BLUEPRINT

THE 2011 SKYGUIDE TECHNOLOGY OUTLOOK
Dear reader,

We are pleased to present you with our 2011 issue of “Blueprint”, Skyguide’s specialist annual publication focusing on future ATM technologies.

As you may recall, the aim of Blueprint is to pass on complex technological expertise in an accessible form, primarily to decision-makers within and outside Skyguide. It is a task that seems to have gained further in importance in the last 12 months.

If we read the signs within our industry correctly, we need to fundamentally change the way we conduct our ATM. To cope with the projected future air traffic demand in safety, capacity, efficiency and sustainability terms, we must make a radical break with current concepts and procedures and seek, find and adopt a bold new ATM approach.

As in every major industry today, the role that technology will play in this process is a key consideration. Will the technology change the face of our business, or will it be the people behind it who do so?

While I am in overall charge of Skyguide’s technological capabilities, I do not believe that technology can be the prime mover here. Technology can enable the change; but it cannot force it itself.

It is our people who must make the changes happen. So it is their minds that we need to win over to the change process: both the urgent need for it and the developments it will entail.

As the aviator and writer Antoine de Saint-Exupéry put it:

“Si tu veux construire un bateau, ne rassemble pas des hommes pour aller chercher du bois, préparer des outils, répartir les tâches, alléger le travail mais enseigne aux gens la nostalgie de l’infini de la mer.”

Let’s follow the great man’s advice; and let’s start building the awareness, the appreciation and the enthusiasm we will need at all corporate and industry levels to respond to the challenge ahead!

Sincerely,

Robert Stadler

Editorial

Robert Stadler, Technical Director
Flight 3767 is on approach to the airport of a city of several million inhabitants. The on-board avionics have just used the data from other aircraft, a central computer on the ground and meteorological data from satellites to select the landing runway. It's the middle of three parallel runways which are only 500 metres apart. The systems manager in the cockpit notes this, checks the predicted trajectory on the display and sits back again in his seat. As he does so, he notices that a flight to his left will be catching up with his aircraft in a few minutes' time to land on the left-hand parallel runway. All systems green.

Shortly before landing, the flight comes out of the cloud. The systems manager sees the other aircraft on his port side as expected. The landing and runway exit are normal, and the flight is automatically guided to its gate. The systems manager makes the final preparations before leaving the aircraft. As he does so, he thinks back briefly to a time when he was permitted to use his various instruments to actually fly the plane. He misses having someone else in the cockpit to talk to, too. But there's no longer any need for a second person on the flight deck.

At the same time, the air traffic manager is just finishing his shift on the other side of town. His two colleagues, who are monitoring all the airspace within a 200-mile radius, will have to stay a little longer. Today, too, nothing out-of-the-ordinary happened. Not a single intervention was required – just like the ten previous days. The system is working perfectly.

No idea what year the above story will be set in. Nor any idea if the air traffic management (ATM) of the future will really be like this. But it's one possible scenario. "No way!" you may say. And maybe it is a little far-fetched. Not much, though. Because if air traffic continues to develop at its present rate, we will inevitably reach the limits of our current ATM systems – limits that simply cannot be overcome. And new systems will need to be developed instead.

This is nothing new. If we give credence to the forecasts of various organisations on the issue, then, depending on the scenario selected, air traffic volumes in Europe will as much as double in the next 20 years. This is not unrealistic: we have seen a similar volume increase in the last 20 years, despite the repercussions of 9/11, financial crises and volcanic ash clouds.

The recent and current volume trends are one reason why such expensive programmes have been launched in the CNS and ATM fields, particularly SESAR in Europe and NextGen in the USA. Further research programmes are also under way at various institutions, spread over a wide range of countries. Among other objectives, these programmes are intended to modernise the entire CNS/ATM sector to such an extent that it can meet these rising demands on the "airspace" resource, while simultaneously enhancing its safety and environmental credentials.

The example of SESAR clearly shows what high ambitions are invested in a programme of this kind. The Single European Sky's performance objectives are to triple capacity, halve ATM costs, improve safety by a factor of 10 and reduce the environmental impact of each flight by 10%. This means enhancing the present performance of CNS/ATM by magnitudes!

Massive efforts will be needed if this goal is to be achieved. On the one hand, various processes in air traffic operations will have to be not just improved but radically revised. At the same time, new technologies will need to be developed and applied. And somewhere between the two is the human factor, which influences the overall system in so many different ways.

Just how these three components will combine and collaborate is still totally open. What is clear, however, is that if we simply further improve and refine the existing system, timidly introducing the occasional new technology, we are bound to see a decline in the system's ability to cope with traffic demands in the years ahead. This is why we must embark on a paradigm shift if we are to maintain our current performance levels in the face of a further steady increase in people's desire to fly.

Anyone who has been involved – actively or passively – in scientific research will be familiar with the problem that a particular phenomenon can be described in any of a number of ways. In many cases, this will be in the form of a mathematical model or a particular physical attribute.

Once the model has been derived, the question will arise as to the extent of its validity. This can be ascertained in any of a number of ways. One fairly crude but simple method is to provide the model with extreme entry data and see what
results. It’s a radical approach that may push the model to its limits; but it does show immediately if the model can cope with such extremes.

So what does an approach like this have to do with the future of the CNS/ATM system? It’s relevant because we can adopt the reverse approach, and derive the future CNS/ATM model needed to cope with such extreme conditions.

