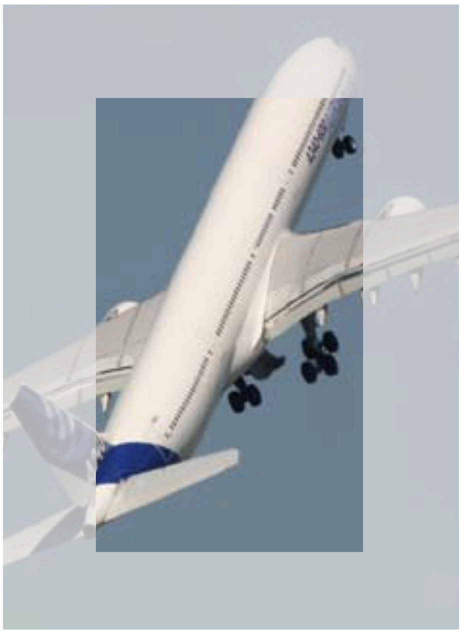
International Committee for Aviation Training in Extended Envelopes

ICATEE



Draft Master Plan

Dr. S.K. Advani, chairman

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1. Introduction

On 3 and 4 June 2009, the Flight Simulation Group (FSG) of the Royal Aeronautical Society organized and ran a conference entitled **Flight Simulation - Towards the Edge of the Envelope**. The conference subjectwas related to a growing need to address aviation safety issues through better training and simulation beyond what is currently covered in flight and in ground-based flight simulators. See Appendix 2 for Conference Notes.

The conference identified the need to improve aircraft upset training, the shortcomings in basic education and readiness of commercial pilots in reacting to upsets, and the technical challenges of upset training. As a result of the conference, the RAeS FSG was requested to form a Committee to explore the formation of an International Working Group (IWG) to identify follow-on steps and to invite participation from other interested parties.

This Working group has been named as the International Committee for Aviation Training in Extended Envelopes (ICATEE)

This document outlines the objectives of the Committee and the resulting Working Group. In Section 1, the industry needs are defined and the scope of the Committee is also explained. The ICATEE Working Group objectives are defined in Section 2, and the participants expected are described in Section 3. The Working Group's Activities, Deliverables, Organization and Execution are given in Sections 4, 5 and 6, respectively, and Conculsions and Action Items are listed in Section 7.

Industry Needs and the ICATEE

The contribution of upset-related incidents to aviation safety is significant. Of all the hull losses during 2009, approximately 33 percent of these can be attributed to upsets or related causes. There is no single root cause to this problem - it can be attributed to human error, systemic error, or atmospheric conditions.

Regardless of the cause, the last stop is always the flight crew who are confronted with a situation for which critical decisions must be made very quickly. This decision may also include *no* intervention, allowing the automated systems to maintain control.

Concepts have been proposed for better training of crews to firstly identify upsets and, secondly, to deal with them well after they have been encountered. The former is well supported within the current training framework as training systems and processes are able to provide reasonable information to the candidate on the entry approaching the upset.

Beyond the initial stages of an upset, the results can be hugely varied due to non-linear aircraft dynamics, the dynamic forces that could be encountered by the pilot, and the non-linear response of the aircraft itself. It is this lack of determinism that makes it challenging to define, develop and to qualify adequate training solutions for upsets.

There are arguments supporting current training methods even though they may be a rough approximation of some upset situations. These arguments are based on evidence that the human pilot is able to adapt to a situation if a basic level of training is provided in representative situations.

Clearly, the subject has a wide scope. There is no single solution or symptom, and there can not be one approach to addressing the problem as there are cost and opportunity implications of providing a minimum level of upset recovery training for the numbers of aircrew likely to require it. Utilising the right expertise, developing a consensus on priorities, and establishing a mechanism of implementation is therefore essential. This is the chief purpose of the ICATEE.

