AEROSPACE SYSTEMS OF MONITORING AND MANAGEMENT

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THE VISION FOR THE NEXT GENERATION OF AIR TRAFFIC MANAGEMENT SYSTEMS

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The introduction of contemporary Next Generation Air Transportation System (USA) and SESAR – the New Generation of Air Traffic Management Systems in Europe is considered.

Розглянуто питання впровадження сучасної Авіаційної транспортної системи наступного покоління (США) та СЕСАР – Системи організації повітряного руху нового покоління в Європі.

Introduction

Most forecasts show that 20 years from now there will be two to three times the passengers, flights and cargo. The Federal Aviation Authority predicts that even more airports will be congested in the 2020 time frame (fig. 1).

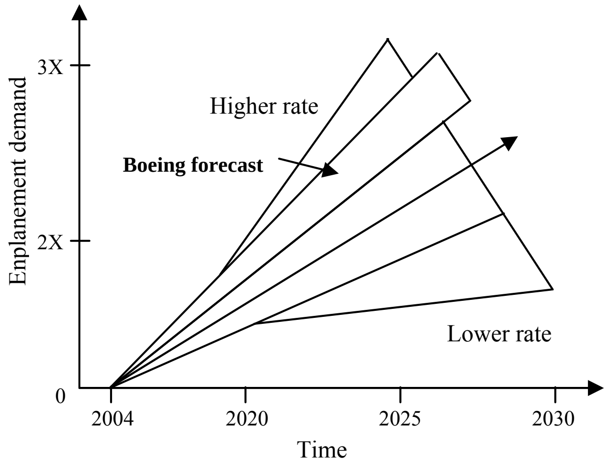

Fig. 1. National range of future demand projections

Clearly, the existing system was not designed to meet this growing demand for air service. It was not designed to handle all of the new security enhancements that were layered over old ones. It was not designed to allow for anything the future can throw at us. The paradigms we have relied upon for almost previous years cannot accommodate the massive change that has already begun.

Air traffic is forecast to grow in Europe at an average rate of 3 to 5% per annum for the next twenty years [1]. Overall, air traffic in Europe will have doubled by 2025. For some city pair's traffic will increase by larger factors.

This expected growth raises a natural question about the ability of the Air Traffic Management (ATM) system to at least double its current capacity.

Even if history has witnessed such a spectacular capacity increase over the last twenty years, this was done mainly through new operational procedures (airspace design, enhanced coordination, traffic management, etc.). One must acknowledge that, as far as technologies are concerned, Air Traffic Control remains principally operated the way it was operated twenty years ago. The current technologies are also beginning to face versatility, perennity, and scalability problems, which contribute to an overall concern on the suitability for accommodating more traffic while maintaining high levels of air transport safety.

It is now widely recognised that, in order to sustain safely and efficiently the expected air transport growth, a 'paradigm shift', supported by state-of-the-art and innovative technologies, is necessary.

Coordinated, parallel activities are underway between the United States and Europe to significantly change how air traffic management will operate. Transformation efforts are targeted at a significant growth in traffic, passengers and cargo. Europe and the United States recognize that air transportation is a significant element of global and national economies. Also there is the information about the Single European Sky air traffic management research (SESAR) that describes the similar approach and the need for integration between the United States' Next Generation Air Transportation System and efforts in Europe.

The Next Generation Air Transportation System (USA)

The Next Generation Air Transportation System (NGATS) will include a number of capabilities that significantly increase the capacity, safety, and security of air transportation operations and through doing so, improve the overall economic well being of the country [2–4].

These benefits will be achieved through a combination of new procedures and advances in the technology deployed to manage passenger, air cargo, and air traffic operations. The NGATS will have a number of features that are only nascent in today's National Airspace System:

– an information-rich environment supporting distributed decision-making, utilizing the principles of network-enabled operations, while including appropriate security and privacy mechanisms for access by individuals or by automated decision-support tools;

– highly automated information integration systems, moving beyond automation of "human-centered" tasks to more direct management of data, processes, and traffic flows;

– a set of performance-based services, with more service tiers than today, providing direct benefits for operators who invest in advanced flight planning systems and avionics.

In addition, management of National Airspace System resources will become more dynamic with an emphasis on the shifting of infrastructure and human resources to meet rising demand and increasing complexity of operations.

Next Generation Air Transportation System Products include following materials.

1. Operational Concept – the starting point for the NGATS, it describes in detail the key design principles used to guide the development of the Next Generation System. It also lays out the eight key capabilities missing from the current system, but which will be an integral part of the future one.

