BLUEPRINT

THE 2015 SKYGUIDE TECHNOLOGY OUTLOOK
Dear reader,

With this 2015 edition of our Blueprint publication we report again from our Virtual Center Program. We are currently designing the technical foundation, so we can begin the process of flexibly managing any sector of Swiss airspace from either of our two control centers.

When I joined skyguide last year, I found a very open-minded and passionate organization. I encountered a strong identification with air navigation services and a very special sense of togetherness.

It also happened that early on in my new role I was called into the Crisis Management Organization, due to a chain of small failures in our usually highly reliable systems. I experienced how fast and efficiently the problem was identified, tackled and solved.

Still new to the organization, I watched how the right people from different units and teams with different expertise and skills scrambled to «fight the fire» which the interface mishap had caused on the operation’s side, how they contained it and how they then fixed the issue. This is an organization which is good at what it does. Crises will happen again, and we will respond again.

I am confident today that with this commitment, this attitude and this expertise, we have the safe basis for an innovative program such as the Virtual Center. And despite the fact that we will be pulled out of our comfort zone, we will have to learn new ways to build solutions and may be scared sometimes of our own courage, we will reach the goals we are setting.

Thank you for taking the time to review our progress.
I appreciate your continuous support in this endeavour.

Sincerely,

Klaus Meier
The air traffic management (ATM) technical world has one huge advantage: all we have to do is look at the global IT market to see what our technological challenges will be for the next ten years!

Doing so has led us to one clear conclusion: we can improve the provision of our technical services by aiming for a systems architecture that is structured around a simple «layered» vision. But providing our ATM technical functions through this «layered» view is quite an innovation in an ATM environment that is more used to vertically-oriented or even completely monolithic architecture.

The architectural approach inspired by the usual systems architecture design methods leads us to identify the following layers:

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<tr>
<th>Layer</th>
<th>Description</th>
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<tr>
<td>Human Machine Interface / User Interface</td>
<td>Flexibly sharing the provision of air navigation services between existing centers and underlying technical services through a few common data providers and systems suppliers.</td>
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<tr>
<td>Technical ATM functions</td>
<td>Structured according to the functional airspace blocks.</td>
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<td>Common Integration Platform (CIP)</td>
<td>Deployment of the technical functions on a CIP using Enterprise Service Bus and Application Servers products.</td>
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<td>Virtualized Platform</td>
<td>The CIP Layer with application is deployed on a virtualized platform («Platform as a Service» approach).</td>
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<tr>
<td>Network</td>
<td>The Virtualized Platforms are laying on a full IP Network creating geographically independent universal access to the data feeders.</td>
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<td>Infrastructure facilities</td>
<td>Adequate to reach the expected Performance Requirements.</td>
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These ideas are nothing revolutionary in the IT world. But the challenge really starts when it comes to translating the ideas into concrete projects that are aligned with the existing legacy environment. And it is this transition from a vertically-integrated technical world to a layered one that is the subject of most of the articles in the next few pages.

The architectural approach inspired by the usual systems architecture design methods leads us to identify the following layers:

- With vertical functional integration, any new functional requirement may mean modifying all the systems on the map.

- Information exchanges through bilateral dedicated links produce a real «spaghetti» network.

- Data replication where the same data are repeated through systems (historically to ensure performance) can end up with slight differences.

These issues are all making the evolutions expected by the business environment and the European programmes more and more complex and more and more expensive. But by drawing on the progress in System Wide Information Management (SWIM), this layered approach will, as in other industries, enable us to address the differing challenges at the right specific layer without disturbing all the others.

The Air Navigation Service Providers (ANSPs) will also have to re-examine their role in the provision of some of these layers. And this may open up new prospects for them to benefit from economies of scale, at the regional or the European level.
Service-Oriented Architecture (SOA) is being promoted in our industry as the next evolutionary step in software architecture to help IT organizations meet and master the increasingly complex challenges they face. Is it real, though? And even if it can be outlined and described, can it really be implemented?

We are sure that the answer to both is yes!

But how does SOA work? The analogy of Lego bricks.

The four characteristics of Lego bricks which are most appropriate to illustrating the strengths of the business services provided via SOA are that:

- Lego bricks are inter-usable. And standardized interfaces are the secret to this inter-usability. To be more precise, in SOA it’s the service contract that matters. We call this encapsulation.

- Lego bricks are unbreakable. It’s not that they are truly unbreakable, but rather that Lego has designed them with significant robustness in mind. In SOA we call such a design for robustness loose coupling. And it means that if one service crashes, it won’t affect the whole system.