State-of-the-Art

There are several programs already under way to enhance pilot training in extended flight envelopes. These range from educational tools, such as the Upset Recovery Training Aid, to simulator-based and in-flight training using conventional or fly-by-wire aircraft. There is no one consistent standard and, perhaps, there will always be different possible methods required in order to provide the level of skill required of pilots.

Furthermore, there has been a large body of research conducted over the past years that deals with the technical and training aspects of extended envelope flight operations. These studies cover areas such as:

- The human factors of extended envelope operations
- Modelling and simulation of high angles of attack, large angles of bank and yaw, and dynamic effects of the stall-regime
- Analysis of training methodologies.

Research programs currently under way include those at NASA Langley Research Centre, TNO Human Factors (SUPRA project), Embry Riddle Aeronautical University, University of Toronto Institute for Aerospace Studies (UTIAS), and others. The inputs from these organizations will be of great value to ICATEE.

One of the objectives of the ICATEE is therefore to identify in an objective manner the current processes used to develop the cognitive and manual skills for extended envelope awareness, identification and recovery.

In order to do this, the ICATEE will involve industry, regulatory, training and academic experts who are involved in defining and providing this training.

Another aspect is to review the work that has been going on in research centres, universities and in industry. Much of this research is targeted at modelling aircraft in the extended flight regimes, from stall buffet, full stall, deep stall, spin, etc.), and exploring different ways of presenting this information in Full Flight Simulators. Modelling in itself poses many challenges, due to the non-linear and less predictable behaviour of airplanes outside normal flight envelopes.

Research centres like TNO, NASA Langley, UTIAS and NLR are involved in research targeted specifically at modelling flight vehicles under large, unsteady disturbances, human perception, and the implementation of these models into various flight simulation devices.

Main Issues and Possible Mechanisms for Resolution

The complexity of flight simulation under normal situations in terms of matching technical requirements with the appropriate training media has been demonstrated during the recent revision of the ICAO 9625 document. In the areas that are beyond the normally-qualified flight simulation regines, the problem can become even more complex. Therefore, prioritization and careful selection of appropriate and suitable - perhaps not perfect - solutions needs to take place.

The issue we are mostly dealing with is human pilot interaction with the vehicle. Recognition, reaction and interaction with the vehicle are all important functions required of the pilot. Part can be learned with training aids (classroom, CBT, etc); part is through experience for the purpose of identification and recognition in order to prevent the situation from worsening; part is interaction with the aircraft during and following the upset.

The need can be defined as:

- What knowledge and capability does the pilot need in order to be able to operate safely in the full flight envelope, and how long does a pilot retain these skills sets before requiring recurrent training cycles?
- What are the foremost areas of training that fall short with today's technologies (from a risk and technical perspective)?
- What information needs to be presented in order to adequately train~~ing~~ the pilot, and how accurate does it need to be?
- How can one predict the required quality of the presented information?
- How does one present the information in the simulator and how are the upset scenarios presented, evaluated and trained to assure fluency?
- How does one gather the required data for the simulation of these conditions?
- How can this be trained in an effective and economical manner?

It is believed therefore that three specialisms are required to evaluate the need:

- Aircraft flight operations
- Human factors of training
- Modeling and simulation technologies

Additionally, the regulatory aspects must be addressed throughout the process as it is the national aviation authorities who will be requested to comment on the processes developed and implement them into their own programs.

2. International Working Group - ICATEE

In order for a Working Group to be successful, it must first recognize the stakeholders and identify their roles. The main stakeholders related to this specific problem are:

- Aeronautical Industry/Scientific Bodies
- Airline pilots associations
- Airline operators
- Transportation Safety Associations
- Civil Aviation Regulatory Authorities
- Airframe and systems manufacturers
- Simulation manufacturers and providers
- Training providers
- Research agencies

There has been sufficient level of interest from each stakeholder group to form this Committee and Working Group. The RAeS Flight Simulation Group, in response to a request during the conference agreed to form the core committee, give form to the group and co-ordinate the Working Group.