Below are brief outlines of three such models. We are well aware that they are all extremely provocative; and this is why we have called them not models but “Provocations”:

**Provocation 1: The Pilot’s View**
From the pilot’s perspective, the CNS/ATM of tomorrow will take place on board. The navigation and surveillance will be provided via satellites, eliminating the need for all such facilities on the ground. Communications will be effected directly from pilot to pilot, too, removing the need for a further set of ground facilities. All the relevant data can be exchanged between flights using air-to-air data links. Since all the information needed will now be on board, tasks such as ensuring adequate separations can be handled among the flights themselves, eliminating the need for ATM from the ground.

The benefits such an approach would bring include lower costs, since ground-based ATM would be effectively abolished. Capacity would also be increased, because the pilots’ current needs could be entered more easily and directly into the system; and efficiency would be enhanced, too, because decisions would no longer have to pass through so many steps and parties.

**Provocation 2: The ATCO’s View**
From the air traffic controller’s perspective, it makes no sense to install heavy and (above all) expensive high-performance equipment into every aircraft to provide an airborne ATM system. With the sizeable computer capacities and performance that these functions require, it is far more efficient to have a few centralised facilities handling them on the ground. In navigation and surveillance terms, the ATCO’s view largely concurs with the pilot’s; but the communications would be via a data link between the air and the ground.

The major innovation here, though, is that the ATCO will communicate not with the pilot but with the aircraft, simplifying the system by removing an entire decision-making level. The ATCO will also be able to control the aircraft from the ground to a certain extent, by transmitting instructions to its inflight systems. The rest of the aircraft’s control will be handled by automated systems on board. With the number of UAVs in controlled airspace sure to increase, the ATCO will also be able to control these airborne devices in a similar way. In effect, this means that the pilot no longer needs to be on board.

**Provocation 3: The ATSEP’s View**
The engineers and technicians in the air traffic services field see one major drawback to both the above scenarios. In both models, people are still required to actively intervene. In the
ATSEPs’ view, as soon as information has to be exchanged between two persons, or between human and machine, the “human factor” will seriously slow down the processes involved. In view of this, they believe, it makes far more sense to develop a system in which the machines communicate and interact directly with each other.

Such a system takes the human factor out of the loop. People will still be involved in the overall system, in developing the new CNS/ATM facility, but only up until its entry into service. An approach like this would eliminate the need for both pilots and controllers, and would automate the entire CNS/ATM system.

As already suggested, the three scenarios above are both provocative and extreme, and should on no account be taken at face value. They are intended solely as starting points in any development of a new CNS/ATM system that can bring greater efficiency to handling tomorrow’s air traffic. The reality will lie somewhere between these three extremes. There is a strong probability that ground-to-air and air-to-air data exchanges will be increasingly effected to the exclusion of any human element. This is because the human factor severely limits the volumes of data that can be transmitted, and thus slows down the entire data exchange process. Automation is sure to see further substantial increases, too, on the ground and in the air, removing the need for people to make the corresponding decisions, and thereby also raising overall system efficiency.

So where are the people in all of this? There is a strong possibility that the duties of the pilot and the air traffic controller will shift towards monitoring traffic and systems and only occasionally intervening in the processes involved. The activities of the ATSEP, meanwhile, will move away from maintenance and focus largely on development. Engineers and technicians may find themselves in more demand than they are today. In this sense, the scene described at the start of this article may not be so far-fetched.

The big question is, of course: how long will it take before we get to this? It could well be that none of us will experience the CNS/ATM world(s) projected in our professional careers. So if it’s all so far ahead, do we really need to concern ourselves with it now? The answer is yes, we do: a paradigm shift of this kind has a long lead time. And the longer we leave it before we start to seriously consider what tomorrow’s CNS/ATM landscape should look like, the greater the risk we run of ending up in a developmental dead-end, and of having to cope with a CNS/ATM system that is no longer adequate, together with substantial declines in the performance and the quality of our air traffic handling.

1 Eurocontrol, 2004, Forecasts from Eurocontrol.
The CHIPS technology roadmap
Stefan Böller, CNS Technical Assistant, skyguide

In industry, roadmaps are used to visualise when new technologies are ready to be applied and when new products will be introduced to the market. A roadmap illustrates the development stages of the individual technologies and products, including their reciprocal dependencies. Roadmaps are valuable decision support tools for management and project and product managers. And a well-devised roadmap not only shows an overview of all the technologies involved and how they are linked together; it also reduces complexity by visualising it.

Description
The purpose of the CHIPS roadmapping project is to transfer the roadmapping methodology familiar in industry to the CHIPS programme (for satellite-based navigation procedures, mainly for arrivals). Many CHIPS projects build on current or future technologies, regulations and the training/certification levels of the people involved. And it’s highly challenging for the CHIPS project managers to consider all these aspects, their reciprocal dependencies and how they influence the realisation of the projects concerned.

The main goal of the CHIPS roadmapping project is to create a roadmap that serves the needs of the CHIPS Board, the CHIPS Steering Committee, the individual project owners and project leaders and additional stakeholders (such as the Swiss Federal Office of Civil Aviation). The roadmapping project team (which consists of myself supported by sat-nav experts and external consultants) chose the following process to achieve this goal: adapt best roadmapping practices from industry, create a roadmapping methodology optimised to the needs of CHIPS, and finally build the corresponding roadmaps using this methodology.

The team soon discovered that the complexity of roadmapping in the airline context was much higher than in traditional industry. As a result, the roadmapping methodology had to be substantially enhanced. The actions taken here ensured continuous feedback on the usefulness of the results, enabling the team to improve, adapt and expand the methodology as needed. And three workshops with international experts produced a huge amount of data.

