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THE DEPLOYMENT OF AUTOMATION IN FUTURE ATM SYSTEMS

(Presented by the International Federation of Air Traffic Controllers Associations)

SUMMARY

Since the Eleventh Air Navigation Conference, ATM has moved nearer to implementation of a global system architecture that is predicated upon significant use of technology and new orders of automation. The desire to use automation, or the need, has not changed. Our understanding of the issues of automation deployment in ATM has, and this provides the industry with a new body of knowledge with which to draw upon. New lessons learnt, that could facilitate and guide us all in what we need for an effective deployment of such technology into the operational arena of the future.

This paper explores the role of the ATCO in future air traffic management systems and their needs to exploit the promise of automation. We contend that safe system operation can only exist because of the effective role played by the humans working collaboratively with the system. To achieve this, a number of facets of the human factors associated with automation are discussed. One of these facets relates to accountability and the responsibilities for both the humans and automated components of the future system. IFATCA emphasises this facet, in the belief that there is an overarching requirement for clear and unambiguous accountability and responsibilities for system actors, supported by an inter-operable rule and procedures set.

1. INTRODUCTION

1.1 The future evolution of ATM is predicated on greater use of technology and significant use of automation to enhance the ATM productive function bringing with it fundamental changes in how functional roles are undertaken and who the system actors will be that undertake these functional roles.

1.2 IFATCA believes that when considering future iterations of deployment and use of automation, there are several dimensions that need to be addressed to make the implementation of the future system designs successful. These dimensions are:

a) the nature of ATM of the future as perceived by the controller;

b) authority and responsibility;

c) the legal implications of future concepts;

d) change management and transition;

e) the human factors of automation; and

f) safety in the operational environment of the future.

1.3 We also contend that it will not be possible to predict total system behaviours because of the inherent limitations in the design philosophies of complex social-technical systems that exist today. Rather, each step of the deployment will need to maximize the lessons of the immediate and current deployment to create the knowledge that will allow safe transition to future iterations of system development.

2. THE CHANGING NATURE OF AUTOMATION

2.1 Automation is not new to ATM. Data transfer across FIR boundaries using OLDI has been a feature of ATM for many years. Code-call sign pairings were an early ATC automated function. The nature of the automation that is envisaged in future iterations of ATM is different from these. OLDI is an example of automation of information provision to ATM. The future envisages the use of automation in other functional areas such as control and management of the system and automation of some or all of ATM functional areas.

2.2 IFATCA's experience of automation in ATM, where automation is defined as the system replacing a function preciously performed by a human, is effectively limited to what Billings[1] refers to as 'information automation – the higher orders of automation such as control and management ATM has yet to truly experience.

2.3 The application of automation that is envisaged in SESAR and NEXTGEN is more than just an extension of the degree or 'level' of automation being employed. What is proposed will increase the complexity of the ATM system over what is experienced today, and will not see just one automated system implemented, but numerous sub-systems or networks of automation supporting a wider community of human actors to deliver new levels of system efficiency and network optimization. This will make predicting the outcomes of system behaviour quite futile in the ways that we conceive such matters today. The system of the future becomes truly complex, in that the outcomes of the possible number of interactions and system behaviours defy prediction because of the numerous ways that system components can interact.

2.4 Non-nominal and failure modes are mitigated by the presence of the human in the system today, and this is a feature of the future. SESAR acknowledges this when it states: "*to accommodate the expected traffic increase and complexity, an advanced level of automation support for the humans will be required"*[2]. In a similar way we can read that NEXTGEN: "*Air traffic controllers will become more effective guardians of safety through automation)*[3].

2.5 THE CANSO/IFATCA NGAP position paper published in February 2010, cites the following. Acknowledgement of the role of the human in the future ATM system: "*The human contribution will be crucial to run the future aviation business in a safe and efficient way, because the human component is the most flexible and adaptive component in the aviation system"*.

2.6 It is our contention that the synergy of automation technology and human needs to be mindful of these attributes and serve to enhance and not weaken or neuter them. To fulfil these ambitions, IFATCA proposes the following solutions.