The ICATEE objectives can be stated as follows:

-To be a body independent of national, corporate or factional interests, amalgamating information on the subject matter
-To identify the problem and recommend prioritization for remedial action
-To identify and help qualify current processes and methodologies
-To collect data on enhanced envelope maneuvers
-To interact with research concerning improved training in extended flight envelopes
-To identify and recommend best practices
-To identify future related research activities
-To support the implementation of regulatory guidelines or updates for enhanced training

3. Participants

During the past weeks, several organizations and indivuduals have approached the author to participate in the ICATEE. These are listed in alphabetical order in the proposed list below.

No.	Affiliation	Contact Person
1	Flight Simulation Group, RAeS	Dr. Sunjoo Advani, Capt. Gordon Woolley, Peter Tharp
2	AIAA MSTC	Ed Burnett
3	Air Canada	Capt. David Butler
4	Airline Pilots Association ALPA	Capt. Bryan Burks
5	Airbus Industrie	Capt. Etienne Tarnowski
6	American Airlines	Capt. Jerry Mumfrey
7	APS	Paul Ransbury
8	Bihrle Applied Research	David Gingras
9	Boeing Commercial Airplanes	Bob Curnutt, Capt. David Carbaugh
10	CAE Electronics	Lou Nemeth
11	CAA (UK)	TBD
12	CALSPAN	Jim Preist
13	Department of Transport, Canada	Ron Sarich
14	Embry Riddle Aeronautical University	Rod Rogers
15	Federal Aviation Administration, Air Transportation Division	Mike Wilson
16	Federal Aviation Administration, National Simulator Program	Arnab Lahiri
17	FlightSafety International	TBD
18	KLM / Air France Flight Training	Capt. Herman Hello
19	National Transportation Safety Board	Dennis Crider
20	NLR	Joris Field

No.	Affiliation	Contact Person
21	RAeS Flight Operations Group	TBD
22	SOS	John Cox
23	Thales	T.B.D.
24	TNO	Eric Groen
25	UTIAS	Prof. Peter Grant
26	University of Sheffield	Prof. David Allerton

4. Working Group Activities

The main activities of the Working Group will be:

- to review current practice in extended envelope training
- identify the main shortcomings
- identify the data and training media requirements and further research required
- recommend the areas that need immediate improvement in flight training
- examine essential and desirable training elements
- suggest how standards can be established.

The following workflow is suggested:

Data Gathering and Collation
Data gathering would be done to bring together all information on all aspects of upset events from which it would be possible to identify representative indications, cues, and behaviours in a range of upset-causing conditions for specific or typical aircraft types, flight regimes, and configurations. Data gathering would also be used to identify gaps in knowledge where further study, trials, or research might be needed.

Definition of Upset Training Scenarios
The data would be used to define a selection of representative dynamic scenarios, upset triggers, and aircraft behaviours in terms of performance, indications, and cues – visual, motion, aural etc – which could form the basis of training events for specific types, groups, or categories of aircraft. These training events would include aspects of recognition, diagnosis, response, and recovery.

Development and Validation of Best Practice Upset Recovery Responses
It would then be used to identify best practice for safe and effective recovery techniques and skills. These would together provide the evidence-based upset scenarios and events, and aircraft management and handling responses, against which training objectives could be validated.

Identification of Appropriate Training Media and Methods
An assessment would then be needed of which characteristics of the scenarios and events could accurately be replicated in what natures and levels of training media: desktop/classroom study/briefings/demonstrations/interactive packages; various levels of FSTD; FFS; and live flying. It should also aim to identify what at stages of training it would most effectively be conducted.

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Validation and Accreditation of Upset Recovery Training Packages
From these assessments it should be possible to arrive at a minimum set of ‘vital training elements’ which could be included in the ICAO flight crew qualification criteria.

5. Deliverables

The real "Customer" of this Working Group will be the air crews as the key goal is to improve awareness and improve capability in handling adverse situations. It is the intention that the processes developed by the Working Group will be fed through the training standards, with the support of the regulatory agencies. Support will be required from all the stakeholders in order to achieve this.

