not meet the system requirements of at least 90% detection for wind shear events and less than 10% false alarms and a combined system may be needed (due to the mix of dry and wet wind shear, siting and clutter issues). Note that one system that met requirements was associated with significant siting risks. Lastly, ownership has not yet been determined.

3.2 Group to develop consensus steps in acquisition process

3.2.1 The group determined the following steps are necessary in determining the most useful wind shear detection system(s) for their aerodrome(s):

- Determine wind shear types, locations, times and frequency at aerodromes
    - Through AT log of aircraft reports
    - MET analysis of logs to determine causes of wind shear and any trends such as prevailing wind over terrain that produces terrain induced wind shear

- Determine system requirements
- Determine ownership
  - Considering liability and maintenance
- Use matrix of wind shear system performance for first guess selection to meet system requirements
- Develop attributes and risk associated for each of these possible wind shear detection systems
  - Cost
  - Siting
    - Environmental risks
    - Clutter issues
    - Easy access
    - Real-estate issues
    - Security
  - Maintenance issues
  - Lifetime
- Consider ATM uses of derivative products

3.2.2 Cost considerations were not exclusive to the purchasing a system alone, but taking into consideration land acquisition where applicable, which may involve many site locations for wind sensors or multiple systems. Furthermore, maintenance cost for the lifetime should be considered and comparisons with other States should be done with caution since manpower expenses can vary significantly.

3.2.3 Ownership of systems was discussed and the group determined that States should examine ownership in view of efficiency for the State. Therefore, one State may have ownership of wind shear systems in a different section of government than another. Nevertheless, the group agreed that the requirements should be developed within the Civil Aviation Authority of the State.

3.2.4 Other systems were discussed such as X-band and Phased Array Radar in that the former is in the process of being validated by Hong Kong, China and the United States. The latter maybe engineered to meet various requirements from various sectors of government.

3.2.5 To assist in the acquisition process, the ICAO Regional Officer, Technical Co-operation, provided the group with information on ICAO's Civil Aviation Purchasing Service (CAPS) that assist States in the procurement of services and equipment. Under CAPS, which is essentially a type of Trust Fund arrangement, there is the flexibility to offer the options of either a complete procurement service (i.e. from specification of equipment through to its commissioning) or with any specific stage(s) of a procurement process. The assistance can be provided in both the administrative aspects of procurement (e.g. preparation and invitation of tenders, evaluation of the tenders and supervision of contract awarded etc...) and the technical aspects (e.g. preparation of detailed technical specifications and detailed systems design, site and equipment inspections, acceptance and commissioning inspections etc...). The service is provided on cost recovery of direct costs where these are incurred by ICAO, plus a modest administrative overhead charge based on the total value of the procurement. The costs of each stage is developed and quoted to the CAPS Member once the tasks required of ICAO are clearly defined. Registration for CAPS with ICAO is performed by completing the CAPS Registration Form and MOU (sample circulated during the meeting). There is no cost involved in registering under the scheme. In cases where utilization of CAPS may not be contemplated within the near future registration and subsequent acceptance by ICAO will ensure that the Service may be utilized at short notice when the need arises.

Discussion Topic 4: Group to identify most suitable wind shear systems for their aerodromes

4.1 Once predominant wind shear types have been determined for aerodromes in a State, each State used the matrix of wind shear system performance for the various wind shear types and steps in the acquisition process and began to develop a draft of wind shear detection system(s) suitable to meet their safety needs.

4.2 The group agreed that even after implementation of systems, ongoing verification and safety warrant periodic analysis and improvements to the wind shear detection configuration at their aerodromes. With the importance of Air Traffic Management efficiency needs, States should also consider deploying systems that meet the safety needs of detecting wind shear reliably and providing ATM with the necessary information to increase efficiency of the airspace in the terminal area and beyond.