- Lego bricks are composable. And with SOA services can be composed into applications that implement business processes in a flexible way. We call it interoperability.

- Lego bricks are reusable. And just as you can reuse a Lego brick in different constructions, you can reuse a specific SOA service in different applications.

Lego bricks and service granularity

But, to extend the analogy, what is the best size for a Lego brick? The point here is that fine-grained services aren’t particularly valuable to a business by themselves. At the same time, services can also be so coarse-grained that they’re too inflexible to meet the business’s needs. The optimum granularity for services generally falls somewhere in the middle.

The SOABASE project

The SOABASE project is supporting skyguide’s Virtual Center initiative, by providing an advanced technical platform for producing and consuming technical services. SOABASE has been tasked with evaluating, designing and implementing a suitable SOA-based Common Integration Platform (CIP).

The various phases of the SOABASE project are:

- specifying the requirements and creating the architecture blueprint;
- submitting the Request For Proposal to a pre-selected list of vendors;
- evaluating the responses, including conducting a proof-of-concept for the shortlisted vendors;
- making a final decision and preparing a contract;
- the rollout of the CIP.

The CIP will run on the new network services provided by the NetBase project and on the new virtual hardware provided by the VIS@S Project. To ensure its coherence, all the services deployed on the CIP will have to comply with a number of rules established relating to such areas as reference architecture, data modelling, governance and ICT security.

Applications

The services, Human Machine Interfaces (HMI) and legacy systems that will be connected to the new Common Integration Platform are all defined in the Architecture Definition Document (ADD). The transition plan is specified in the Virtual Center Program. The first applications to be deployed on the new CIP will be the Flight Object Service and the Route Expansion Service.
The need for flexibility and efficiency can be met with a very well-known solution: infrastructure virtualization. The concept here is to share physical resources such as the processor, memory or storage between virtual machines (VM). The great added value in this approach is the ability to create or delete a host in a few clicks and allocate resources to it dynamically. This massively reduces the server/application ratio; and this in turn delivers a drastic improvement in both data centre agility and cost efficiency.

When multiple virtual machines run on a single physical host, however, they will be sharing the same physical resources. This adds a level of unpredictability to the performance that may be exhibited (compared to what is expected) by any individual virtual machine. For example, a VM with a temporary compute-intensive peak might disturb the other VMs running, causing a significant and undesirable temporary drop in their performance. The same thing can happen through a VM flooding the memory or a network adaptor.

What we need to do, therefore, is to find a compromise between predictability and flexibility.

And what about reliability and resilience? Resilience is one of the key benefits of infrastructure virtualization. This is because resources can be shared not only on a single physical host but also between multiple physical machines. A VM can be started on one host and moved to another manually or automatically, based on certain rules. It can also be restarted on another host in the event of a hardware failure, or even hot swapped to a secondary host with no service interruption. Redundancy is fully delivered here at the infrastructure level, meaning there is no need to implement complex scenarios at the application level!

In terms of reliability, looking at the end-to-end chain, the virtualization layer is obviously an additional source of possible failure and adds overhead, too. But the technology is now clearly mature and very stable, so in practice this overhead is negligible. At skyguide, the technology has been in use in simulation since 2006 with no negative feedback; and other ANSPs such as MUAC have already gone a step further ahead.

When it came to defining the systems architecture for its Virtual Center, one of skyguide’s main challenges was to provide a technical solution to host the Common Integration Platform (CIP) bridging all application services. This key element of the architecture can be seen as a single point of failure, as all services will be integrated through the CIP. If the CIP goes down, the entire information system will be turned off. And in view of this, a fault-tolerant and redundant virtual infrastructure has been selected to support the CIP.

The skyguide virtual platform will be composed of two isolated and self-redundant virtual instances, each consisting of two or more servers and two replicated storage systems. All the connections between these elements are also being provided with all the redundancy required. The aim here is to get the very best out of all the technology: isolation for predictability, and redundancy for availability, reliability and resilience.

Applications
As it is currently being studied, a SOA framework could help define and shape the look of skyguide’s ATM and AIM systems in the decades ahead. SOA could also help to orchestrate a series of business process-aware services around the flight object: one for trajectory calculations, one for route extractions, one for coordination and so on.
Communications between air traffic controllers and pilots still rely on voice and a very old technology: Amplitude Modulated radio in the VHF (and UHF) bands. This technology will not be superseded by any new air-to-ground communications standard before 2040 at the earliest. In view of this, and even though the new Virtual Center is prompting the adoption of brand-new technical architectures and standards, we must find smart solutions to respect the specific characteristics of ATC speech and adapt key radio functionalities throughout the new Virtual Center radio chain.