The findings will be submitted to the regulatory bodies and training providers, as these will also be participants in the Working Group.

A list of proposed deliverables will be derived from the initial meeting of the Working Group, and assignments requested from the participants to fulfill the realization of these deliverables.

6. Organization and Execution

The FSG has established an ICATEE steering group consisting of Sunjoo Advani (chair), Gordon Woolley (co-chair) and Peter Tharp (co-chair). This group will set up and confirm the plan of the Working Group, assign tasks, request the support of the participants to fulfill these responsibilities, establish the time lines,and report the findings outside the group. It will also prepare the Committee's Constitution and Terms of Reference. Participants in the group will be expected to finance their own involvement.

The Working Group will bring in further capabilities and expertise from a cross-section of interested parties by invitation as noted under "Participants" on page XXXX.

It is the intention to present the findings of the ICATEE at an RAeS Conference in the first half of 2011.

Dissemination of Information

The first form of dissemination of the information gained within the Working Group will be through the Royal Aeronautical Society FSG meetings and conferences. It is proposed that several channels be established in order to disseminate the information from the Working Group:

-a web-based forum through the RAeS
-a limited number of meetings
-presentation at the appropriate conferences (e.g. FSG, AIAA, FSEMC, WATS)
-industry white papers to feed back key findings to the stakeholders.
-inputs to the International Committee for FSTD Qualification (ICFQ)

7. Conclusions and Action Items

The steering group has met as planned in July, and concluded the following actions:

1. Circulate the Master Plan document and invite participation in the Working Group
2. Issue Constitution and Terms of Reference, and obtain FSG approval
3. Establish the Working Group on the basis of responses to the invitation
4. Request the Working Group at its initial meeting to:
   a. Review its objectives
   b. Identify Work Packages, leaders and assistant leaders. See Appendix 1 for possible Work Packages.
   c. Define meeting targets
   d. Agree outputs and timetable
   e. Set methodology for future meetings and discussions
   f. Set up a reporting procedure to the Steering Group

Appendix 1 - Suggested Work Packages

The Steering Group has defined possible work packages for the Working Group. These will be discussed during the initial meeting.

WP1 - Review of Current Knowledge

- what data do we have
- where do current resources and aids fall short
- how well do current simulators reproduce these situations
- how can next-generation improved simulators reproduce these situations
- what info is available from extended envelope research
- what information is available from QAR's, FDR's, etc. from actual aircraft in upset events
- what knowledge do we have on the information processing by the pilot

WP2 - Training Priorities

- where are the problems in today's training
- priorities
- required accuracy of response
- experience based on current extended-envelope training (ground-based, in-flight, classroom)

WP3 - Extending the Envelope in Current Training

- tools required at all levels
- implementation into the simulator environment
- definition of training scenarios required to meet extended envelope training objectives
- definition of essential and desirable training elements
- additional training methods that may complement and enhance upset recovery training (in-flight simulation, actual aircraft training, ground-based full-motion capable devices)
- what will still not be covered

WP6 - Regulatory Conditions

- how do the regulators view the qualification of "good enough" data
- what processes are in place to accept extensions to the current training methods
- how does one accredit alternative training methods
- is an "endorsement" or special qualification necessary, or do all pilots require this basic training
- how much freedom do we allow to the training solutions

WP4 - Research and Development Requirements

- what questions need to be answered (and prioritized)
- who is already doing part of it
- what specific questions do we need to ask the current research programs
- what additional programs are required

Appendix 2 - FSG Chairman's Notes from RAeS Conference

By Gordon Woolley, Chairman, Flight Simulation Group

UPSET RECOVERY – A SUITABLE CASE FOR TRAINING

The RAeS Flight Simulation Group 2009 Spring Conference (3rd & 4th June), 'Flight Simulation: Towards the Edge of the Envelope' had identified upset recovery as one of its major themes. The Conference attracted an audience of well over 100, and featured 23 papers and presentations from speakers representing airline pilots, aircraft manufacturers, the US NTSB, flying training service providers, and a number of academic and research institutions from North America and Europe. The Conference ended with an open forum for proposals and resolutions for further collaborative work which are summarised below.