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[1] Billings, C.E, (1997). *Aviation Automation: The Search for a Hunan-Centered Approach* Mahweh, NJ, USA, Lawrence Erlbaum
[2] European ATM Master Plan (2011), page 141, first edition
[3] FAA's NEXTGEN implementation plan, (2011), page 20

3. THE NATURE OF ATM OF THE FUTURE AS PERCEIVED BY THE CONTROLLER – HUMAN-CENTRED AUTOMATION *QUO VADIS*

3.1 Many developments in ATM have evolved principally as a result of the experience of flight-deck automation. Human centred automation is but one of these. Many, if not all of these approaches have effectively legitimated one or other component of the total system – human-centred automation the human, whilst system or technology centric approaches the engineered systems. Approaches that seek to maximize the benefits of technology or the human in effect achieve the same outcome, skewed towards and optimising the system in one specific direction or another.

3.2 What is apparent to IFATCA is that a common feature of these developments has been that the engineered system has been designed without a thorough appreciation of the role of the human – and their specific and unique needs to fulfil the function required of them. These needs are irrespective of the stage or degree of sophistication of automation – if a human is present in the system working with the automation there will be some specific requirements that will need to be satisfied to allow the human to undertake their role.

3.3 Aviation will evolve as a result of technological advances, with concomitant additions to system complexity, and new paths for system failures such as common mode failures as a result of new system dependencies. The entire system will need to be treated as one large resource with interaction among all elements, with the human operator(s) remaining a key element.

3.4 If the human controller (or pilot) is to be accountable, then there are clear requirements upon the system design to enable meaningfully fulfilling these responsibilities and accountability's. Relegating the human's role to one of passive and opaque authority will not enable the function to be enacted by the human. The development of decision aids to conflict resolution and separation assurance is a critical element for controllers – this function is an essential component of the air traffic controller's role, and one for which there is a clear responsibility and accountability. Choosing what to automate should be guided by the need to compensate for human and system limitations, and at the same time take advantage of human strengths. Involving users in the development of automation is considered essential and evaluation(s) must include the "human-in-the-loop" approach.

4. AUTHORITY AND RESPONSIBILITY

4.1 The role of automation in the future is inseparable from the role, responsibility and authority that system actors – be they engineered or technical or human components of the systems - have. Any form of automation must assist the enactment of the functional role as well as the responsibilities and accountabilities that the human or technical actor has – be it pilot, controller, engineer or network manager or indeed electronic team-member.

4.2 We do not want controllers, pilots, engineers, dispatchers or even our electronic team members to be faced with authority double-binds that undermine the resilience and safe operation of the system. Neither do we wish to see the human actor resolving technical system double-binds. There must be clear and unambiguous rules that govern authority and responsibility, that are trained globally, that are interoperable across a range of differing ATM system components and capabilities that are supported by the legal framework.

4.3 The challenge is to produce a durable procedure and rule-set that sees unambiguous accountability and responsibility in an operational environment where the executive decision makers may be distributed. Where executive authority for decisions may reside with a component of the engineered or technical system. Where the mechanisms to ensure that the system are resilient functionally for all system agents.

5. THE LEGAL IMPLICATIONS OF FUTURE CONCEPTS

5.1 Underpinning the authority and responsibility of system actors is a clear, unambiguous understanding of the liability that system actors have when making executive decisions – when carrying out 'work' in the new ATM paradigm.

5.2 Where the future system design employs technology – automation – to play an active part of within the executive decision-making processes, knowing the distinction as to where liability resides is obvious. This should apply to, as Billings would define it, to information, management and control automation. Is it possible for the electronic team member or automated function to hold liability for the functions it enacts? We do not know. But if the human is to hold liability then there are significant consequences for the design and functional work of the ATM system as a whole. The system needs to be designed to allow the human to accept this liability knowingly willingly.

6. CHANGE MANAGEMENT AND TRANSITION

6.1 A well-known problem connected with the introduction of a new system (or even changes to an existing system) is that people in the workplace may feel threatened, alienated or otherwise uncomfortable with the change. The appendix to this working paper provides specific detail on some, but by no means all, of the areas that IFATCA argue should be taken into account.

