Challenges and Opportunities in Search-and-Rescue Operations, post-MH370/MH17

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Summary

2014 has been a defining year for the civilian aviation industry with the tragic fates of Malaysian Airline flights MH17 and MH370. The loss of MH370 and the shooting down of MH17 have been "black swans" that caught everybody by surprise and have shocked people all over the globe. That a modern, technologically sophisticated passenger jet could simply disappear without a trace or any workable clue was a shock that has gripped the world.

This paper provides recommendations covering challenges and opportunities in civil aviation and search-and-rescue operations, post-MH370/MH17 covering

- Legal Framework and Governance of civil aviation,
- Technology and
- Standard Operating Procedures.

New available technologies and new concepts of operations need to be integrated timely. Issues such as coordination and interoperability, situational awareness, knowledge management and collaboration have come to the fore. The challenge as well as the opportunity has become to foster a holistic and comprehensive approach that applies modern (particularly information and communication) technologies and serves people and societies, business, international organisations and governments in a well-balanced fashion. Voluntary standards adopted by the airline industry have the potential to accelerate the development.

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Analysis

Tragic Fates

2014 has been a defining year for the civilian aviation industry with the tragic fates of Malaysian Airline flights MH17 and MH370. The loss of MH370 and the shooting down of MH17 have been "black swans" that caught everybody by surprise and have shocked people all over the globe. That a modern, technologically sophisticated passenger jet could simply disappear without a trace or any workable clue was a shock that has gripped the world. Governments, airlines and customers have been raising concerns about passengers' safety. Consequences need to be and have been drawn.

The disappearance of MH370 on March 8, 2014 has led to the largest search in aviation history, involving 26 countries pooling their resources in SAR efforts and spanning half the globe. Obviously the plane flew directly above the Straits of Malacca and then turned again and travelled south over water for about seven hours before crashing in the Indian Ocean. It avoided flying over land and flew along a route apparently designed to prevent it being detected by military radars.

An air search was called off after several hundred flights failed to find floating wreckage. Since then an unmanned submarine has continued the search for the remains of MH370. Refined analysis of the satellite data has led to the establishing of a "Priority Search Area". The latest calculations suggest MH370 changed course earlier than previously thought, allowing it to fly further south before losing "fuel autonomy" and crashing in the sea. Survey vessels have been mapping the ocean floor in the area, which is up to 6,000m deep. A new search with ships and unmanned submarines has started in early October 2014.

The investigation report from April 8, 2014 on the disappearance of MH370[1]

- states that air traffic controllers did not realise that Malaysia Airlines Flight 370 was missing until 17 minutes after it disappeared from civilian radar;
- confirms there was a four-hour gap between the plane's disappearance from air traffic control screens and the activation of a rescue operation;
- states that the plane's unexpected westward turn was observed by the Malaysian military;
- details the attempts by authorities in Malaysia, Vietnam and Cambodia to locate the plane, which had its communications system disabled about 40 minutes after take-off.

On July 17 MH17 became the first passenger plane to be shot down at cruise altitude. Three days before Ukrainian officials had released a "*notice to airmen*" which instructed pilots to increase their altitude to a minimum of 32,000 ft. The Dutch preliminary investigation report stated that the airplane was shot down over Eastern Ukraine with a surface to air missile. It notes in detail:

"… no indications of any technical or operational issues were found with the aircraft or crew prior to the ending of the CVR and FDR recording at 13.20:03 hrs.

[1] Ministry of Malaysia. „MH370 Preliminary Report". Serial 03/2014. http://www.thestar.com.my/News/Nation/2014/05/01/mh370-prelim-report-cockpit-tower-recordings-released/ (accessed: 10 October 2014)

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The damage observed in the forward section of the aircraft appears to indicate that the aircraft was penetrated by a large number of high-energy objects from outside the aircraft. It is likely that this damage resulted in a loss of structural integrity of the aircraft, leading to an in-flight break-up." [2]

Malaysian Airlines flight MH17 was shot down at 33,000ft. This is clearly beyond the range of man portable air defence systems such as the SA 18/24 IGLA, which have previously formed the backbone of separatist anti aircraft firepower. Everything points at the SA 11 "BUK" surface to air missile as likely employed weapon system as it is the only system known to have been deployed in the Donetsk area capable of destroying aircraft at 33,000ft. Reports that separatists had obtained this system started appearing three days before MH17 was shot down. It is likely to have been responsible for shooting down a Ukrainian AN-26 military transport aircraft on 14 July.