The primary outcomes and conclusions from the Conference were:

Passenger aircraft are subjected to in-flight upsets at various stages of flight because of:

- Environmental factors (such as turbulence, icing),
- Malfunctions (AMS, engine failure),
- Human factors (Inattention, mis-selections of trim).

Large passenger aircraft, particularly turbine-powered swept wing aircraft, can depart rapidly and unpredictably from controlled flight following an upset.

Loss of control following an upset is the largest single cause of airline crashes and fatalities.

Few aircraft have attention-getters or other warning systems which provide early indication that the aircraft is entering an upset-probable flight regime.

Stick shakers and pushers are warnings of last resort, and pilot attitudes or experience may lead to such indications being ignored or wrongly attributed, resulting in no or incorrect actions.

Aircraft handling guidelines often instruct the crew to disconnect automatic flight control systems when an upset is experienced; this may not be the optimum recovery technique.

There is no current regulatory requirement to train aircrews to handle aircraft upsets, apart from a recently issued FAA draft which is at the consultation stage. This is however expected to come into effect on 10 October 2009, and requires then that upset training be conducted. It does not stipulate what means of training are acceptable, training criteria, etc.

Currently mandated training rarely takes the crews beyond the initial onset of stall-warning devices.

There is an Upset Recovery Training Aid, developed by Boeing and Airbus, which provides guidance on handling techniques. There is also a textbook entitled 'Handling the Big Jets', but although useful primers neither provides practical training on which to base in-flight response to an upset event.

Civilian aircrew training contains little aerobatic or post stall flight training; such as there is taught on propeller-driven aircraft whose performance and handling are totally different from the aircraft the pilots routinely operate. Similarly, in civilian flying schools' academic instruction of aerodynamic principles and their implications for flight and handling, is limited.

The introduction of the MPL training regime is likely to dilute both extended envelope flying training and academic instruction still further.

Militarily-trained aircrew have much more extensive academic and flying training which equips them better to deal with potential upsets. MPL, however, is designed to help solve the pilot shortage problem, by training the pilot for one specific task. MPL training provides a mechanism by which young pilots can be recruited to that specific task. However, due to the decreasing availability of ex-military pilots for civil airlines, how this demographic change will influence the ability of the future pilot to handle upsets is unclear.

There are civilian training service providers who conduct academic instruction, simulator-based training, and live flying training on appropriate aircraft, who have demonstrated that the keys to avoiding aircraft upsets are:

- understanding of aerodynamic and handling characteristics at the edge of the flight envelope,
- the ability to recognise the conditions leading to or indicative of an upset,
- and the skills and procedures to recover safely and effectively from an upset as it occurs.

Trials and training show that although post-upset behaviour is unpredictable,

- It is possible for the crew to recognise how the aircraft is behaving as it enters an upset, and as the upset develops.
- It is possible to identify best practice procedures and techniques to achieve safe and effective recovery from upset, optimised for the flight regime in which it occurs.

Research has confirmed that the necessary understanding, awareness, and handling skills and can be trained for.

Live flying training on representative aircraft types is expensive, and could not be provided to more than a small fraction of the pilot community. It does however offer the ability to demonstrate the extremity of the flight envelope. Simulation of large transport aircraft through in-flight simulation using fly-by-wire technology to represent another aircraft permits experiencing the flying characteristics of these vehicles in a much smaller one.