2. Evaluating the Concept – a preliminary analysis was conducted that assessed and subsequently validated the NGATS' ability to accommodate three times the current number of National Airspace System operations while maintaining or reducing the current level of delays.

3. Next Generation Air Transportation System Roadmap – a high-level path was created for achieving the eight key capabilities. It also identified important transition states and sequences and mapped them to the timeline leading to the envisioned future system.

4. Next Generation Air Transportation System Portfolio Management – focused on time-phased portfolios of specific improvements; the research, analysis and demonstrations that will lead to these future system gains; and the investments contained in the roadmap needed to achieve them.

The concept also emphasizes end-to-end strategic flow management with minimal individual flight interventions.

The Next Generation System will be highly automated and network centric so users get the right information to the right person at the right time keeping the nation safe and the flow of traffic running smoothly (fig. 2).

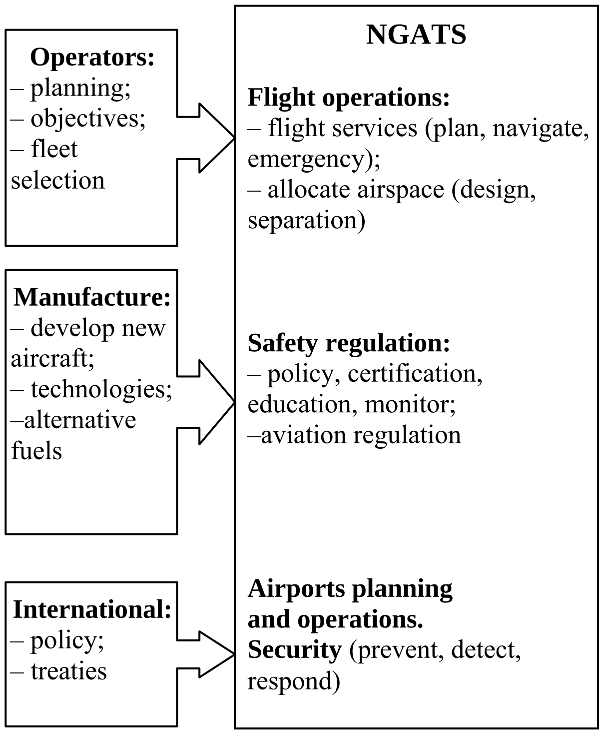

Fig. 2. NGATS Scope and Periphery

And users will increasingly cut the cord between ground and air as they put more data directly into the cockpit of intelligent aircraft through sensors and satellites.

The future system has safety and efficiency built right into it. Ultimately, air traffic management services will be tailored and flights will be managed based on individual aircraft and flight crew performance capabilities.

Users can reward aircraft that have advanced efficiencies and capabilities, such as precision navigation and the ability to land automatically, by allowing them greater operating flexibilities, such as flying in all but the worst of weather.

That way a pilot can alter course and pick the fastest, smoothest and safest route and get you to your destination on time.

And through data sharing users will move from the old command-and-control regulations to risk management so they can prevent accidents before they happen.

Users can increase capacity three fold while bolstering our enviable safety record.

To help in reaching this bold operational concept, was created the NGATS Capability Roadmap.

It sets forth a clear, high-level path, timelines and key transition states and sequences leading to the 2025 system. And based on the roadmap, was developed the first portfolio of needed policy, research and modernization efforts.

It is also laid out in the progress report the findings of the first preliminary interagency program review where were identified six examples of how the partner agencies could collaborate during 2007 to accelerate NGATS capabilities. They are:

(1) jump-start ADS-B;
(2) jump-start Network Enabled Information Access;
(3) synchronize weather research and accelerate development;
(4) define Required Total System Performance levels of service;
(5) initiate dynamic airspace research;
(6) align environmental R&D.

The concept is multi-dimensional in scope– incorporating technological innovation, but also addressing the critical aspects of change and innovation in organization, culture, and policy. Safety in the NGATS is approached in a prognostic fashion, establishing a new safety culture that assesses risk in a predictive environment, instead of the existing reactive context. The system will enable integrated management of environmental performance to foster continued growth of aircraft operations in an expected future where the environmental impacts of aviation are increasingly scrutinized.

Key to the complete success of NGATS is the ability to match land and airside meet future demand. The realization of the previously described capabilities will enable peak throughput performance at the busiest airports while protecting the communities. Airport taxiway and runway configuration requirements will be specified to enable high capacity traffic operations on the airport surface. Arrival and departure spacing will be reduced, as a result of enhanced surveillance and navigation performance and the development and integration of tools to detect and avoid wake vortices.