6.2 It is therefore crucial to manage the change and to make sure that its introduction is successful. Integrating human factors into the system life cycle is one way of fulfilling this.

7. SAFETY IN THE OPERATIONAL ENVIRONMENT OF THE FUTURE

7.1 Safety cases can focus entirely what is measurable i.e. the engineered system. Where automation is deployed, the task is to validate and verify the *Total system* i.e. the air and ground components. Assumptions used in safety arguments need to take meaningful positions of the role of the human and the capabilities that they bring to the total system – be they in the air or on the ground. A critical philosophy of safety arguments should be not just the formal arguments of safety assurance, but an operationally focused approach and this should extend to certification as well. Hazard analysis supporting safety assurance, validation and certification should also be operationally focused i.e. operational assurance. The nature of the future system will defy the certainty that is attendant in current safety assurance techniques and philosophies.

8. THE HUMAN FACTORS OF AUTOMATION

8.1 A perennial issue that has been in the human factors and human performance agenda, since Chapanis first conducted his research into the frequency of accidents of the C47 circa 1943, is automation. The IFATCA position is well known – we accept that automation is a feature of future of ATM.

8.2 We argue that the following facets of the human factors of automation are those that we will need to understand fully, as well as the industry itself, to achieve a robust and sustainable future ATM system. These being (with a detailed discussion contained within the accompanying appendix of this working paper):

a) recruitment and selection;

b) training;

c) transition;

d) trust in automation; and

e) fatigue management.

9. CONCLUSIONS

9.1 These issues are not insuperable to resolve. They will require the industry to work together, with due regard paid to the requirements of the evolving role and functions that the human plays and will play in the system. The solutions to the challenges of automation, discussed in this paper may not be immediately apparent to us today. The federation believes that as we approach each automation facet and issue, and working collaboratively with the industry as a whole, solutions will be found that will enable us to confront the intangible issues of the future, that we know little of today.

10. ACTION BY THE CONFERENCE

10.1 The Conference is invited to establish the formal means by which the human factors and human performance facets of automation deployment in ATM, as proposed by the Federation, are recognized and embedded in the deployment philosophies, paying particular regard to facets discussed in 8.2 of this working paper.

10.2 The Conference is invited to request ICAO to determine and set in train the necessary steps to develop the procedures and rule sets that enable unambiguous operation by system actors in future iterations of ATM system development.

10.3 The Conference is invited to take steps to ensure that human factors considerations are fully integrated into ICAO guidance material on the implementation of automation in all areas of its sphere of responsibility, and integrating human factors across the ATM system lifecycle.

10.4 The Conference is invited, in recognition of the importance of human performance in safe ATM systems, to task ICAO with mandating change management standards and processes that facilitate deployment.

10.5 The Conference is invited to undertake and develop training standards that facilitates effective training of the competencies required by the human at all stages of future deployment.

10.6 The Conference is invited to task ICAO with developing guidelines that provide indemnity for all ATM system operators when following conflict resolution advisories from any automated system, including ground conflict resolution systems. in line with unambiguous lines of accountability and responsibility for human and system actors in the future ATM system.

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APPENDIX

THE NATURE OF ATM OF THE FUTURE AS PERCEIVED BY THE CONTROLLER

1. When we consider the aviation system of the future we must consider not only the impact that automation will have on the human operator within that system, be that human role be the pilot, controller, engineer or new roles that are emergent from ATM in the future but also, how these will change over time. Our understanding of how technology, the engineered system and the human can work collaboratively will change with our experience along the development and implementation trajectory. What role will they play? What authority will they have, and how will this tangibly affect the 'system'?