The challenge in the second phase was to find a way to manage these data and visualise them in a useful way. With the help of “use cases” (which can be compared with a predefined scenario of an application), the team was able to visualise all the attributes concerned and their further development for the coming 20 years. These values will, of course, change over time.

Application
The CHIPS roadmap will provide an introduction to and an overview of today’s satellite-based navigation procedures. With some 20 use cases, the project leaders will have an up-to-date tool which describes all the attributes concerned and their projected further development within the coming 20 years. This information will be presented in booklet form. An interactive web-based application is being discussed, too. The expert network used will also be maintained by skyguide’s satellite specialists.

Impact

<table>
<thead>
<tr>
<th></th>
<th>CNS</th>
<th>ATM</th>
<th>AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
</tbody>
</table>

2000 05 10 15 20 2025
Wide area multilateration or WAM is becoming an increasingly important surveillance technology, competing today with Mode S radars in the provision of countrywide secondary coverage. WAM is also seen as the way to go for the transition from radars to a future ADS-B infrastructure. But although WAM offers obvious benefits, it will not totally replace radars: the future of surveillance lies in a mix of different technologies, with each one used where it best fits the needs and constraints.

Description
Multilateration is a well-known surveillance technology at skyguide, having provided ground surveillance at Geneva and Zurich airports since the early 2000s. Multilateration is basically an inverted GPS: several sensors spread over the area of interest measure the time of arrival of transponder signals, information that a central computer then uses to calculate aircraft positions. The principle is perfectly scalable, and deploying the sensors over a wider region provides a “wide area multilateration system” or WAM that is able to detect transponder-equipped aircraft in approach and en-route airspace.

Operational WAM systems are now growing in number all over the world. Austria has been operating such a system in the Innsbruck TMA since 2004 and bought a countrywide WAM in May 2011. Sweden made the same decision in March of this year, and a WAM system has been operational over the North Sea since 2010.

WAM is now clearly seen as a possible replacement for secondary radars, though in Switzerland radars still have an advantage for en-route coverage: to provide the same coverage as Lägern or La Dôle, a WAM system would require the installation of numerous sensors in three or four countries, which would be neither easy nor cheap.

In fact, the WAM option is most attractive in places where no radar currently exists or in mountainous areas: the small sensors required can be piggybacked onto existing masts; and once an initial system has been deployed, coverage can be improved locally (e.g. in a valley) by adding a few sensors, where a dedicated radar would otherwise be required to do the same job.

Some question marks do remain over the WAM technology and its application. These include high-frequency pollution due to interrogation with omnidirectional antennae, the costs linked to telecommunication services, and the maintenance demands of such a widely-spread system.

The major advantage of the WAM technology may well be that, while it works with current transponders, it can also extract ADS-B positions. WAM is thus seen as the way forward for the transition from radars to ADS-B.

Applications
WAM is already a possible solution for ensuring secondary surveillance over areas not yet covered, or to replace ageing radar facilities. And WAM will certainly be part of Switzerland’s future infrastructure, together with Mode S radars and later ADS-B beacons, with each technology providing services where it makes the most sense.

Impact

<table>
<thead>
<tr>
<th>CNS</th>
<th>ATM</th>
<th>AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>low</td>
<td>medium</td>
</tr>
</tbody>
</table>

2000 05 10 15 20 2025
ADS-B: a possible future replacement for radars?

Maurizio Scaramuzza, Head CNS Experts Group

The principle of ADS-B (automatic dependent surveillance – broadcast) is simple. An appropriately-equipped aircraft determines its own position and regularly broadcasts this together with other information such as its speed and heading to stations on the ground. This information is then displayed to the air traffic controller. ADS-B is considered a candidate to replace today’s radars in the longer term. But despite its advantages, due regard must be paid to the system’s major drawbacks, too.

Description
A larger number of commercial aircraft are already equipped with ADS-B. Typically they determine their position using their global positioning system or GPS, though other means may also be used. The system further determines the integrity of the data provided, to ensure a certain system safety level. Finally additional information such as speed, heading and turn rate are broadcast as well. All these data are received by small antennas on the ground and are then further processed to provide an adequate representation on the air traffic controller’s display.

One major advantage of ADS-B for an air navigation service provider (ANSP) is its lower equipment and maintenance costs compared to today’s radar systems. In the air, moreover, any aircraft equipped with a dedicated receiver can use ADS-B to enhance its traffic collision avoidance system (TCAS).

Two major drawbacks of ADS-B must be pointed out, though. ADS-B could only replace today’s radars (as some sources advocate) if every single aircraft were appropriately equipped. And this could only be achieved by order from above. The USA has chosen this approach, with a long lead time; by 2020 all aircraft flying in the US airspace will have to be equipped with a minimum variant of ADS-B (one which, for instance, does not offer the benefit of enhanced TCAS). Operators have so far been reluctant to retrofit their aircraft, however, due to a lack of clear incentives. The USA now intends to set up an equipment fund based on a public/private partnership model to speed up the installation rate.

The second major drawback of ADS-B is that, in future, it will rely solely on the positions determined aboard the aircraft concerned. These positions will ultimately be used for both surveillance and navigation. So any degradation of the performance of the positioning system carries a bulk risk which needs to be avoided in high-density traffic areas such as Central Europe. ADS-B could, however, be a valuable solution for low-density areas without surveillance coverage.

A combination of ADS-B and WAM (see the previous article) could also be an interesting solution. WAM could be used to determine an aircraft’s position independently of its on-board positioning system, with ADS-B providing additional flight information.