Capacity will be increased with closely-spaced and converging approaches at distances closer than currently allowed and through simultaneous operations on a single runway.

The airport "landside" (including security systems) will be sized to match the passenger and cargo flow to the airside throughput.

SESAR: The New Generation of Air Traffic Management Systems in Europe

The European Union's Single Sky legislation, adopted in 2004, sets out an in-depth institutional reform of ATM.

It enforces the principle of separation, within Member States, between regulatory activities and service provision; establishes the ground for substantial cross-border operations, and sets up the framework for operational and technical interoperability standards in Europe. Moreover, the Single European Sky confers extensive competencies to the European Commission, using "comitology" principles, under which the European Commission discusses with the Single Sky Committee, made up of Member States and consults the stakeholders through the Social Dialogue and the Industry Consultation Body.

The Industry Consultation Body consists of stakeholders from industry, including aircraft operators, airports, staff representatives, manufacturing industry and air navigation service providers.

These competencies in particular give the European Commission the possibility to mandate equipage of specific technologies for aircraft flying in the European Union's airspace, or for ground systems. The Single Sky legislation also offers the possibility to earmark in the route charges a specific contribution to "projects of common interest".

The Single Sky legislation therefore enables the aeronautical community in Europe to solve one of the most important shortcomings for efficient implementation of a modernized ATM system: lack of cohesive decision-making and commitment by the many stakeholders.

A challenge has also been to achieve the optimal overall functioning of the network, which consists of the aircraft operators, airports and ATM. In this network, the processes and decisions of many different actors and their competing objectives interact closely, both at the planning and operational stages, requiring high levels of information sharing and cooperation.

SESAR has been divided into two main Phases:

– the Definition of a European ATM Master Plan (up to the end of 2007);
– implementation, phased over the 2008-2020 period.

The SESAR Definition Phase will deliver a European ATM Master Plan up to 2020 and the work programme to execute it. It will also identify the actions and means to make change happen.

This ATM Master Plan will formulate operational concepts and propose new systems, as well as define the roadmap for their implementation.

The SESAR Definition Phase is a collaborative effort of the whole aviation industry, co-financed by EUROCONTROL and the European Commission.

It will bring together the full range of stakeholders and they will define, agree, and commit to the results of the ATM Master Plan.

In the definition phase, most of the work will be performed by a consortium comprising a representative sample of air traffic management stakeholders:

– aircraft operators, including general aviation;
– air navigation service providers;
– equipment manufacturers;
– professional organisations;
– airports;
– military, etc.

Non-European companies will also participate in the work.

The implementation of the Master Plan will start in 2008 and will organise the introduction of new technologies, resulting in a safe and efficient high-performance air transport system with minimum environmental impact by 2020. For the successful transition to 2020, it is necessary to perform, in parallel, a range of tasks supporting the short-, medium- and long-term developments. These range from innovative research to actual implementation.

However, from a programme perspective, the Implementation Phase is articulated around two main steps.

1. Development (2008–2013), including the development of those technologies upon which the new generation of systems will be founded. It will allow major functional advances, in particular in terms of automated assistance or task distribution between the air and the ground.

2. Deployment (2014–2020): large-scale deployment of the new systems and generalised implementation of associated functionalities. The resulting ATM system will represent the anticipated new generation.

For the implementation phase, the same level of commitment and buy-in from industry is needed. For this reason, the European Commission has proposed to the Transport Council and the European Parliament that a separate organisation for the management of SESAR be set up. This will take the form of a joint undertaking between the European Community and EUROCONTROL and, on its administrative board, contain industry representatives, including aircraft operators, air navigation service providers, equipment and systems manufacturers, airports and staff representatives.

There is a general agreement that the current fragmentation in the European sky translates into unnecessary costs and inefficiencies.

Less fragmentation of the European ATM systems means more fluid and economic traffic flows, more compatible system solutions, and a simplified regulatory framework.

SESAR means that the plans to develop the European air transport will be synchronised (both in a geographical sense and from a system–ground and air-perspective), and integrated from research to operations. In practice real issues will be more clearly identified and addressed more completely; research results will be exploited to their full potential and deployed more expeditiously, thereby allowing more cost-efficient use to be made of the important resources spent by the different actors (e.g. European Community, EUROCONTROL, aircraft operators, industry). This is of great value in an industry that faces strong competition and is under much pressure to save costs wherever it can. In creating SESAR, the future European ATM landscape is addressed consistently and holistically from an operational and a technical point of view. By jointly defining SESAR, the ATM actors will address all these difficult issues together.