The shrapnel damage observed on the wreckage of MH17[3] looks exactly like what could be expected after an SA 11 warhead interception. An alternative option such as air-to-air missiles like the R 60/AA 8 or the R 73/AA 11 which can be carried by attack jets such as the Su-25 – which the Russian Ministry of Defence has implied was involved in the incident – cause significantly different damages as the Su-25 feature a 'continuous rod' warhead. This warhead inflicts deep 'cut' damage patterns. Also an infrared (heat) seeking missile could have been used, but this would have detonated near the engine pods on MH17, opposed to the shrapnel damage found near the cockpit. Anyhow, the Su-25 has a service ceiling of roughly 10,000ft below the altitude MH17 was flying.

Black Boxes and Aircraft Tracking

The first question that comes to mind in looking at the loss of MH370 is: Why wasn`t MH370 properly tracked? And then: What about the black box? Why don`t we find it? In the case of an aircraft incident or accident, public expectations have been particularly centred on the "black box".[4] Actually the black box is in reality two boxes, i.e. the cockpit voice recorders (CVRs) and digital flight data recorders (DFDRs). And actually, these two boxes are orange. They are designed to survive high impact, fire, seawater and as many as possible types of catastrophe.

However,

- Sometimes the boxes are never found (i.e. from the two aircraft that hit the World Trade Center on 9/11) or only years later (i.e. from Air France Flight 447 2 years after it disappeared over the Atlantic Ocean in June 2009).
- In many accidents the data are – due to severe damage – not retrievable.
- The locator beacon has a relatively brief life expectancy of roughly 30 days.

[2] Dutch Safety Board. "Preliminary report Crash involving Malaysia Airlines Boeing 777-200 flight MH17". Hrabove, Ukraine. 17 July 2014. Pg. 30. http://www.skybrary.aero/bookshelf/books/2875.pdf (accessed: 10 October 2014)
[3] Bronk, Justin. "Examining the Evidence of the MH17 Crash". RUSI Analysis, 23 Jul 2014. https://www.rusi.org/analysis/commentary/ref:C53CFE6CDCAB2F/#.VD508974dd0 (accessed: 10 October 2014)
[4] Adler, Jerry. "Banish the Black Box: There's a Better Way to Capture Plane Crash Data". Wired 19 July 2014. http://www.wired.com/2011/06/ff_blackboxes/ (accessed: 10 October 2014)

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Consequently, technological solutions have been discussed that do not rely on recovering data from accident scenes, but would rather transmit data continuously. Actually multiple layers and capabilities for tracking aircraft already exist – from position reporting by the pilot to sophisticated satellite-based systems. Some aircraft have been equipped with the most advanced technologies. There are also aircraft that are not so well equipped. All of these must interact with air navigation service providers. And also these have – in line with market needs – a range of capabilities from ultra-sophisticated in high-density airspace to more basic operations.

Generally, it comes as a surprise that the aviation industry has no tracking capabilities implemented as a standard. Networked capabilities and situational awareness have long conquered our private homes and cars, public and commercial entities such as police and military, banking, production and logistics, social networks and cyber space. Today people are used to tracking packages and friends via smartphones. Yet, up to now there is no clear cut-tracking requirement of civil aircraft.

Airspace is principally controlled[5] through the use of two types of surveillance radars:

- Primary Surveillance Radar (PSR) – it provides an active scan of the airspace. This is the radar that actually "paints" the aircraft with radar energy. It is considered non-cooperative meaning the system functions independently of the aircraft and its crew. Non-cooperative systems can provide real time location information of aircraft in flight.
- Secondary Surveillance Radar (SSR) – it is essentially a transponder interrogator. It sends out a coded signal, which the transponder on-board the aircraft receives, interprets, and responds with a coded signal of its own. Because of this two-way interaction SSR systems are considered cooperative systems.

Future cooperative systems – i.e. WAM or ADS-B – will provide more options and details than current systems but will likely be susceptible to the same limitations as current systems.