2. Computers already perform many of the tasks associated with navigation so do we need the human at all? We humans are far from perfect. But we do have the ability to reason effectively, to think in the abstract, and conceptualize when solving problems. Humans have five senses along with common sense and intuition. Of course, we do not use them all in every situation, but, automation does not have these capabilities, so therefore should be a "tool" or "resource" for the human operator: a facilitator of the negotiating process between aircraft and ground-based control facilities, with the operator deciding the final outcome of this process in all cases. How can the technical system and human work collaboratively? Mindful that the nature of this collaboration will justifiably change over time.

a) Automation has the potential not only to provide advice to controllers of a series of potential solution to a tactical problem (in the form of decision-making support), but also to provide a particular solution i.e. the technical systems makes the decision itself, and provides a range of options with which the human can use the system derived solutions. This can present a dilemma, a possible "no-win" or double bind situation for the controller. If he/she follows the "suggested" course of action and an incident ensues, are they accountable? If the "suggestion" is not heeded, and another course of action results in a loss of separation are they held accountable? These two particular positions involve an important attribute of human-machine interaction – Trust.

b) Implementing advanced functions in the management of ATM will require the management of change and transition in the operational environment that acutely supports the requirements of all actors in the system. Gradual introduction of automation, with attention to training and human acceptance is necessary. Systems must be capable of being modified to suit the users' requirement, rather than the other way around.

c) A common strand of Air Traffic Management concepts of the future, are those that endorse the responsibility for control and separation of aircraft transferring from the air traffic controller to the pilot. Under these conditions, and in scenarios involving varying degrees of both difficulty and complexity, the active control task is one of 'management by exception. This will fundamentally alter the role of the controller from one of active participation as a controller to that of being a monitor of this complex system processes. He/she would be in the background to monitor separation, or to respond in the event of some unforeseen circumstance in normal operations or in an emergency. Detailed studies have shown that when this shift in responsibilities occurs, it has a detrimental effect on inter alia, conflict detection, memory, and situational awareness. It has been shown that when controllers are removed from situations of direct authority and engagement, and are subsequently required to resume executive control and management, detection and resolution of conflicts takes longer than when someone has been actively involved throughout.

3. The scientific and technical literature is pregnant with observations drawn from accidents and incidents about the system deficiencies that represent technology-centred approaches to automation. These can present and pose certain and specific concerns to us. Equally, there are also examples in this same literature of the successes of the deployment of automation. Aviation is just one of these. The lessons from many other domains – positive and negative - apply equally to the cockpit environment as well as the ATC environment, and include: poor interface design; motivation and job satisfaction; complacency; distrust; intimidation; workload, and loss of situational awareness. These examples of "incompatibility" can (and have) lead to accidents and /or incidents. Concerns for the way that humans react and interact with automation will always be a legitimate concern. Reliance on automated systems can result in a natural change in controllers' tasks, and functional role. The control paradigm will change thus the skillset must change – it is different, and this must be recognized. New controllers entering today's ATC environment will not be immersed and conditioned in the ATC lore's of the past, it will not be possible to retain facets of the past to compensate for deficiencies in the system of tomorrow. The future is different, and this requires commensurate consideration, which we do not see today.

4. The development of any formal design methodology for the future ATM system should ensure that Human Factors in the widest context are fully integrated into the philosophy of the system design at the outset. All such approaches need to garner the evidence that can be used to assure the safety as well as the efficiency of the total system. All too often this is an afterthought, or changes over the development lifecycle. The plan is first developed at the start of a project and updated during each subsequent phase. These methodologies need to use a representative sample of all of the users and operators (e.g., pilots or controllers), and as long as they are knowledgeable of current issues, procedures, and practices and also well versed and trained in the future concepts and method of operation of the future, they can be the most appropriate source for information and advice.

Authority and responsibility

5. In aviation today, the procedural rule-set and experience gained since the introduction of ICAO and the Chicago Convention in 1948, has provided a durable and stable philosophy and method of operation. This is both a virtue, but also increasingly a hindrance, to the progressive development of the ATM and air transport system.

6. The principles of the authority of pilot and controllers in the context of separation enshrined in PANS-RAC and Doc. 4444, the rules of the air and ATC and the safe operation of commercial aircraft, have served us well. They are largely, unambiguous, inter-operable and standards that are trained globally. The future trajectory of ATM development rightfully seeks to change these. In so doing the tenets of today's authority and responsibility will change.