SESAR will federate resources and increase the coordination of planning, development work, and decision-making in order to build the new ATM infrastructure which will increase air transport safety in Europe and sustain air traffic growth in the coming years.

Principles of life-cycle risk management in perspective Air Traffic Management systems

Life cycle risk management in perspective ATM-systems is a systematic, continuous, top-down approach to managing risk. Implementation of the life-cycle risk management requires a critical mass of expertise and captured both the engineering judgment as well as available quantitative data. The additional data may result from models, layouts, prototype testing, other focused risk evaluations and institutional experiences.

Risk management has some well defined phases and objectives. The main elements of risk management for perspective ATM-systems can be summarized as (fig. 3):

– risk identification;
– risk analysis;
– risk planning;
– risk tracking;
– risk control.

Using all of these elements is essential to the successful life-cycle risk management in perspective ATM-systems.

Risk identification

In order to manage risk, one needs to know what the risks are. They may result from a variety of sources including the technology content, environmental interactions, the implementation and operation approaches.

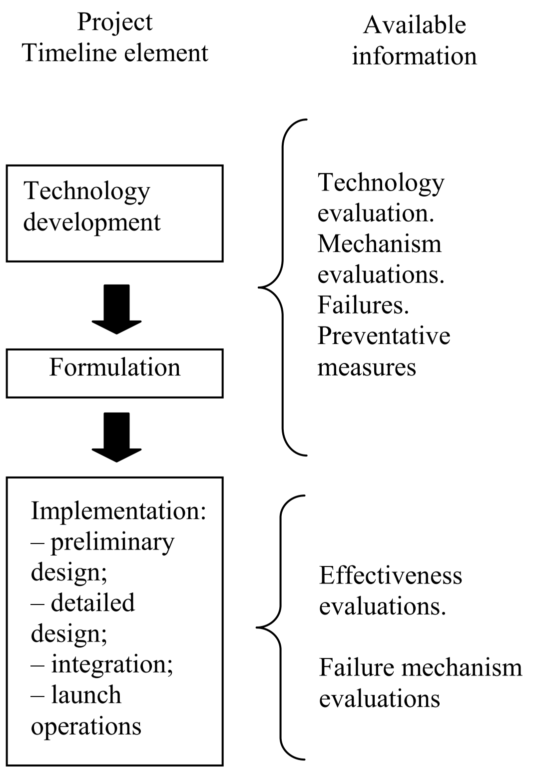

Fig 3. The life-cycle risk management

The process begins with articulating the requirements and then utilizes available project information, experts, and brainstorming to develop an initial tree of potential failure modes in perspective ATM-systems.

Risk analysis

Experts analyze the consequences of the potential risks (failure modes) by scoring their impact on the requirements should they occur. This results in a requirement-driven risk list where failure modes derive their criticality from their impact on (possibly) weighted requirements. This risk analysis also results in a prioritized list of driving requirements so it is immediately visible which requirements are at risk and to what extent.

Risk planning

The number of possible preventative measures available for implementation far exceeds the resources of any project. Furthermore, different preventative measures have different effectiveness against different failure modes. In most cases, there are also a number of preventative measures available for each failure mode of perspective ATM-systems.

Risk tracking

The risks can be listed and include the preventative measures which were selected to ameliorate their impacts. These preventative measures may often be examined in detail to ensure the adequacy of the overall mitigation approach. In addition, the user can generate a report of the preventative measures selected and what they were intended to prevent or detect.

Risk control

If requirements change, or preventative measures which were planned for implementation are not performed, or new potential failure modes are discovered , it is performed real-time modification of the resultant risk so the project always has an up-to-date top N risk list. This allows the team of developers to effectively control risk and watch it's growth.

Conclusions

Europe and the USA face the same challenges for the transformation of their ATM systems in order to be able to sustain air traffic safety and efficiency. NGATS on one side, SESAR on the other, are similar initiatives, and need to be coordinated in order to make sure that technology implementation is synchronised across the Atlantic Ocean. This has to be done institutionally, through cooperation agreements between the FAA and its European counterparts, and also at an industrial level. On the latter aspect, the SESAR definition phase will incorporate US industry contributions. Reciprocal arrangements should be enabled within NGATS.

References

1. http: // www. jpdo. aero / NGATS _ Institute. html.
2. http: // www. aero-space. nasa. gov / nra_pdf / airportal _project_c1.pdf.
3. http://www. simlabs. arc. nasa. gov / airport_ workshop /2005/airport_workshop/downloads/Fralick_NGATS.html.
4.http: // acast. grc. nasa.gov/resources/NGATS-Airpace _ test_fac.shtml.

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