Applications
ADS-B will find its application mainly in low-traffic-density or non-radar areas. In these cases, ADS-B may be an alternative to conventional radars. Another option could be to combine ADS-B with WAM. In the longer-term future, ADS-B may be one option for replacing conventional radars.

Impact

<table>
<thead>
<tr>
<th>CNS</th>
<th>ATM</th>
<th>AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>low</td>
<td>medium</td>
</tr>
</tbody>
</table>

2000 05 10 15 20 2025
Back in the 1970s, it was clear that the pilot was in charge of flying the aircraft. This was done by manually selecting and following ground stations such as VOR, NDB or ILS navigation aids. Today, with the introduction of performance-based navigation, we may ask: who is flying the aircraft now? Is it the pilot, the air traffic controller, the flight procedure designer or simply the aircraft’s navigation computer?

Before area navigation
Back in the days when area navigation – the capability to navigate from waypoint to waypoint – did not yet exist, the flight procedure designer had no other choice but to base their flight trajectories on ground navigation infrastructure such as VOR, NDB or ILS. The essential data for designing such flight procedures were the positions of those navigation facilities. The tools used by the procedure designer were basic, including manual drawing using pen and paper. The pilots of the time were interested not in the coordinates but in the descriptive text and chart of the flight procedure concerned. With the amount of data provided to the pilots limited, cross-checking the data received was part of their airmanship activities. The equation representing the aircraft’s navigation was something like “navigation system (e.g. VOR) + pilot flying technique”. And this is why we can say that before the introduction of area navigation, the pilot was really in charge of flying the aircraft.

Towards performance-based navigation
With the development of performance-based navigation, supported by GPS and a database containing the waypoint coordinates, the flight procedure designer is now free from the constraints of ground infrastructure – so free, in fact, that it is becoming essential to involve all the various stakeholders to set a common direction for what to do. On the pilot’s side, it is becoming difficult to cross-check complex data such as coordinates and procedure coding. This is why a quality assurance process, including training, is needed to maintain safe levels of data quality and procedure design. The corresponding tools have also evolved: no procedure is designed today without procedure design software and a means of creating, using, managing and exchanging aeronautical data. This is why it is so worthwhile investing in that domain. And the equation of the aircraft’s navigation today is something like “navigation system (e.g. GPS) + flight management computer flying technique + database”. So flying the aircraft is now a collaborative affair.

Applications
All phases of flight will benefit from performance-based navigation and its collaborative design. Approaches with vertical guidance are an alternative to ILS; and terminal operations can also be improved with the introduction of transition-to-final where continuous descent operation is enabled.

Impact

<table>
<thead>
<tr>
<th>CNS</th>
<th>ATM</th>
<th>AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>low</td>
<td>medium</td>
</tr>
</tbody>
</table>

2000 05 10 15 20 2025
Performance-based navigation

Thomas Buchanan, Head of International Affairs & Corporate Strategy, skyguide (and former Chairman of the ICAO Instrument Flight Procedure Panel or IFPP)

calling for the implementation of PBN within all states in a phased approach. This resolution was superseded at the 37th Assembly by a new Resolution 37-11, which extends the PBN requirement to lateral-only approaches to avoid circling-to-land operations. The aim of this article is to outline the consequences of this at a regional, national and local level.

ICAO ensures the safe and efficient performance of the global air navigation system and improves the performance thereof on a harmonised, worldwide basis and with the collaboration of all stakeholders. It does so while paying due regard to advanced airborne GNSS technologies, ensuring accuracy in maintaining separation through curves, enabling flexible approach line-ups and enhancing the operational safety of all aircraft by permitting lower minima in obstacle-rich or constrained environments.

States are encouraged to implement approach procedures with vertical guidance (APV) in accordance with ICAO provisions and to eliminate circling approaches where possible by providing straight-in procedures using RNAV-lateral-only (LNAV) functionalities as a safety enhancer.

All ICAO member states are required to adopt RNAV and RNP ATS routes and approach procedures in accordance with the ICAO PBN concept. They are also required to give a clear indication to ICAO, by providing a PBN implementation plan, of how they intend to:

1) implement RNAV and RNP operations (where required) for en-route and terminal areas;

2) implement approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV-only minima, for all instrument runway ends, either as the primary approach or as a back-up for precision ap-

proaches by 2016, with the intermediate milestones of 30% by 2010 and 70% by 2014;

3) implement straight-in LNAV-only procedures where needed.

The adoption of such procedures will mark a major change from the current system. The validation of the procedures concerned will be based on information that is simulated (satellite coverage) and is assessed in a totally different manner than at present. The new procedures may also permit the decommissioning of some ground-based navigation infrastructure, reducing infrastructure costs. Skyguide actively participates in and chairs the European PBN task force, reporting to ICAO headquarters in Montreal.

Applications

In the longer term, such applications should be deployed globally for all IFR runway ends, including those equipped with ILS, providing full system redundancy. The corresponding work will be conducted within the CHIPS programme.
A-CDM: boosting the airport turnaround process
Hervé BRETON, CDM@CDG Programme Manager, DSNA

Airport collaborative decision-making (A-CDM) is a concept formulated by the European Commission which should help ensure the rational use of airspace in Europe. Developed by Eurocontrol, A-CDM is intended to improve airport operations by ensuring better coordination among all on-site partners: airport managers, air traffic control, airlines, meteorological services, ground handling and more. One of the main products of the CDM process is a very accurate target takeoff time (TTOT) which can enhance ground and en-route planning.