7. This is wholly legitimate, but we argue that this is not trivial. It is not possible to garner the wisdom and experience of seventy years of operational practice in the time that is available to us to implement the systems that will sustain the development of commercial air transport. It would be calamitous were we to underestimate the challenge in producing a rule-set, rules of the air and procedures for our future ATM system.

8. The challenge is to produce a durable rule-set that sees unambiguous accountability and responsibility in an operational environment where the executive decision makers may be distributed. Where executive authority for decisions may reside with a component of the engineered or technical system. Where the mechanisms to ensure that the system are resilient functionally for all system agents.

The legal implications of future concepts

9. As with accountability and responsibility, this is not trivial. Does legal precedent exist for the complex nature of the operations that will characterize our ATM system of the future? This is outside our sphere of competence. However, it concerns us because of the current tendency for the criminalization of aviation professionals when they are held to account for system failures. Inherent in this argument is the notion that system failures are the consequence of system attributes or design features that were unintended and unanticipated.

10. It is in the nature of complex systems, as understood by modern conceptions of complexity theory, that a complex system is one where it is not possible for all outcomes to be predicted. It therefore falls to those actively engaged in a purposeful and legitimate functional role in the ATM to mediate these unknown or unanticipated system behaviours. How can they be held liable for the consequences of the actions and decisions of the system designers or rule-makers? This is the nature of the liability issue in our future ATM system.

11. Perhaps for us, this is nowhere more an acute issue than in the specific case of separation provision. Who is liable for separation where separation provision is distributed across multiple actors? We will need robust and enduring arguments that the liability of controllers – or whatever role the control task evolves too over time – is clearly formulated and understood by all those who have a part to play in the ATM system. We would contend that the greatest risk is not in some future and advanced steady state, but in the inter-mediate and transitional steps. This serves to add another challenging dimension to the development of our future ATM system

Change management and transition

12. Communication becomes a key activity in the change process. It is important to inform, to the maximum extent possible, in order to avoid uncertainty among employees. Rumours can be detrimental to the change process. It is equally important to receive feedback during the change process to obtain an accurate feeling of how things are being received and to improve implementation.

Gaining energetic commitment to the change:

13. In the short-term, commitment can be gained from a focus on the survival of the organization. In the long-term the commitment has to come from system reward structures, employment policies and management practices.

Early involvement: Early involvement of the people affected by the change will go a considerable way towards reducing behavioural resistance during implementation. It will considerably reduce the amount of energy that has to be expended on coercion and power strategies to enforce compliance.

Turn perception of 'threat' into opportunity: A change process is likely to be seen as a threat by people. Experience shows that an organization, which can change this perception so that the change is seen as an opportunity, is more likely to succeed.

Avoid over-organizing: The change process should be well thought-out before it takes place, but it should be recognized that the process is very organic in nature. One should not stick to the plan just because it is there, but rather learn from the situations as they develop, a change process is a learning process.

Train for the change: People's perception of the change may transform significantly if they have an opportunity to understand better what will be required of them.

The substitution myth of automation

14. It is a common misconception in the design and implementation of automation that automation can be used to compensate for lack of experience and as a justification for reducing training time. This is a fallacy. Automation can justifiably increase training needs and the challenge is to make the training effective

15. An important factor with regard to training in any environment is the associated cost. A human factor in itself does not cost much to implement. Perhaps having Human Factors Specialists available full-time could prove to be a cost-effective way of identifying and resolving incorrect procedures and/or unsafe working conditions at the outset. IFATCA feels that if sufficient resources, (financial and human) are made available to guarantee the best training possible, a "team approach " led by HF specialists could lead to better education, cost-savings, and a happier, healthier workplace.

16. There are a number of formal human factors integration strategies available today that have evolved through practical experience of implementing complex systems. One such method is the Human Factor Case, as developed by Eurocontrol. The Federation proposes that formal processes of human factors integration, such as the Human Factor Case is a pre-requisite to effective change management and implementation and transition to our future ATM system. We are convinced that without these methods of Human Factors Integration, the path to the future will be more difficult than it need be.