- Wide-area multilateration (WAM) is a surveillance technique that exploits the 1090 MHz transmissions from aircraft. From these signals it can create a track containing parameters such as identity, position, height, etc. Active interrogation is also possible in order to trigger transmission.
- The Automatic Dependent Surveillance Broadcast (ADS-B) is a satellite-based successor to SSR radar. It is a surveillance technique that relies on aircraft broadcasting their identity, position and other information derived from on board systems. In the U.S. aircraft operating in areas currently requiring a transponder will be required to have ADS-B no later than January 1, 2020. In addition to ADS-B, NextGen also includes Data Communications. Data Communications will be also mandatory for all commercial airlines.

To track all aircraft in all phases of flight, substantial technological upgrades are required. These upgrades (or changes to planned upgrades) can be expensive for commercial airlines. As a specific example, American Airlines has estimated that it will cost an average of $2,500,000 per aircraft to upgrade their fleet with NextGen technology. Despite the same issues (i.e. aircrew turning off transponder and delayed ability or

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inability to identify a specific aircraft) following the U.S. attacks on September 11, 2001, there was no mandate for an inaccessible transponder.

The MH370 investigation report recommends that the International Civil Aviation Organisation consider measures to ensure commercial planes are tracked in real time, citing the disappearance of an Air France flight in 2009 that crashed in the Atlantic Ocean on its way to Brazil and was only found in 2011. The need for streaming data – basic flight parameters, downlinked at a high rate via satellite links during an emergency – was a key lesson learned in the 23-month search for AF447's flight data and cockpit voice recorders, where the search zone was a 40-nm radius around the final transmitted position. For MH370, the search zone is now 17,500sq.nm.

Both MH370 and AF447 were ADS-C-equipped. Automatic Dependent Surveillance (ADS) is a specific application on top of the Aircraft Communications Addressing and Reporting System (ACARS), which transmits non-voice messages to and from the ground. It is essentially reporting – either automatically or on request – the position of the aircraft. The C in application ADS-C stands for "contract" – as it sends the position reports to a specific station that needs to *ask for reports*.

In the MH370's case, the aircraft was under radar control when it dropped from radar screens, negating the need for remote position reporting. As it appears, both of the 777's transponders stopped transmitting radio-frequency signals. This can only be caused by manual disengagement or catastrophic failure. Yet the aircraft's ACARS continued operating after the transponders shut down. So it remains unclear exactly which communication channels remained open, and for how long.

Clearly, the MH370 incident shows that there is a tracking requirement of civil aircraft in flight that cannot be interrupted by anybody on board. There should be a re-examination of how the airline industry monitors its aircraft and with whom and under what circumstances data should be shared. Tracking would provide for both, increased safety and security in airspace and locating a downed airliner with a much greater degree of accuracy, which would significantly enhance the timely search for possible survivors.

Obviously today´s dynamic innovation cycles do outperform the regulatory framework governing air traffic. To a degree it needs to be slow, because one flawed decision can lead to the loss of aircraft in flight and result in many lives lost. Yet, not meeting innovation requirements may also turn out to be a flawed decision. There is room for improvement.

Improving Situational Awareness

Looking at the shooting of MH17: Why didn´t airlines and civil aviation authorities have a relevant situational awareness? In the case of MH 17 airlines were instructed by the Ukraine in a "notice to airmen" that pilots should increase their altitude to a minimum of 32,000 ft. Today it is clear how insufficient and even misleading that guidance was. Within the aviation industry, there is no overarching regulatory body to declare routes unsafe to fly. Currently it is up to individual countries to release warnings about their airspace, such as the Ukrainian officials released prior to the shooting of MH17. With dangerous weaponry having been plundered

[5] CAPT Kopplin, Shannon H. Mail-exchange in September/October 2014 on cooperative and non-cooperative systems, U.S. adoption of NextGen technology and Chicago Convention

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in recent years across Iraq, Syria and Libya, and in Eastern Ukraine, civilian airlines have been facing a growing risk. It is an illusion to expect always-valid information from fragile states. Consequently, Situational Awareness needs to become a focus area in civil aviation.

The International Civil Aviation Organisation, which is setting global aviation standards, has been urged to take a bigger role in regulating routes for civilian aircrafts.[6] As only a few airlines have access to national security information needed to support decisions in such circumstances. ICAO as a member of the Task Force on Risks to Civil Aviation Arising in Conflict is working to identify exactly the kind of information needed, when it is needed and how best it can be provided. There are also suggestions that a new body could be formed to pool and distribute intelligence to airlines.