Description
On 16 November 2010 Paris Charles de Gaulle became one of the first airports to be awarded the European “Airport CDM” label. The distinction was bestowed in a ceremony that brought together Pierre Graff, Chairman & CEO of Aéroports de Paris, Matthew Baldwin, European Commission Director for Air Transport, David McMillan, Eurocontrol’s Director General, Patrick Gandil, Director General of the DGAC (the French civil aviation authority) and Maurice Georges, Director of the DSNA (France’s air navigation service provider).

The collaborative decision-making (CDM) workplan at Paris Charles de Gaulle is shared by the various airport partners, and is structured around multiple parallel themes (information sharing/operational collaboration implementation, adverse conditions [de-icing/snow/LVP/thunderstorms], airport capacity optimisation in nominal situations, website, collaborative pre-departure sequence tool [C-PDS] and more).

The C-PDS system, which is connected to Eurocontrol’s Central Flow Management Unit, was developed with the stakeholders (Aéroports de Paris, the DSNA and EgisAvia) and has been operational at the airport since November 2010. The resulting enhanced flow and capacity management means better slot compliance and fewer missed slots. C-PDS provides more stable traffic flows and has reduced taxi times, apron and taxiway congestion and runway queues. The ATCOs involved also report that C-PDS has reduced their ground sector workload and optimised runway and capacity planning.

The airport operator also reports improvements in the use of stands and gates. CDM enhances the reliability of airport slots and improves transparency (thanks in no small part to the CDM@CDG website). For travellers themselves, the benefits of CDM include fewer delays and missed connections, quicker post-disruption recoveries and more accurate information at service desks and on passenger displays.

Applications
Thanks to CDM, passengers at Paris Charles de Gaulle have seen improvements in flight punctuality, with over 85% of flights departing on time. CDM also ensures a smooth flow of ground traffic, cutting aircraft taxi times by 2–4 minutes and reducing CO2 emissions by some 44 tonnes a day. The airlines benefit in the form of reduced fuel consumption, with an average saving of 14.5 tonnes of fuel a day.

A-CDM and CDM@CDG are both part of SES II and SESAR.

Impact

<table>
<thead>
<tr>
<th>2000</th>
<th>05</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>low</td>
<td>medium</td>
<td>high</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The CDM Cell keeps airport operation as efficient as possible in adverse conditions (e.g.: during last 2010/2011 winter, Paris CDG was opened when major European airports were closed).

A-CDM: boosting the airport turnaround process
Hervé BRETON, CDM@CDG Programme Manager, DSNA

Airport collaborative decision-making (A-CDM) is a concept formulated by the European Commission which should help ensure the rational use of airspace in Europe. Developed by Eurocontrol, A-CDM is intended to improve airport operations by ensuring better coordination among all on-site partners: airport managers, air traffic control, airlines, meteorological services, ground handling and more. One of the main products of the CDM process is a very accurate target takeoff time (TTOT) which can enhance ground and en-route planning.

Description
On 16 November 2010 Paris Charles de Gaulle became one of the first airports to be awarded the European “Airport CDM” label. The distinction was bestowed in a ceremony that brought together Pierre Graff, Chairman & CEO of Aéroports de Paris, Matthew Baldwin, European Commission Director for Air Transport, David McMillan, Eurocontrol’s Director General, Patrick Gandil, Director General of the DGAC (the French civil aviation authority) and Maurice Georges, Director of the DSNA (France’s air navigation service provider).

The collaborative decision-making (CDM) workplan at Paris Charles de Gaulle is shared by the various airport partners, and is structured around multiple parallel themes (information sharing/operational collaboration implementation, adverse conditions [de-icing/snow/LVP/thunderstorms], airport capacity optimisation in nominal situations, website, collaborative pre-departure sequence tool [C-PDS] and more).

The C-PDS system, which is connected to Eurocontrol’s Central Flow Management Unit, was developed with the stakeholders (Aéroports de Paris, the DSNA and EgisAvia) and has been operational at the airport since November 2010. The resulting enhanced flow and capacity management means better slot compliance and fewer missed slots. C-PDS provides more stable traffic flows and has reduced taxi times, apron and taxiway congestion and runway queues. The ATCOs involved also report that C-PDS has reduced their ground sector workload and optimised runway and capacity planning.

The airport operator also reports improvements in the use of stands and gates. CDM enhances the reliability of airport slots and improves transparency (thanks in no small part to the CDM@CDG website). For travellers themselves, the benefits of CDM include fewer delays and missed connections, quicker post-disruption recoveries and more accurate information at service desks and on passenger displays.

Applications
Thanks to CDM, passengers at Paris Charles de Gaulle have seen improvements in flight punctuality, with over 85% of flights departing on time. CDM also ensures a smooth flow of ground traffic, cutting aircraft taxi times by 2–4 minutes and reducing CO2 emissions by some 44 tonnes a day. The airlines benefit in the form of reduced fuel consumption, with an average saving of 14.5 tonnes of fuel a day.

A-CDM and CDM@CDG are both part of SES II and SESAR.

Impact
Distant aerodrome control

Detlef Schulz-Rückert, Head of Tower Systems & Services, DFS Deutsche Flugsicherung GmbH

It’s still a basic principle of aerodrome control today that air traffic controllers need to have their working position high above the ground, to observe traffic on the ground and in the air. With its Distant Aerodrome Control Service, DFS Deutsche Flugsicherung GmbH is heading in a different direction. The service provides the aerodrome controller with reliable systems and instrument data and the option of complementary visual data about the situation on the ground.

ICAO regulations permit only one alternative to visual observation – the use of A-SMGCS – as the principle of aerodrome control. DFS has developed a solution that complies with these ICAO provisions. In various trials, DFS has also shown that its Distant Aerodrome Control Service meets all the requirements which were laid down by the German supervisory authority in 2007 for the awarding of a distant tower procedure certificate.