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ATTACHMENT 1

International Civil Aviation Organization

ASIA/PACIFIC WIND SHEAR SYSTEMS ACQUISITION WORKSHOP

Bangkok, Thailand, 1 – 3 December 2010

LIST OF PARTICIPANTS

STATE/ORGANIZATION/NAME	DESIGNATION/ADDRESS	TEL/FAX/E-MAIL
AUSTRALIA (1)		
Mr. Rodney Potts	Centre for Australian Weather and Climate Research GPO Box 1289 Melbourne VIC 3001 **AUSTRALIA**	Tel: Fax: E-mail: R.Potts@bom.gov.au
BRUNEI DARUSSALAM (2)		
Ms. Rokiah Haji Angas	Meteorological Officer Brunei Meteorological Service Department of Civil Aviation Ministry of Communications BB2513 **BRUNEI DARUSSALAM**	Tel: +673 (2) 381 342 Fax: +673 (2) 343 134 E-mail: rokiah.angas@civil-aviation.gov.bn
Ms. Marzeti Haji Mahadi	Meteorological Officer Brunei Meteorological Service Department of Civil Aviation Ministry of Communications BB2513 **BRUNEI DARUSSALAM**	Tel: +673 (2) 381 342 Fax: +673 (2) 343 134 E-mail: marzeti@yahoo.co.uk
HONG KONG, CHINA (1)		
Mr. P.W. Chan	Senior Scientific Officer Hong Kong Observatory 134A Nathan Road Kowloon **HONG KONG, CHINA**	Tel: +852 2926 8435 Fax: E-mail: pwchan@hko.gov.hk
FRANCE (1)		
Mr. Gérard Bossaron	Deputy Manager Meteo France/DIRPF BP 6005 98702 FAA'A – Tahiti **FRENCH POLYNESIA**	Tel: +689 803 303 Fax: +689 803 309 E-mail: gerard.bossaron@meteo.fr
INDIA (2)		
Mr. S. Chadha	Joint General Manager (ATM) Corporate Hqrs. Airports Authority of India Rajiv Gandhi Bhavan Safdarjung Airport New Delhi 110003 **INDIA**	Tel: +91 (11) 2462 9012 Fax: E-mail: schaddha@aai.aero

STATE/ORGANIZATION/NAME	DESIGNATION/ADDRESS	TEL/FAX/E-MAIL
Dr. R. Suresh	Scientist Aerodrome Meteorological Office Meenambakkam India Meteorological Department Chennai – 600027 **INDIA**	Tel: +91 (44) 2256 1636 Fax: +91 (44) 2256 0790 E-mail: suresh.imd@gmail.com rsuresh.imd@rediffmail.com
INDONESIA (6)		
Mr. Tri Samyo Rumidi	Chief of Aeronautical Meteorology Division Indonesia Meteorological, Climatological and Geophysical Agency Jalan Angkasa I, No. 2, Kemayoran Jakarta Pusat 10720 **INDONESIA**	Tel: +62 (21) 424 6321 Ext. 8405 Fax: +62 (21) 654 6315 E-mail: meteo.penerbangan@bmg.go.id
Mr. Zulkarnain	Aeronautical Meteorology Forecaster Indonesia Meteorological, Climatological and Geophysical Agency Jalan Angkasa I, No. 2, Kemayoran Jakarta Pusat 10720 **INDONESIA**	Tel: +62 (21) 654 6318 Fax: +62 (21) 654 6315 E-mail: cillo_85@yahoo.com
Mr. Edwin Arif Wibowo		Tel: Fax: E-mail:
Mr. A. Budi Fathoni		Tel: Fax: E-mail:
Ms. Suyanti Aviany		Tel: Fax: E-mail:
Mr. Eko Wit Jaksono		Tel: Fax: E-mail:
JAPAN (1)		
Mr. Hiroki Sekino	Senior Scientific Officer Office of Aviation Weather Observations Observations Division Observations Department Japan Meteorological Agency (JMA) 1-3-4 Otemachi, Chiyoda-ku, Tokyo **JAPAN**	Tel: + Fax: + E-mail: sekino@met.kishou.go.jp
LAO PDR (4)		
Mr. Bounthueng Soumontha	Deputy Director of Telecommunication Division Department of Civil Aviation	Tel: +856 (21) 512 163 Fax: +856 (21) 520 237 E-mail: b_soumontha@yahoo.com