Already in the past the intelligence services have been cooperating closely with the airlines and airports in order to identify possible terrorists. The "liquid bomb" threat was communicated this way. This is why the plastic bag was introduced and the restrictions of the amount of liquid. In future, the services should also work closely with airlines to identify threats of terrorist groups that are not on board.

A culture of "Need to Share" should be developed for example among airlines sharing their risk assessments as well as among airlines and national respectively regional intelligence organizations. Also the development of a stronger relationship between the regional air traffic control authorities and the regional intelligence would enhance the knowledge base for responsible decision-making. In the Eastern Ukraine Security agencies from many different countries have been watching developments. British Airways (BA) for example has profited from a close working relationship with the British intelligence services. Consequently, BA was among the few airlines that had stopped flying over eastern Ukraine already in March 2014, assessing that it was no longer safe to continue flying over the area. Whether Lufthansa or Air Berlin have been closely cooperating with the German Intelligence Service may be doubted. As services don`t like direct exposure the coordination of information could run via the respective Ministries of Transport.

Obviously aviation safety continues to suffer from inconsistent standards. Different tactics are still apparent within the civilian aviation industry. Particularly on the issue of cost frictions between regulators and the aviation industry continue. Since MH17 was shot down, airlines have adopted a principally more cautious approach. They now avoid flying over conflict zones, even if this means following a lengthier and more costly alternative route. The industry is counting on the International Civil Aviation Organization (ICAO) to mandate necessary upgrades.

ICAO, EASA and IATA

The controlling international legal framework for aviation is the Chicago Convention on Civil Aviation. This multilateral treaty established the International Civil Aviation Organization (ICAO), a specialized UN agency with more than 190 members. These comprise practically all UN member states with commercial airlines. ICAO

[6] Tyler, Tony. „Remarks at the ABA Air & Space Law Annual Forum", IATA. 19 September 2014, Montreal. http://www.iata.org/pressroom/speeches/Pages/2014-09-19-01.aspx (accessed: 10 October 2014)

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has procedures for review and amendment of technical annexes governing international air travel. Given over 190 State Parties, consensus can be difficult to obtain.

In the aftermath of the loss of MH370 the International Civil Aviation Organization (ICAO) has recently reached consensus with the airline industry and various other key stakeholders that changes have become necessary. This includes improved Global Flight Tracking[7], i.e. a set of short, medium and long term goals aimed at better ensuring that information is provided in a timely fashion to the right people to support search and rescue as well as recovery and accident investigation activities. Yet, these efforts may take – as usual – some time to materialize.

In the meantime, the European Aviation Safety Agency (EASA) has provided recommendations for flight recorders[8] and underwater locating devices, which aim at facilitating the quick recovery of an aircraft and of its flight recorders in case of an accident. These include extending the transmission time of Underwater Locating Devices (ULD) fitted on flight recorders from 30 days to 90 days. EASA has also proposed to equip large airplanes flying over oceans with a new type of ULD that have a longer locating range than the current flight recorder's ULDs. It remains to be seen whether other national and regional aviation safety regulators will follow suit.

Some airlines have turned to the International Air Transport Association (IATA) for advice thus demonstrating the deficits of information available. IATA represents primarily major carriers and helps formulate industry policy and standards. With view to MH370 IATA has agreed that its members will voluntarily start tracking with existing on-board equipment and a new batch of procedures being developed by the Aircraft Tracking Task Force (ATTF).[9] Roughly 80 per cent of wide-body aircraft flying long-haul oceanic routes have already been equipped with Future Air Navigation Systems (FANS) to supply ATC with ADS-C position reports over satellite networks using ACARS. Yet, a number of airlines have not activated the service.

The ATTF has been created by the IATA on April 1, 2014, and comprises key stakeholders such as ICAO, the Flight Safety Foundation, Boeing, Airbus, Bombardier and Embraer. Presently there have been three "work streams" engaged:

- Identifying gaps in the current state of flight-tracking;
- Defining the minimum requirements that any tracking system should meet;
- Developing a Concept of Operations (CONOPS) for global flight tracking.