Description
According to Albert Mehrabian, who is currently Professor Emeritus in Psychology, there are basically three distinguishable elements in human communications: words, which account for 7% of the communication; tone of voice, which accounts for 38%; and body language, which accounts for 55%. This is known as «The 7%-38%-55% Rule».

In the ATM world, pilots and air traffic controllers cannot establish visual contact to communicate. As a result, they talk with each other through radio using the standardized ICAO phraseology. This solution is efficient, and has the sizeable advantage of reducing the risk of incidents due to communications misunderstandings.

The studies conducted by Mehrabian – and, incidentally, our own experience – clearly show that tone of voice is more important than words in communication terms. As a result, and beyond the intelligibility of the message itself, speech characteristics such as speech flow, loudness, intonation and intensity of overtones must be preserved as extensively as possible throughout the radio chain.

Our current skyguide radio architecture will be deeply impacted by the Virtual Center initiative. Up to now, hundreds of robust and high-quality point-to-point circuits have been installed between each item of radio equipment and its local radio Voice Communication System (VCS) to provide voice communication channels for both pilots and air traffic controllers that are as «transparent» as possible. From 2017, though, this situation will change, because any air traffic controller will be able to access any radio equipment from any working position.

As a result, the present static point-to-point solution will be replaced by a new technology that is able to deliver dynamic or «on-demand» voice connections: Voice Over Internet Protocol (VoIP).

This evolution was already triggered by the telecom operators some years ago and European regulations are now asking all the continent’s Air Navigation Service Providers to implement the ATM VoIP standard by 2020. That’s convenient for skyguide: it coincides perfectly with our own Virtual Center planning.

The challenges ahead of us here are not negligible, though. In fact, we will be keeping a very high-quality radio service by combining VoIP and Radio Frequency (RF) technologies. By migrating from a circuit- to a packet-based network architecture, we will also be dealing with new issues – voice compression, delays, jitter and packet loss. And these will affect not only specific ATC speech characteristics such as the speech flow, but also some key radio functionalities such as the frequency coupling and the climax. The adoption of this new architecture will also have an impact on the organization. And we will need to define new and clear rules between the network and voice/communication system teams to manage the different network layers and protocols in a safe and efficient way.

Applications
Radio services are vital to skyguide’s operations. The new Virtual Center will not change this; so air traffic controllers and pilots will still need to be provided with a robust and high-performance radio architecture.

Our challenge here will be to combine the RF and VoIP technologies in a smart way, so as to maintain the very high availability and reliability levels that we have consistently achieved for years. This is not enough in itself, however; and the greatest challenge that we will probably face is respecting the transparency of the specific ATC speech characteristics and adapting some key radio functionalities through IP.
Towards full IP networks: a challenge for skyguide

Nicolas Devincenti, Head of Internal Services Networks, skyguide
Marc Epalza, Enterprise Architect for Network Services

A pan-European approach under the umbrella of ICAO, CANSO and Eurocontrol is leading to an increased sharing of information among all the members of the aeronautical industry, including ATM, based on standard IP technology. But why should ANSPs migrate towards full IP-based applications, and thus networks? Besides the market pressure, there are major benefits for ANSPs here; but there are also challenges along the way. And this change will affect all technical aspects at skyguide.

Description
Communications service providers and equipment vendors are phasing out their support for legacy protocols such as X.25, analogue voice and time division multiplexing (TDM). Future networks will be fully Internet Protocol or IP-based, and ANSPs will have to adapt and migrate their applications to operate via IP. Besides the market trends, other drivers are also pushing towards an all-IP world. These include regulatory pressures mandating some applications on IP, and our own Virtual Center initiative, which demands more flexibility in communications.

Having a full IP network will allow skyguide to consolidate all types of application data on high-availability mission-critical IP infrastructure. It could also significantly reduce the current costs of national and international multi-technology ANSP interconnections. Standard IP networking will also transform ground ATM communications by providing a harmonized, secure and cost-effective connectivity service for all ATM stakeholders. And finally, full IP communications will facilitate increasing levels of automation and the expected predominance of data over voice exchanges.