STATE/ORGANIZATION/NAME	DESIGNATION/ADDRESS	TEL/FAX/E-MAIL
Mr. Buonlieng Syphaxay	Deputy Chief of Air Traffic Management Lao Air Traffic Management (LMAT) Vientiane **LAO PDR**	Tel: +856 (21) 512 006 Fax: +856 (21) 512 216 E-mail: buonliengsyphaxay@yahoo.com
Mr. Somboon Pongkhamsao	Department of Meteorology and Hydrology Avnue Souphanouvong Ban Akard Sikhotabong District Vientiane **LAO PDR**	Tel: +856 2126 3657 Fax: +856 2151 2216 E-mail: pongkhamsao@yahoo.com
Mr. Soulin Ditphavong	Dispatcher Lao Airlines	Tel: +856 (21) 512 195 Fax: +856 (21) 512 002 E-mail: soulindpv@yahoo.com
MALAYSIA (1)		
Mr. Jenal Hamizun	Assistant Director Malaysia Department of Civil Aviation Regional Office Block A, Kuala Lumpur Air Traffic Control Centre Sultan Abdul Aziz Shah Airport 47200 Subang, Selangor **MALAYSIA**	Tel: +603 7846 5233 Fax: +603 7846 4376 E-mail: hamizun@dca.gov.my
MONGOLIA (2)		
Mr. Tserendorj Bodigerel	Researcher Aviation Meteorological Center of Mongolia Khan-uul District Ulaanbaatar 17120 **MONGOLIA**	Tel: +976 (11) 325 622, 283 235 Fax: +976 (11) 325 622 E-mail: tserendorj.b@aviationweather.com
Mr. Enkhbold Janchiv	Researcher Aviation Meteorological Center of Mongolia Khan-uul District Ulaanbaatar 17120 **MONGOLIA**	Tel: +976 (11) 325 622, 283 235 Fax: +976 (11) 325 622 E-mail: enkhbold.j@aviationweather.com
PHILIPPINES (1)		
Mr. Angelito T. Moncerate	Supervising A.T.C./Acting Chief Manila Control Tower #55 Pitacaion Street Elysian Sub-division Marulas, Valenzuela City **PHILIPPINES**	Tel: +63 (2) 8799203 Fax: +63 (2) 8799 203 E-mail: limoncerate@yahoo.com
REPUBLIC OF KOREA (4)		
Mr. Jae Soo Chang	Assistant Director ATM Division Civil Aviation Office Ministry of Land, Transport and Maritime Affairs 1-8 Byeoryang-dong Gwacheon-si Gyeonggi-do 427-822 **REPUBLIC OF KOREA**	Tel: +82 (2) 2669 6422 Fax: +82 (2) 6342 7289 E-mail: atcchang@korea.kr

STATE/ORGANIZATION/NAME	DESIGNATION/ADDRESS	TEL/FAX/E-MAIL
Mr. Jin Won Kim	Forecaster Korea Aviation Meteorological Agency 2172-1 Woosneo-dong Joong-ku Incheon City **REPUBLIC OF KOREA**	Tel: +82 (32) 740 2800 Fax: +82 (32) 740 2817 E-mail: Kjw21@korea.kr
Mr. Ho Jin Kim	Manager Korean Air Operations Control Center Building A, 8th Floor Korean Air O.C 1370 Gonghang-dong, Gangseo-gu 152-712 Seoul **REPUBLIC OF KOREA**	Tel: +82 (2) 2656 6045 Fax: +82 (2) 2656 6086 E-mail: kimhojin@koreanair.com
Mr. Min Ku Kang	Senior Specialist Korean Air Bangkok Airport Office 999 Suvarnbhumi Airport Passenger Terminal, 2nd Floor Room No. G2-091C Moo 1, Nongprue Bangplee, Samutprakarn 10540 **THAILAND**	Tel: +66 (2) 134 7617 Fax: +66 (2) 134 2220 E-mail: minkkang@koreanair.com
SINGAPORE (2)		
Mr. Chieng Hai Ang	Head, Systems & Communications Singapore/National Environment Agency Meteorological Services Division P.O. Box 8, Singapore Changi Airport Singapore 918141 **SINGAPORE**	Tel: +65 6542 8358 Fax: +65 6545 7192 E-mail: ang_chieng_hai@nea.gov.sg
Mr. Wee Poh Goh	Meteorological Officer Head, Systems & Communications Singapore/National Environment Agency Meteorological Services Division P.O. Box 8, Singapore Changi Airport Singapore 918141 **SINGAPORE**	Tel: +65 6542 5059 Fax: +65 6545 7192 E-mail: goh_wee_poh@nea.gov.sg
THAILAND (11)		
Dr. Manop Chitcharus	Aeromedical Advisor 1579/1 Bangkok-Nonthaburi Road Bangsue Bangkok 10800 **THAILAND**	Tel: +66 (2) 286 3374 Fax: +66 (2) 289 2913 E-mail: manop_chitcharus@hotmail.com
Mr. Wiwat Ngamwinijsagul	Aviation Safety Inspector Department of Civil Aviation Flight Standards Bureau 71 Soi Ngarmduplee, Rama IV Road Bangkok 10120 **THAILAND**	Tel: +66 (2) 287 3198 Fax: +66 (2) 286 2925 E-mail: wiwat.n@aviation.go.th