The recommendations derived from the three work streams are supposed to enable enhanced global aircraft tracking. On 30 September the draft recommendations was to be presented to ICAO for consideration in their deliberations. This now has been postponed[10] to the IATA's board of governors meeting in December[11] and

[7] ICAO, „ICAO Delivers Agreement Between States, Industry Groups on Global Airline Flight Tracking Capability". Montreal, 14 May 2014. http://www.icao.int/Newsroom/Pages/ICAO-delivers-agreement-on-global-airline-flight-tracking-capability.aspx (accessed: 10 October 2014)
[8] EASA, „EASA publishes new proposals for flight recorders and locating devices". 6 May 2014. http://easa.europa.eu/newsroom-and-events/news/easa-publishes-new-proposals-flight-recorders-and-locating-devices (accessed: 10 October 2014)
[9] Tyler, Tony. „Remarks at the ABA Air & Space Law Annual Forum", IATA. 19 September 2014, Montreal. http://www.iata.org/pressroom/speeches/Pages/2014-09-19-01.aspx (accessed: 10 October 2014)
[10] Martell, Allison. „Task force delays aircraft tracking plans promised after MH370 mystery". Toronto.

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subsequently presented to its airline members. ICAO will hold a high-level safety conference in February 2015, at which ATTF's CONOPS might be approved as part of a broader effort to draft performance-based international standards.

Beyond that, ICAO is investigating midterm initiatives that include space- based surveillances improving search–and-rescue notifications, accurately defining an accident location, and gaining additional spectrum for "safety of life" aviation services. ICAO has also been considering long-term upgrades such as cloud-based remote storage of flight information.

With view to MH17, on 29 July, following a critical meeting between ICAO, IATA, Airports Council International and the Civil Air Navigation Services Organization[12] two broad fields of work were launched.

Firstly, a task force was convened to find ways to improve dramatically the accuracy, consistency and reliability of threat information delivered to civil aviation authorities and airlines. It will report to a special meeting of the ICAO council. In particular, the organisation wants the task force to examine, "*how information can be effectively collected and disseminated*". The organisations stated in their joint statement about the fail-safe channels that: "*We recognise the essential need for information and intelligence that might affect the safety of our passengers and crew. This is a highly complex and politically sensitive area of international coordination, involving not only civil aviation regulations and procedures, but also state national security and intelligence gathering activities*." The need for this was re-emphasized shortly after the MH17 tragedy when governments gave conflicting and unclear advice to airlines flying to Tel Aviv.

Secondly, industry has asked of ICAO to seek improvements in the international legal framework that governs the design, manufacture, and trading of weapons with anti-aircraft capability. After KAL 007 was shot down in 1983 by Soviet aircraft an additional article was added to the Chicago Convention stating that states should not shoot down civilian airliners. In the aftermath of shooting MH 17 we have learned that weapons with the capability to shoot down civilian aircraft at cruising altitudes are in the hands of non-state entities. Consequently state obligations need to be expanded. Treaties need to be amended. Such amendments take time.

Search And Rescue (SAR) and Fact Finding Missions

With regard to the related SAR respectively Fact Finding Missions the challenge of coordinating activity and aligning communications amongst multiple and multi-jurisdictional stakeholders was manifest for both, MH370 and MH17. When MH370 disappeared, 26 countries were ultimately involved in the search efforts to find it, including China, Japan, Vietnam, Australia, Great Britain and the United States. The diplomatic crisis that resulted from the shooting down of MH17 involved countries spanning from Malaysia to the U.S., not to mention supranational organisations such as the UN and NATO. With regard to both there has been obviously a lack of effective coordination.

Tue Sep 30, 2014 http://uk.reuters.com/article/2014/09/30/uk-airlines-safety-tracking-idUKKCN0HP2C420140930 (accessed: 10 October 2014)

[11] Allison Martell, Task force delays aircraft tracking plans promised after MH370 mystery, Toronto, Sep 30, 2014 http://uk.reuters.com/article/2014/09/30/uk-airlines-safety-tracking-idUKKCN0HP2C420140930 (accessed: 10 October 2014)

[12] ICAO, IATA, Airports Council International Civil Air Navigation Services Organization. Joint Statement on Risks to Civil Aviation Arising from Conflict Zones - Jul 29, 2014. http://www.aci.aero/News/Releases/Most-Recent/2014/07/29/Joint-Statement-on-Risks-to-Civil-Aviation-Arising-from-Conflict-Zones (accessed: 10 October 2014)

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Effective, disciplined stakeholder management has become an essential component of any qualified response in SAR. It is particularly important when an organisation's external stakeholders need to become active participants in managing a critical situation. With MH370, Malaysia Airlines often had to work around a timetable set by the Malaysian Government. Both entities had to create order around the numerous countries' search operations. With MH17, Malaysia Airlines also had to navigate an escalating political crisis between the West and Russia.