The major challenge in all this is the complex migration of legacy infrastructure from TDM to ground communications networks based on IP technologies. The two technology types differ greatly, both in normal operation and in their response to failures. The high-reliability requirements of ATM demand a relatively strong coupling between the network and time-sensitive voice/data communication needs. And security, almost a given in the TDM world, will also be a major challenge in a fully internetworked IP world.

If the migration is to succeed, we will need to ensure very close collaboration and coherence among all the parties involved, both during the transition and in the resulting full IP world – on the technical side to ensure that the end-to-end solution allows networks to seamlessly and securely transport all data following their specific functional and non-functional requirements, and on the governance side to manage the exchange of information between stakeholders via interoperable services, as defined by Service-Oriented Architecture (SOA).

Applications
All skyguide’s technical units are affected here: Data Processing mainly through SOA and virtualization, and CNS with Radar and Voice over IP (VoIP). SOA lays the foundation for the distribution of functionality, be it national (the Virtual Center) or international (System Wide Information Management or SWIM). Virtualization requires high bandwidth and low-latency transparent connections. Radar requires low delay with zero packet loss. Finally, VoIP replaces static circuits with dynamic packet flows, keeping to very strict delay requirements.

The transition is already under way. But in our niche market, the last legacy systems will probably remain operational for another decade.
Improving the technical contribution to explicit safety
Dr. Patricia Bomme, Head of Safety & Compliance, skyguide

This article presents ideas driving the safety activities conducted in technical projects of the Virtual Center in line with the new «Accident Incident Model» safety approach developed by skyguide’s Safety unit. These ideas result from analyses of the current situation and our intention to transparently contribute to explicit safety. This, while facing the challenges emerging from new technologies and supplier involvement.

Description
Skyguide’s current safety activities are well integrated into its processes and are systematically applied. At the same time, however, the present safety approach does suffer from limitations relating to its underlying principles. Specifically, its being change-centric and based on the «existing-is-safe» assumption. These two principles prevent skyguide from creating and maintaining an explicit safety risk overview of the existing situation. But in the near future, obtaining and maintaining such a safety risk overview will be essential if we are to achieve safety excellence and meet the regulators’ expectations.

Being change-centric means that the hazard definition is linked with the scope of the changes involved, and that hazard formulation varies with the granularity of such changes. Without an agreed level at which safety hazards are defined, incremental hazard consolidation is impossible. And as consolidated information is unavailable, similar analyses are repeated for different changes. Eventually this creates a perception of inefficiency.

In addition, the safety data produced during safety assessment workshops do not have any defined life-cycle. These data remain scattered around the changes, hidden in multiple safety case documents, and it is impossible to develop any consolidated view. The safety requirements relating to equipment can be neither identified nor traced back to their originating hazards.

The creation of the Virtual Center relies on new technologies that are organized around the concept of a Common Integration Platform delivering a Service-Oriented Architecture. These new technologies will coexist with the existing ones used for legacy systems.

External suppliers contribute in a different way here than they did before. Our job is to ensure that safety changes accordingly. On the one hand the supplier is responsible for the execution of activities; on the other hand we remain ultimately accountable for the results of these activities.

Technical architecture is complex and difficult for our partners to understand. This can cause misunderstandings which might induce doubt and mistrust. To prevent this, the technical contribution to safety must be transparent, structured, documented, understandable and usable by other stakeholders.

The implementation of the Accident Incident Model (AIM) provides a means of establishing a standard level at which hazards are identified and maintained. This will lay the foundation upon which a consolidated view can be acquired. Given the Virtual Center implementation timeframe and organization, though, it would be unwise to wait until this approach is totally crystallized before starting our homework without endangering the final result.

It is thus our duty to drive the activities in technical projects according to a documented vision. This vision describes the current situation, highlights challenges and defines objectives. And it will guide us to produce and organize the information needed for the new safety approach which is now under development.

Applications
The Virtual Center technical projects will identify the activities to be conducted that produce the necessary safety data for further consolidation. This can only be meaningfully done, though, if the gaps in time between technical projects are closed. Organizing a transversal sharing of safety data will close these gaps.

Safety vision contributors

- **Upcoming Regulations**
  - NPA 2013-008: Requirements for ATM/ANS providers...
  - NPA 2014-013: Assessment of changes to functional systems...