STATE/ORGANIZATION/NAME	DESIGNATION/ADDRESS	TEL/FAX/E-MAIL
Mr. Auttapon Wijitphan	Aviation Safety Inspector Department of Civil Aviation Flight Standards Bureau 71 Soi Ngarmduplee, Rama IV Road Bangkok 10120 **THAILAND**	Tel: +66 (2) 287 3198 Fax: +66 (2) 286 2925 E-mail: auttapon.w@aviation.go.th
Mr. Somchai Yimsricharoenkit	Director, Aeronautical Weather Forecast Div. Bureau of Aeronautical Meteorology 6th Floor, ATC Complex Suvarnabhumi International Airport Rachathewa, Bang Pli Samut Prakarn 10540 **THAILAND**	Tel: +66 (2) 134 0011-14 Ext. 214 Fax: +66 (2) 134 0009-10 E-mail: somchai_yim@tmd.go.th
Mr. Nattawut Dandee	Meteorologist Aeronautical Meteorology Forecast Division Bureau of Aeronautical Meteorology Thai Meteorological Department 6th Floor, ATC Complex Suvarnabhumi International Airport Bang Pli, Samut Prakarn 10540 **THAILAND**	Tel: +66 (2) 134 0006-7 Fax: +66 (2) 134 0009-10 E-mail: wdee1616@hotmail.com
Mr. Nipon Juthong	Meteorological Observer Aeronautical Meteorology Forecast Division Bureau of Aeronautical Meteorology Thai Meteorological Department 6th Floor, ATC Complex Suvarnabhumi International Airport Bang Pli, Samut Prakarn 10540 **THAILAND**	Tel: +66 (2) 134 0011-14 Ext. 214 Fax: +66 (2) 134 0009-10 E-mail: njvtbd@hotmail.com
Capt. Piroj Doungprasert	Deputy Director, Regional Flight Deck Crew Training Department Thai Airways International Public Co., Ltd. 89 Vibhavadee Rangsit Road Ladyao, Chatuchak Bangkok 10900 **THAILAND**	Tel: +66 (2) 545 2602 Fax: +66 (2) 545 3787 E-mail: piroj.d@thaiairways.com
Capt. Pachon Thanasumitr	Manager, Operations Specification Division Thai Airways International Public Co., Ltd. 89 Vibhavadee Rangsit Road Ladyao, Chatuchak Bangkok 10900 **THAILAND**	Tel: +66 (2) 545 2665 Fax: +66 (2) 545 3849 E-mail: pachon.t@thaiairways.com
Capt. Pichet Nilasena	A340-500/600 Simulator Instructor Thai Airways International Public Co., Ltd. 89 Vibhavadee Rangsit Road Ladyao, Chatuchak Bangkok 10900 **THAILAND**	Tel: +66 (2) 545 2828 Fax: +66 (2) 545 3850 E-mail: pichet_teh@hotmail.com

STATE/ORGANIZATION/NAME	DESIGNATION/ADDRESS	TEL/FAX/E-MAIL
Capt. Rittee Saengmay	Aircraft Engineer Thai Airways International Public Co., Ltd. 333/2, M.1 Nongprue Sub-district Bangphli Samutprakarn 10540 **THAILAND**	Tel: +66 (2) 137 6206 Fax: +66 (2) 137 6940 E-mail: rittee.s@thaiairways.com
Ms. Rangsiya Ocharoen	Aircraft Engineer Thai Airways International Public Co., Ltd. 333/2, M.1 Nongprue Sub-district Bangphli Samutprakarn 10540 **THAILAND**	Tel: +66 (2) 137 5118 Fax: +66 (2) 137 6910 E-mail: rangsiya.o@thaiairways.com
IFATCA (1)		
Mr. John Wagstaff	IFATCA Representative International Federation of Air Traffic Controllers Associations Air Traffic Management Division ATC Complex 1 Control Tower Road Hong Kong International Airport **HONG KONG, CHINA**	Tel: +852 2910 6453 Fax: E-mail: joh.wags@gmail.com
ICAO (1)		
Mr. Christopher F. Keohan	Regional Officer MET International Civil Aviation Organization 252/1, Vibhavadee Rangsit Road Ladyao, Chatuchak Bangkok 10900 **THAILAND**	Tel: +66 (2) 537 8189 Ext. 153 Fax: +66 (2) 537 8199 E-mail: ckeohan@bangkok.icao.int

International Civil Aviation Organization

ASIA/PACIFIC WIND SHEAR SYSTEMS ACQUISITION WORKSHOP

Bangkok, Thailand, 1 – 3 December 2010

LIST OF PRESENTATIONS

SP No.	Subject	Presented by
SP/1	ICAO APAC Wind Shear Systems Workshop	Secretariat
SP/2	Wind Shear and Turbulence Alerting Services	Hong Kong, China
SP/3	Wind Shear Detecting Systems in Japan	Japan
SP/4	ICAO APAC Wind Shear Systems Workshop	Australia
SP/5	Doppler Weather Radar (DWR) for Low Level Wind Shear (LLWS) Detection – Necessity of Aircraft Reports and Feedback	India
SP/6	ICAO Civil Aviation Purchasing Service	Secretariat

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