DFS’s Distant Aerodrome Control Service supports the aerodrome controller with both instrument and visual information. Instrument data are derived by the PHOENIX multisensor data fusion system, which displays the situation both in the air and on the ground. Data about weather, flight plans and surveillance are supplied to the controller while they review the traffic situation. The sensor technology enables the controller to zoom in easily from the air to the ground situation. The ground situation display shows runways, buildings and the lighting system.

To provide visual data, DFS has also installed video sensors that offer tower controllers a view of the airfield and a way to automatically identify and locate ground movements. DFS has successfully demonstrated that this technology fulfils the international requirements for an A-SMGCS non-cooperative sensor. By adopting this approach, DFS can significantly reduce the costs of A-SMGCS, and also gains the capability to augment instrument data with visual information.

Using the same logic that a pilot applies when navigating their aircraft in response to visibility conditions, the controller can decide to use the PHOENIX instrument data under instrument meteorological conditions or to switch to visual observation under visual meteorological conditions.

Applications

After preparation at Munich, Cologne and Erfurt, DFS is now in the process of setting up its Distant Aerodrome Control Service for actual use. At Munich Airport, the concept will be adopted in the existing tower for the control of the third runway, as an alternative to building a new tower. For Frankfurt Airport, a “virtual contingency tower” is planned; and DFS is also considering adopting the concept for the airport’s ramp control. Elsewhere, DFS plans to create a single control room to control three smaller aerodromes.

Impact

CNS | ATM | AIM
---|---|---
none | low | medium | high

2000 | 05 | 10 | 15 | 20 | 2025
Today’s telecommunications service providers tend to offer their customers ever more elaborate services, up to the application layer. These are produced following masses and money-making business models, with no design or cost transparency for the user. Network design mastery is our key contribution to the HRO ideals, providing the unprecedented continuity of services required by ever more distributed CNS systems architectures and supporting the ATM business, all with cost audit ability.

**Description**

Telecoms operators (TELCOs) are diversifying from their core business by offering added-value services. For the public market, this ranges from IP telephony and TV broadcasts to online internet data storage. For the industry market, they now offer server farms and application management in addition to the traditional transport and networking services.

More and more services are also being produced within a "cloud", a trendy term inviting the user to enjoy peace of mind and flexibility and focus on their own core business. But behind this apparent comfort lies a profit-making optimised business and an absence of either design or cost transparency for the customer.

Meanwhile, the pressure for speed to market, combined with constantly-increasing technological complexity, are leading to equipment instabilities that make the dependent ATM systems further vulnerable and malfunctions unavoidable.

In addition, the merciless competition between TELCOs leads all too often to cheap price-optimised network designs which are incompatible with critical ATM application requirements. Under service level agreements, “money back” is, when it exists, the most common form of compensation for service discontinuity.

Within an ANSP, its ATM applications, its CNS systems and their related access (LAN) and transport (WAN) networks jointly form the third of the three pillars (humans, procedures, equipment) on which all ATM services rest, and for which integrity, availability, continuity and accuracy are paramount requirements.

To achieve the levels of continuity and availability that its CNS systems and ATM applications demand, therefore, skyguide’s Communication Unit (TC) provides the following uniquely essential added values:

- design mastery of access and transport networks, together with the use of well-proven technologies backed with proactive supervision;
- managerial control over the entire equipment stack from ATM applications down to transport services, ensuring that the equipment pillar architecture’s integrity and the service’s cost transparency can both be effectively audited.

**Applications**

With ever more distributed system architectures – such as the FABEC applications, the virtual centre, the common controller cockpit/CPDLC project and critical telephony/radio applications – a mastery of network design makes an undeniable contribution to anticipating and containing the unexpected, as well as to skyguide’s consistent achievement of the ideals of a High-Reliability Organization.
Mission-critical transport networks
Philippe Borghini, Transport Networks Engineer, skyguide

The move among the players in the telecoms market from legacy “circuit-switched” to “packet-switched” networks is being fuelled by their quest for cost savings and profit maximisation. The downsides to this trend are increased technological complexity, less network predictability and the rise of IT security risks, all issues whose consequences must then be faced by the customers. For an ANSP’s transport networks, which are mission-critical by nature, technological simplicity, maturity, determinism and security are paramount characteristics to balance bandwidth optimisation.

Description
Legacy “circuit-switched” network technologies, which were originally designed for voice transport, are being progressively replaced by “packet-switched” networks which are better suited to data transport (see also Theo Jöhner’s article “From voice to data networks” in Blueprint 2010).

In a sector in which the competition is tough and profit margins are increasingly slim, the network service providers are aiming to reduce their CAPEX and OPEX by optimising their networks. But beyond the promises of an idealised all-IP world, it is up to the customers to pay for the countermeasures required to circumvent the IP protocol’s inherent security flaws and support technical issues such as a lack of predictability and traffic congestion, as well as for migrating their applications over IP.

Transport networks do not interface directly with IP applications. They essentially provide to the packet-switched access networks layer above the high-capacity point-to-point connectivity needed between sites, a mission for which the routing flexibility offered by packet-switching technology is not a must, but bandwidth optimisation is key.

The requirements of transport networks in the ATM domain are different from those of the TELCO industry. Not only are these networks mission-critical prior to being business-critical; their smaller scales and capacities further reduce the benefits of transport packet-switched technologies.