Safety in the operational environment of the future

Verification, validation and certification

17. In the development of a complex system, specifically where extensive use of software is made, it is important to be able to determine if it meets specifications and if its outputs are correct. This is the process of verification and validation (V & V) and its planning must start early in the development life cycle.

18. Software development has evolved from small tasks involving a few people to enormously large tasks involving many people. Because of this change, V & V has similarly also undergone a change. It became necessary to look at V & V as a separate activity in the overall software development life cycle. The V & V of today is significantly different from the past as it is practiced over the entire software life cycle. It is also highly formalized and sometimes activities are performed by organizations independent of the software developer.

19. Experience shows that the implementation of safety-critical software is a complex task. There is evidence showing that new systems have been implemented before being fully ready and problems occurred when issues with the software were subsequently discovered.

20. According to the definitions by the IEEE Standard Glossary of Software Engineering Terminology, verification simply demonstrates whether the output of a phase conforms to its input as opposed to showing that the output is actually correct. Verification will not detect errors resulting from incorrect input specification and these errors may propagate without detection through later stages in the development cycle. It is not enough to only depend on verification; Validation is the process to check for problems with the specification and to demonstrate that the system operates correctly. Certification is defined as *a written guarantee that a system or component complies with its specified requirements and is acceptable for operational use*. The certification process also starts from the beginning of the life cycle and requires cooperation between the developer and regulatory agency.

21. An important aspect of certification is that it does not prove that the system is correct. Certification only proves that a system has met certain standards set by the certifying agency. The standards show that a product has met certain guidelines, but it does not mean that the system is correct. Any problem with the system is ultimately the responsibility of the designer and manufacturer, not the certification agency.

22. The safety case is an important document used to support certification. It contains a set of arguments supported by analytical and experimental evidence concerning the safety of a design. It is created early in the development cycle and is then expanded as safety issues arise. In the safety case, the regulatory authority will look to see that all potential hazards have been identified, and that appropriate steps have been taken to deal with them. The safety case must also demonstrate that appropriate development methods have been adopted and that they have been performed correctly. Items that should be in the safety case include, but are not limited to: specification of safety requirements, results of hazard and risk analysis, verification and validation strategy, and results of all verification and validation activities.

23. Development life cycles are characterized by the way they organize the interactions between technical development processes. Three basic types of life cycle models may be distinguished; waterfall-, V- and Spiral Model. The various models are well described in different specific literature and have all advantages and disadvantage. What becomes of importance in complex socio-technological system such as Air Traffic Control is the validation of the new process, in particular the interaction between the Human operator and the new systems. This has to be carried out in parallel with running the normal operations. Adding an additional layer of complexity to the undertaking of modernization of the ATM systems.

The human factors of automation

24**.** **Recruitment:** ANSP's globally are recruiting individuals today to perform the ATM task of the future. These controllers are implicit in the future, were they selected for this, for the functional role that they will undertake in 2025 or 2030? Or were they recruited with today and the near future in mind? The selection and preparation of the next generation of ATM aviation professionals is a subject that is actively pursued by ANSP's today. It is recognized that selection will need to match the requirement of the next generation. However, the controllers that are recruited in 2012 are in the system today and will have to transition to a role that potentially they were not selected for.

25. **Training** per se is an issue that is of significant interest to us. This interest extends across the whole gamut of training activities. It is yet another issue that is not trivial, because the effectiveness of the training, and the means to be able to gather the evidence of the effectiveness of this training systematically for the system as a whole is a very extensive undertaking. It is one that we feel is underestimated. There are a number of claims made for the benefits of the use of automation that it reduces training requirements. In some cases it has been argued that automation can provide a substitute for experience. We are optimistic that there will be a point in the future where this will be the case. But we contend that this point is further away than we might desire, and until then we should not use technology and automation in this way. Training requirements in the future will be greater not less in our view. The training should provide the means by which humans can acquire maintain and extend the skills to fulfil the function that they are requited so to do. As air and ground integrate in the future, so the training should be integrated for pilots, engineers and controllers commensurate with it providing the means for an effective understanding that allows the system to function in nominal, non-nominal and emergency situations