During the investigation of Malaysia Airlines Flight 370 much went wrong. Each development has been watched by millions around the world to include numerous false leads, along with dissemination of misinformation. Media coverage, cable news and Internet sites provided countless opportunities for experts to weigh in.

All of this underlines that preparedness is critical. Stakeholders have to prepare for and finally ensure that effective mechanisms and procedures are in place that supports appropriate responding in a timely manner. All actors involved should be intimately familiar with the protocols and procedures of the jurisdictions with which they engage, so that they know who to call, and how to call them.

Throughout the contingencies situational awareness is important to take decisions and plan actions. There is always the need for quick situational awareness to help authorities respond effectively.

With regard to the plenty of involved stakeholders and actors, situational awareness can be enhanced by social media as the focus is on the speed and effectiveness of the initial response. People can document their situation, observations or anything around the crisis at hand, despite overloaded phone lines or not yet arrived emergency agencies.

Social media tools allow engaging community networks in order to gather, analyse and disseminate information in a timely manner. A couple of emergency agencies (e.g., police forces) have already included this new communication channel into their work. Acquiring data from social media broadens the perspective of agencies as they now can see the situation from the perspective of victims, bystanders or any other related persons. The – via social media – identified incidents and threats can also be used to plan emergency response in a more efficient way.

Social media also offer a collaboration platform between emergency agencies, e.g., for knowledge sharing and information exchange. With increasingly more individuals using their mobile phones to go online worldwide, it should be considered to incorporate social media applications into an integrated collaboration & management platform for effective management of SAR and Fact Finding contingencies.

The introduction of new collaboration technologies enhancing the cooperation of involved actors and seamless delivery of SAR is of crucial importance. Based on the nature and location of a SAR incident – the complete response is frequently multi-jurisdictional. To this end the ease and speed with which a responsible jurisdiction can access the most capable, timely and appropriate assistance will become critical to the success.

Initiatives to enhance interoperability should be pursued, to include training, exercises and operations with likely partners and organisations. This applies both on national and regional (international) levels. Opportunities for standardization should be explored. All technology needs to be subordinate to the primacy of saving a life, and mutual aid – across organizations. With that in mind, technology such as sensors, radio communications, GPS/mapping, etc. can serve as a force multiplier in enabling a more effective SAR response.

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Recommendations

Not all tragedies can be avoided. And yet, there is room for improvement. Because aircraft and aviation are very complex, experts tend to treat related governance and regulation as an autarkic matter. Yet, aircraft and aviation are no closed systems. They are subsystems in global transportation systems that provide services in a networked world with rapid innovation cycles. Last but not least, aircraft provide services for people and societies, business, international organisations and governments.

My recommendations cover

- Legal Framework and Governance,
- Technology and
- Standard Operating Procedures.

With regards to air traffic legislation and governance obviously there is a need to

- **Adopt the Legal Framework** (Chicago Convention[13]) in order to
  - address the capability of non-state entities to shoot down civilian aircraft at cruising altitude;
  - introduce amendments to cooperative search and rescue in these situations;
  - possible limit legal liability as determining the causal factors of an aircraft tragedy is the only way to make informed changes for the safety of passengers.
- **Improve Responsiveness** of the regulatory framework governing air traffic to react more timely to dynamic innovation requirements. The time it takes to transfer relevant innovation into the cockpit, airframe and transportation systems can be measured in years, if not decades. This is no longer adequate.
- **Voluntary Standards should be adopted by the airline industry** with view to more immediate and compelling solutions. U.S. adoption of NextGen technology, while it will increase flight tracking, was driven by the need to create more efficient routing and reduce aircraft separation. EU has even greater congestion problems at major airports than the U.S. In the given tough competition between airlines voluntary standards may also offer a unique selling proposition.