When applied to transport networks, circuit-switched technology uniquely offers the feature of complete traffic isolation between critical applications and redundancy chains. As user traffic is isolated from network management traffic, IT risks are kept at the lowest levels. In addition, the capacities of the circuits concerned can be defined individually according to specific application requirements.

In short, the simplicity, maintainability, maturity and deterministic behaviour that are inherent in well-known and proven circuit-switched technology will continue to make it a prevailing choice for transport networks supporting critical ATM applications.

Applications
ANSPs’ mission-critical transport networks must provide a robust layer with abstraction to the type of media used, its quality and any factors related to long-distance communications. At present, and for the next decade, the determinist carrier-class circuit-switched synchronous digital hierarchy (SDH) technology is and will remain the best candidate to offer mission-critical inter-site transport services at the capacity levels required by ANSPs. Its globally-recognised protocol robustness, allied to its inherent bandwidth scalability and its competitive equipment costs make it optimally suited to the requirements of the ATM industry.

Impact

<table>
<thead>
<tr>
<th></th>
<th>CNS</th>
<th>ATM</th>
<th>AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>none</td>
<td>low</td>
<td>medium</td>
</tr>
<tr>
<td>2005</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>2010</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>2015</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>2020</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>2025</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
</tbody>
</table>
The basic concept of cloud computing is to offer the three core elements of IT – computing power, storage and network access – in an abstract and standardised way. A cloud user no longer knows on which microprocessors and disk drives their application is currently running: they just access these resources via the network, and the rest is handled by the underlying technologies.

Large service providers need this kind of technology because their applications require more performance than any server could provide. The approach also allows them to rent out free capacity, of which there is a lot outside peak hours, to third parties in the form of virtualised infrastructure, platforms or software.

It’s an approach that appeals to a wide range of customers. Some lease MS Office over the web instead of purchasing it; some run web applications in the cloud; and some buy cheap CPU cycles on the spot market to run computationally-intensive simulations, research or even hacker programs.

Similar concepts can also be applied in-house: the technologies required for server, storage and network virtualisation are all commercially available and are evolving fast. The economic potential here is significant: if well executed, a private cloud solution requires less energy, less floor space and less human support than conventional set-ups.

The potential pitfalls are sizeable as well, though. Since a cloud set-up involves different areas of expertise, it is highly interdisciplinary. Let’s look for example at one of the network aspects. A modern blade centre adds at least two elements, a software switch within the virtualisation software itself and a physical switch within the chassis which finally connects to the traditional network switch in the rack.

If it is not well defined which element is doing what, the risk of network issues or security breaches is significant. Similar risks lurk in other areas. Industry analysts expect a drop in availability and security within enterprises that rush into virtualisation on a case-by-case basis instead of defining a harmonised architecture, since only the latter can offset the complexity added by the intermediate layers. Let’s not be one of them.

Applications
Cloud technologies offer the potential to enhance the efficiency of an ANSP. In some areas, such as portals for company and AIM information, public cloud services are an option. Parts of ATC data processing, meanwhile, would fit well within a private cloud infrastructure.

Impact

<table>
<thead>
<tr>
<th>CNS</th>
<th>ATM</th>
<th>AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>low</td>
<td>medium high</td>
</tr>
</tbody>
</table>

Ever since some of the world’s largest internet content providers started to sell spare capacity within their highly-scaled IT infrastructure to third parties, “cloud computing” has become a darling of IT publications. But there’s more to it than just the hype: the underlying technologies are about to transform parts of our IT infrastructure.
Connecting the sky
Marc Schulte-Elte, TNV

Ever since the early 20th Century, safety-critical communications between ATC and aircraft have been based on voice communications using amplitude modulation. This vintage technology is not only inefficient in terms of the spectrum it uses; it is also prone to errors, induced by misunderstandings between ATCOs and pilots. In today’s crowded airspace, this form of communication has reached its operational limits. A new means of communication must be developed if we are to continue to handle the constant growth in air traffic volumes.

As far back as the early 1990s, ICAO was working together with partner bodies on a new Aeronautical Telecommunication Network (ATN), based on the then-available technology. At the time, there was no intention to develop an entirely new type of network; the strategy was to integrate the various existing ICAO air/ground and ground/ground networks into a single global framework.

One strong reason behind this strategy was the desire to permit the development of independent applications such as Controller-Pilot Data Link Communications (CPDLC), using the ATN to deliver the messages to the aircraft without having to worry about the sub-networks used. The sub-network which is now going to be deployed throughout Switzerland and connected to the ATN is named VDL2, which stands for VHF Data Link Mode 2. VDL2 is based on a digital modulation technique, and will offer a 31.5 kb/s data transfer rate.

The radio equipment used for VDL2 is very similar to the equipment in use today at our radio stations, and these may be integrated directly into the existing infrastructure. Promoted by the Eurocontrol Link 2000+ program and subject to an implementing rule issued by the EC (IR 29/2009), the combination of ATN and VDL2 has to be deployed in the European core region by February 2013. This must be done to reach the target date and develop synergies between the ANSPs of the core region, especially in the deployment of the ATN ground network with its specific air/ground router.

FABEC has now created a dedicated Air-Ground Data Link Task Force (AGDL-TF), which has been charged with designing the ATN network with the existing means of communication and establishing the technical operating concept. The task force has already created a consortium for acquiring the equipment needed, and will also act as one towards the aeronautical communications service providers. Skyguide has also signed a contract, within the framework of this consortium, to procure the necessary ATN/VDL2 equipment. The deployment of the network and the radio equipment is scheduled to begin in early 2012.