26. **The transition steps**, and we envisage several of these potentially from one implementation step to the other in the future, is a particular facet of system evolution that in our experience hitherto has been neglected. It should be recognized that effective training will need to be provided to enable certain elements of

human performance. For example, mode confusion, something we know is an automation issue on the flight deck is a phenomenon that may work subtly in the ATM ground environment. It is known that the human has to develop a new mental model to work with new systems. It is possible for the outgoing model to be more dominant than any new one. This can be resolved by training, but training programmes need to be designed to achieve this objective, and be able to garner the evidence that humans have achieved the desired standard of competence and capability.

27. **Trust in the automation**, and trust in the automation with the human is a critical element of the human performance and human facts of automation. It is easy to envisage situations, drawn from our knowledge of safety related events in aviation in the past thirty years, where humans have been cited as overly reliant or trusting of the automation supporting their function. We as an industry need to be mindful of the influence of trust, and the seductive nature of modern day automated systems on human performance and the salience of the information provided that facilitates human-system collaboration that can influence trust. This is as much a matter influenced system design, the philosophy of automation, robust rule and procedure sets as training. It may well influence the selection of those who will perform the ATM task and function in the future.

28. **Fatigue management** has long been recognized as an issue that influences safety and efficiency, and is of increasing salience in ATM. We do not believe that there is a thorough understanding of the impact of fatigue on the human in the system of the future, and how the working regime and practices of high orders of automation will influence both human behaviour and performance. Nevertheless we postulate that fatigue will be an issue that will influence the successful implementation of the future ATM system; that the effects of fatigue will be different for different system increments and that it is therefore a facet of automation that should not be dismissed. It is perhaps timely that the fatigue debate that is current in aviation today, can embrace the ATM domain

29. The facets discussed are in effect a sub-set, combined with other facets discussed in the previous sections, of the human factors issues appertaining to the automation and human interaction in the ATM system of the future. There are others, some we know of and some that we do not, but those presented here are those that, today, we consider are an imperative set.

Conclusion

30. The Federation has consistently placed the application of Human Factors knowledge high on its list of priorities. The human is the central element in our aviation system(s) today. As such, he/she is entitled to all available resources that will promote and facilitate functioning, as a system component, at optimum levels regardless of how that function changes structurally over time. As discussed above, our concerns are not limited to those of a technical/human nature, but also of the legal issues of formal safety assurance and system validation, as well as the soft issues involving fatigue management.

31. We believe that any understanding of automation Human Factors issues that is limited solely to individual operators in a complex system such as aviation, whether they be controller, pilot or other vital component, is undesirable. The human works within a system, they are not just system components they use the system. As such they have specific needs to fulfil the accountabilities and responsibilities of the functions that supports the total system.

32. Change management needs to be equal to the promise that automation itself holds. But the lack of it, or weak commitment to it, will hinder progress. It is IFATCA's objective that Service Providers will take positive steps to provide training programs for ATC staff (controllers and engineers), not only in the area of Human Factors however. Fatigue is another area that requires dedicated training. Moreover, the philosophy and

nature of training to facilitate the ATM system of the future itself needs to be equal to the task. The training task being, in our view, unequivocally, to provide the skill set and experience that enables the human to undertake the function and task in a manner that affords them the confidence to work in a progressively changing system. To be able to work effectively with automation, and others who use automation, equipped with the knowledge that gives others in the system confidence that the ground element of ATM is safe, efficient and progressive. If we as an industry can start to resolve those discussed here, recognize their legitimacy and enter a discourse on these facets, then as an industry we will have made significant progress.

33. Many challenges remain in the field of automation Human Factors in the ATM domain. IFATCA is committed to an evolutionary improvement process that builds on the strengths of our existing, and proven aviation-system. We agree with the philosophy that the human must play an essential - and where necessary, central - role in the global ATM system; and that the human is responsible for managing the system, monitoring its performance, and intervening, when necessary, to ensure the desired system outcome. To achieve this requires studied attention on the facets that we have discussed here.

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