With regard to Technology and Equipment

- **Implement Global Flight Tracking as a Standard** to ensure that information is provided in a timely fashion to the right people to support search and rescue as well as recovery and accident investigation activities. To maintain positive contact on aircraft in all flight phases would require a system with a coded transponder inaccessible to the aircrew – with the exception of military aircraft and VIP-flights – that broadcast via satellite the aircraft's identification and flight data in real time.
- **Accept EASA Proposals** globally to extending the transmission time of Underwater Locating Devices (ULD) fitted on flight recorders from 30 days to 90 days and equip large airplanes flying over oceans

[13] CAPT Kopplin, Shannon H. Mail-exchange in September/October 2014 on cooperative and non-cooperative systems, U.S. adoption of NextGen technology and Chicago Convention

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with a new type of ULD that have a longer locating range than the current flight recorder's ULDs.

- **Develop Comprehensive Situational Awareness** to adequately support airlines and aeronautical authorities in increasingly demanding operations (i.e. role-based day-to-operations of stakeholders, teams and functions, but also with view to preparedness vis-à-vis unforeseen SAR contingencies).
- **Improve Collaboration & Management** in support of stakeholders, teams and functions for effective management of SAR and Fact Finding contingencies. **Include social media applications,** as the effective use of social media tools will be critical to engage community networks in order to gather, analyse and disseminate information in a timely manner. Social media also offer a collaboration platform between emergency agencies, e.g., for knowledge sharing and information exchange.
- **Implement further technological innovations** in the aircraft related to safety and security such as space-based surveillances improving search-and-rescue notifications, accurately defining an accident location, and gaining additional spectrum for "safety of life" aviation services. This is of general importance as in oceanic regions; in larger parts of Africa and Asia often neither the airline nor ATC has adequate situational awareness. Technology is also of importance in enabling a more effective SAR response – i.e. sensors, radio communications, GPS/mapping, etc.

With regard to **Standard Operating Procedures** I recommend to

- **Emphasize Preparedness** as a core element of effective SAR. Preparedness is the decisive prerequisite that enables the different stakeholders, teams and functions to perform their roles adequately. Stakeholders and involved actors need to be committed to continuous improvement.
- **Prepare for "*black swans*".** Malaysia Airlines' experience proves that the 'impossible' is possible – even twice. Whilst organisations cannot and should not prepare for every eventuality, they need to ensure that their structures and processes are flexible enough to accommodate appropriate response to any kind of accident/incident or even combination of accidents/incidents.
- **Focus on effective, disciplined stakeholder management** as an essential component of any qualified response. Build strong relationships with government officials in order to establish a shared understanding of the need to work together effectively. Practise multi-actor response, agree the structures and processes required to coordinate activity, and develop stakeholder engagement skills.
- **Ensure consistent standards**. Address urgently the issue of inconsistent standards, as they have become apparent in Eastern Ukraine and Tel Aviv. Re-examine present concepts of how the airline industry monitors its aircraft and with whom and under what circumstances data should be shared. Airlines should know where their aircraft are.
- **Test and Train SOPs** in team- and function-specific, scenario-based planning sessions to verify what human, operational, financial and logistical resources are needed to respond effectively to different types of Search and Rescue respectively Fact Finding missions. Once established, these resources – and access to them – should be tested in an exercise, to ensure that agreements made in theory, work in practice. Focus should be on regional settings.

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- **Develop a "*Need to Share Policy for Aviation Safety and Security*"** building on bilateral and regional agreements. Airlines should share their risk assessments and could consequently benefit from the situational awareness of the different carriers. A new body could be formed to pool and distribute national and regional intelligence to airlines.
- **Enhance interoperability and explore opportunities for standardization** in multi-jurisdictional SAR contingencies, to include training, exercises and operations with likely partners and organisations. This applies both on national and regional (international) levels.

In sum, air traffic legislation and governance, technology and standard operating procedures need to be adapted to new challenges and opportunities in aviation and related search and rescue operations. New available technologies and new concepts of operations need to be integrated timely. Issues such as coordination and interoperability, situational awareness, knowledge management and collaboration have come to the fore. The challenge as well as the opportunity has become to foster a holistic and comprehensive approach that applies modern (particularly information and communication) technologies and serves people and societies, business, international organisations and governments in a well-balanced fashion. Voluntary standards adopted by the airline industry have the potential to accelerate the development.

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Remarks: Opinions expressed in this paper are those of the author.

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