Simulator-based training could provide more representative training than is now the case. However:

- Robust and reliable data on which to base the modelling necessary to achieve representative behavioural characteristics is needed.
- Validation of the data is limited by the traditionally-accepted methods of gathering data through flight-testing
- Better understanding of what information is required for human perception and action from the perspective of physical cueing needs to be developed.
- Further studies into motion and G cueing in simulator-based training are needed.
- The stages and types of training when upset recovery is taught and practised must be identified.
- Any training solution must lead to acceptable standards allowing for better interaction with the aircraft by the pilot
- The costs and resources required to train very large numbers of pilots must be borne in mind

It also became clear that there is no single panacea for this problem in terms of technology. First of all, as there are enormous differences between various types of engine failures, there are also many different kinds of upsets. Secondly, the type of aircraft, the level of automation, and the regime of flight dictate what the crew are required or even able to do.

Finally, the goal is to come with an accident mitigation problem through better design and better training, and this can also have many solutions.

There is little hard data on aircraft performance characteristics following an upset. Such data as there is, from trials, FDRs, and aircrew reports and observations, is not widely disseminated nor aggregated. However, taken together there is sufficient data available from which to model a range of behaviours for most aircraft which would illustrate their performance and handling characteristics sufficient for modelling simulation and for demonstrating and teaching recovery principles and techniques.

Data gathering elements should include the following:

Gather all available data on from aircraft performance:

- Trials reports
- Flight data recordings of real-world events
- Pilot/crew reports
- Observational and anecdotal reports

Flight Schools' upset recovery training reports

On:

Aircraft type

Operating conditions; Flight regime, AUM, aircraft configuration, atmospheric etc conditions,

Entry into upset conditions

Nature of the upset forces and initial cause/trigger

- Motion, aural etc cues
- Cockpit indications and warnings,
- Aircraft behaviour and performance
- Crew actions

Aircraft behaviour and performance during the event

- Motion, aural etc cues
- Cockpit indications and warnings,
- Crew actions
- FMS responses
- Aircraft behaviour and performance

Aircraft response/recovery/failure to recover

Pre-stall indicators do not provide sufficiently timely or accurate cues to alert the crew to a developing situation. More flexible types of indicators, which can be integrated into primary cockpit displays, have been developed which provide dynamic information on the aircraft's attitude and velocity with respect to its normal flight envelope. These could provide the cues needed to alert pilots to developing situations, and to provide guidance on aircraft handling and performance during recovery manoeuvres.

Simulator based training should eventually be accredited under ICAO 9625. However, Rev 3 is at a late stage of acceptance, and it would take some time to develop and validate an upset recovery training regime. Therefore the development of this regime should take place separately from the ICAO acceptance procedure, but visible to the ICFQ, until it is mature enough to be considered for incorporation.

Conclusions and Recommendations.

There was an extremely high level of interest in all aspects of upset recovery shown throughout the Conference, and the concluding discussion period was very fully attended and highly animated. There was strong agreement from all sections of the flying and simulation communities represented that:

- In-flight upsets are the highest single cause of aircraft accidents and therefore the primary safety concern of pilots and operators,
- Current training does not adequately prepare pilots to understand, identify, or respond to upset events.
- An extended training regime to overcome these concerns is urgently needed,
- Training must be mandated to ensure that adequate resources are devoted to achieving an acceptable solution.
- Academic and simulator-based training could be developed to provide the necessary extended training regime.
- The training thus developed must be incorporated into the regulatory system in due course.

The RAeS Flight Simulation Group recognises that this is an important initiative that should be taken forward to achieve a solution, and is happy to lend its support.

The Group recommends that the way ahead comprises an initial planning phase under a small steering group, followed by the main working phase undertaken by a broadly representative Working Group.

The Steering Group would comprise the Conference Chairman, Sunjoo Advani, and the Chairman and Deputy Chairman of the Flight Simulation Group, Gordon Woolley and Peter Tharp

The initial phase should have the aim of:

- Defining the objectives of the Working Group
- Defining what the main output/deliverables of the Group will be
- Producing the program time scale and meeting arrangements.
- Agreeing the Working Group members
- Agree on website facilities and other resources
- Investigate procedures to link the Working Group to the activities of the ICFQ