Application
The deployment of ATN/VDL2 will permit CPDLC to be implemented on the ATM side. This new means of communication will reduce the radio workload and thus enhance safety. It is also seen as the first step towards replacing traditional voice communications, and as a door-opener for the future digital communications envisaged.

Impact

<table>
<thead>
<tr>
<th>CNS</th>
<th>ATM</th>
<th>AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>low</td>
<td>medium</td>
</tr>
</tbody>
</table>

2000 05 10 15 20 2025
Why do accidents happen?
A recent study of hundreds of accident investigation reports produced during the past 50 years revealed that in the 1960s and 1970s, the most frequently-cited “cause” of an accident was technology. In view of this, it is easy to appreciate the great efforts that were made during these times by engineers and technicians to minimise the potential harm of their technological achievements. Quality control became a key concern, and careful design based on reliability and redundancy principles led to robust solutions that were prone to respond more adequately to unexpected developments when operated under uncertain conditions. Surprisingly, though, accidents continued to happen. And so, consistent with the need that we human beings have to explain accidents by producing “proximal causes”, society’s attention suddenly focused on the next possible fallible system component: the operator. As a result, in the 1980s and 1990s, the most popular explanation for an accident or failure became “human error”. Time, then, for hordes of psychologists to put huge efforts into better understanding these apparent human weaknesses that were newly responsible for causing accidents within otherwise safe systems. Many theories about human error emerged; and these in turn prompted an understandable tendency to develop more technology to either assist or replace those in charge of operating accident-prone systems. Again, though, accidents continued to occur. So what happened then?

Understanding complex systems
Following the previous “safety quests” engaged in first by engineers and later by psychologists, an increasing number of sociologists have now proposed another perspective on accident occurrence. Studies of such disasters as the loss of NASA’s Challenger space shuttle in 1986 have revealed that accidents can happen without any disruption to individual system components. This suggests that complex systems cannot be understood by breaking them down into independent elements and looking at these individually: the whole is always more than the sum of its parts.

Are reliable systems safe?
Stéphane Barraz, Head of Safety Reporting & Investigation, skyguide

For years now, there has been a prevailing belief within the technical community that designing and implementing reliable solutions make a positive contribution to safety. But is that really so? This question raises several issues that are worth addressing by those in charge of introducing new technologies within complex socio-technical systems. The aim of this article is to explore the well-known concept of reliability in the light of modern safety precepts.

Why do accidents happen?
A recent study of hundreds of accident investigation reports produced during the past 50 years revealed that in the 1960s and 1970s, the most frequently-cited “cause” of an accident was technology. In view of this, it is easy to appreciate the great efforts that were made during these times by engineers and technicians to minimise the potential harm of their technological achievements. Quality control became a key concern, and careful design based on reliability and redundancy principles led to robust solutions that were prone to respond more adequately to unexpected developments when operated under uncertain conditions.

In such a situation, the people involved will tend to do exactly what they are expected to do: adapt their performance to get the job done. This means, then, that failure and success both have the same source: people’s adaptive capabilities. And “human error” is nothing other than an after-the-fact social construct. In this respect, it is interesting to note, too, that High-Reliability Organisations (HROs) develop a culture within which failure is considered a normal by-product of operating complex systems under pressure. But let’s go back to our initial question: what is the influence (if any) of reliable systems in this context?

Highly reliable versus highly safe systems
Before we continue with this debate, it is important to understand the fundamental difference between reliability and redundancy. A “reliable” system is a system which satisfies its specified behavioural requirements over time and under given conditions, while a “redundant” system is a system which provides the service it was designed for independently of failures occurring at the level of its components. Thus, redundant design can be seen as a means to achieve reliability.

Let’s go back now to the idea that within complex systems, accidents emerge from the interactions that develop between perfectly-functioning components. In this context, redundancy – as a means to increase reliability – can be seen as making a limited and potentially dangerous contribution to safety. Limited because reliability only provides protection
against random component failures, and is by nature totally inefficient in addressing underlying system design errors; and potentially dangerous because reliability may introduce new interactions which are usually difficult to anticipate and understand at the system level. This leads us to the conclusion: highly reliable systems are not necessarily safe, and highly safe systems are not necessarily reliable.

Managing unruly technology
In formal terms, “unruly” is used to qualify something which is not amenable to discipline or control. In the present context, the term “unruly technology” is being used to describe the gap between our image of our control over technology through design, certification, regulation, procedures and maintenance on the one hand, and the messy interior of that technology as it behaves when released into a field of practice.

Following the argument developed above, a safety perspective that is based only on redundancy and reliability design is insufficient, because it imposes a “component-based bottom-up approach” which provides only limited and sometimes dangerous protection against accidents. That perspective needs to be supplemented by a “top-down” approach which considers the system as a whole, as an aggregation of redundant components engineered to provide reliable services.

Adopting this dualistic perspective at the earliest possible stage of system design is one potential way to better understand and manage unruly technology and increase our chances of being effectively protected against accidents. This does, however, require from us a willingness to adopt challenging safety perspectives which, for instance, renounce the traditional and very popular idea that accidents develop in a linear and causal-effect manner.

In other words, we need to abandon the well-known and very reassuring “Swiss Cheese” model introduced by psychologist James Reason 20 years ago. It’s a long and difficult road, and it calls for a profound paradigm shift at all levels of our society. So: there’s a long way to go. But having read and hopefully understood the essence of this modest article, you’ve taken your own first step in that direction!

Sources used in the writing of this article:
- Marais, K., Dulac, N., Leveson, N. (2004). Beyond normal accidents and high reliability organizations: the need for an alternative approach to safety in complex systems. MIT, USA.