- **Stakeholder Needs**
  - T Lines
  - Program Safety Manager
  - Program Compliance Manager

- **Existing Compliance**
  - Surveillance Chain Safety Case
  - Interoperability
  - QMS & SMS

- **Virtual Center**
  - Target & Transition Architectures
  - VC Project Charter
  - VC Roadmap

- **Vision incl. High-level Objectives**
**Virtual Center: collaboration company-wide and beyond**

Klaus Meier, Chief Information Officer, skyguide

An undertaking like skyguide’s Virtual Center Program (VCP) is not «business as usual». The VCP cannot be tackled simply as an additional project in our portfolio. It is massive in its requirements, and will have a deep impact on how we run our operations tomorrow and how we provide our technical services in the future. It is the question of «how to eat an elephant?» The obvious answer – *in small bites* – reveals the challenge and the risk. Make the pieces too big and we might choke; make them too small and it might take too long.

**Description**

Being a multi-year program, the VCP has been split into phases or waypoints to ensure that we are moving in the right direction, to create benefits en-route and to periodically re-energize the program organization. The program thus consists of several «tranches», which refer to the major conceptual operational phases:

**Tranche 1**: New harmonized services built on top of the existing different systems in Zurich and Geneva

**Tranche 2**: Joint upper airspace management based on a mixed hybrid system architecture

**Tranche 3**: Joint airspace management based entirely on the new system architecture

**Tranche 4**: Inclusion of external services.

**Technical capability development**

Tranche 1 is currently finalized and can simply be summarized with the successful launch of the first-of-class stripless solution for Geneva and Zurich, together with sector harmonization of the two different upper airspaces.

In Tranche 2, which we are currently preparing, our emphasis is on information technology. Here we are building the systems foundation which will permit the seamless and flexible management of any airspace sector from either of our two control centres. This new systems foundation is based on architecture and service orientation, and requires a new approach in how to design, build and operate air navigation services.

**Application**

Managing the risk is critical in such an undertaking, and we are taking prudent steps here. From a technical viewpoint we have decided on a «hybrid approach» for Tranche 2, building up the new systems in parallel to the existing legacy solutions. This will enable us to move functionality from the legacy environment to the new systems in defined pieces or layers.

The challenge here is to combine existing expertise with new knowledge and skills – some of which are coming from outside our domain, are new and demand a modified organizational approach to how we plan, design, develop, test and launch solutions for skyguide.

A thorough planning and design phase is equally critical. Here we define the parameters and guidance within which we can operate as an enterprise. It’s all about working out the «what» and the «how», in close collaboration between the stakeholders and the stakeholders’ experts. And in simple terms, it ensures that we know what we want to do and how we want to do it.

We rely on having good people. Good staff are usually already busy: they don’t sit around and wait until a project comes along. But unless we focus, prioritize our activities and identify the correct staff for critical projects, we will fail. After all, it’s the right people who make a program successful.

At skyguide we operate in a highly regulated environment, and following procedures is intrinsic to how we work. At the same time, we take care to ensure that we don’t follow processes «because we have to follow processes». The process supports us to meet the objective. Project managers and subject experts lean in, declare and expose themselves in order to lead to the target. They take responsibility and are accountable for what they do – even for the things they don’t know yet.

We also look and ask for help from outside of our expertise and comfort zone to do what we want to do. Where it makes sense and where we have the opportunity to do so, we use ideas even if they were not invented here. We operate in a cross-functional and a cross-company set-up, too. Successful innovation thrives on different perspectives.

At the end it comes down to the fact that we collaborate within skyguide, with our partners and with our suppliers. We look for support and ideas where we can get it and we take responsibility because we feel strong and enjoy working together.
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<th>Abbreviation</th>
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<td>ACC</td>
<td>Area Control Center</td>
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<td>AM</td>
<td>Amplitude Modulation</td>
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<td>ANSP</td>
<td>Air Navigation Service Provider</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<td>CANSO</td>
<td>Civil Air Navigation Services Organization</td>
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<td>CNS</td>
<td>Communication Navigation Surveillance</td>
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<td>ICAO</td>
<td>International Civil Aviation Organization</td>
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<td>IP</td>
<td>Internet Protocol</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>RF</td>
<td>Radio Frequency</td>
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<td>SOA</td>
<td>Service Oriented Architecture</td>
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<td>SWIM</td>
<td>System Wide Information Management</td>
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<td>TDM</td>
<td>Time Division Multiplexing</td>
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<td>UHF</td>
<td>Ultra High Frequency</td>
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<td>VCS</td>
<td>Voice Communication System</td>
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<td>VHF</td>
<td>Very High Frequency</td>
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<td>VC</td>
<td>Virtual Center</td>
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<td>VoIP</td>
<td>Voice Over Internet Protocol</td>
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<td>VCP</td>
<td>Virtual Center Program</td>
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