ARINC STRAWMAN 449: SIMULATOR CONTINUING QUALIFICATION
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APPENDICES

1.0 INTRODUCTION

1.1 Objectives

Working Title: Optimizing Simulator Continuing Qualification using Profile Testing

This report consists of fourteen (14) parts and was generated as a result of establishing a Simulator Continuing Qualification (SCQ) Working Group (WG) as part of the overarching SAE / ARINC Flight Simulator Engineering and Maintenance Conference (FSEMC). The SCQ WG was established to identify an additional recurrent / continuing qualification (CQ) method whereby the performance and handling qualities of a flight simulation training device (FSTD) could be rapidly evaluated after successful completion of an aviation regulatory onsite initial evaluation or simulator load changes//updates.

The proposed CQ method does not replace the QTG testing presently required by an aviation regulatory authority / agency. Instead, the QTG testing is augmented by value-driven engineering-based automated flight profiles that offer, from a training as well as a maintenance perspective, improved test and evaluation repeatability, time/effort efficiency, easier pass/fail criteria, oversight acceptance plus other efficiencies.

The parts included in this report are:

- Section 1 – Introduction
- Section 2 - Mission & Goal
- Section 3 - Background / Historical Information
- Section 4 - Who Is On-Board
- Section 5 - Assumptions
- Section 6 - Frequently Asked Questions (FAQ)
- Section 7 - Continuing Qualification / Load Check Issues
- Section 8 - Initial Discussions
- Section 9 – Optimized Control Inputs (OCI)
- Section 10 - Initial Testing and Results
- Section 11 - Error Introduction
- Section 12 - Tolerances
- Section 13 - Definition and Interpretation
- Section 14 – Conclusion

1.1.1 Outcome

1.2 Goal

“To make FSTD Recurrent / Continuing Qualifications more valuable and efficient, time and cost effective, and smarter for the operators and regulators.”

1.3 Scope

The guidance in this report is intended to complement an airlines or operators' qualification processes using the ancient scrolls known as Qualification Test Guides (QTG). Information is provided to enable an organization to prove the fidelity of their Flight Simulation Training Devices (FSTD) using an alternate method.

1.4 Benefit

1.4.1 Operational

An airline or operator could improve reliability, decrease the use of scarce resources, and ultimately more operational availability of their devices.

1.4.2 Regulatory

During recurrent evaluations by regulatory agencies, a reduced overall time coupled with an accurate snapshot of performance will provide time savings to both the operator and the regulator.

1.5 Stakeholders

The flight training industry will realize this benefit through a coordinated effort to utilize these methods of qualification validation in an increasing scope and span. The stakeholders include:

- Airlines
- FSTD Operators
- Airframe Manufacturers
- Training Device Manufacturers
- Regulatory Agencies

1.6 Reference Documents

The documents referenced in this report are intended to the latest version published.

1.6.1 ARINC Standards

In this report, other ARINC Standards are referenced or paraphrased. It is advisable to review the referenced documents for better understanding of the topic.

- **ARINC Specification 450:** Flight Data Documentation Requirements
- **ARINC Report 444:** Guidance for Export Control in Flight Training Devices
- **ARINC Report 446:** Guidance for Flight Training Device Documentation Structure, Content, and Maintenance
- **ARINC Report 610C:** Guidance for Design of Aircraft Equipment and Software for Use in Training Devices

1.6.2 Other Standards

In this report, other ARINC Standards are referenced or paraphrased. It is advisable to review the referenced documents for better understanding of the topic.

RTCA DO-178()

ICAO 9625, Ed. 4

1.7 Document Conventions

ARINC Standards are voluntary and intended to ensure interchangeability and interoperability between equipment, independent of manufacturer or airframe. In this standard, the following terms carry key significance:

Term	Usage
must	Obligation, no other choice.
should	Used to recommend approaches to optimize transactions and management.
will/is/does	Used to express a statement of fact based on other requirements.
may	Used to express an optional capability or choice.

2.0 QTG HISTORICAL DISCUSSION

2.1 Introduction

"It used to be seven pages in 1967. Nineteen years into the 21st Century, it is 400 pages of tests." – Kneisler, 2019

2.2 Proof of Fidelity

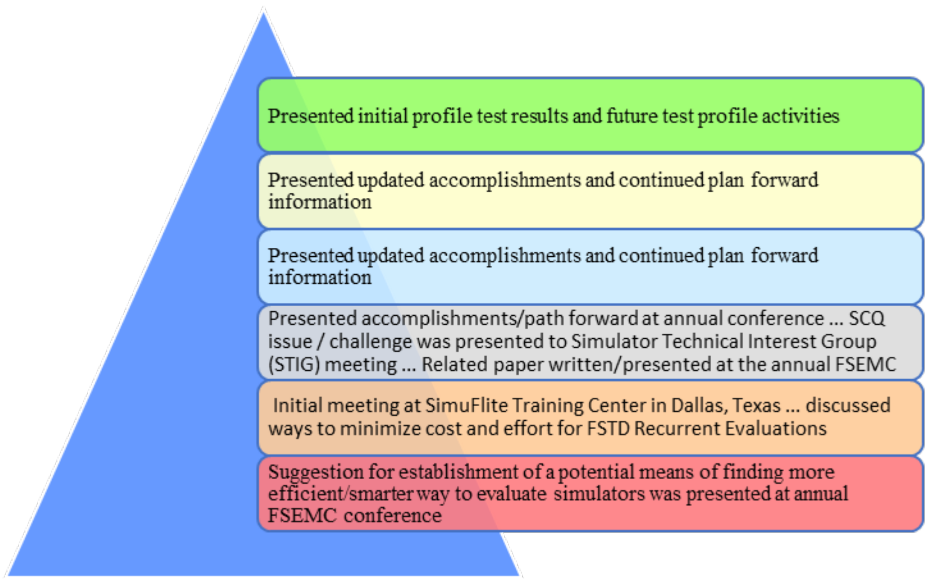


Figure 2-1 – SCQ Accomplishements

2.2.1 SCQ Origins

The origins of the SCQ working group stem from operator comments and input received during FSEMC Conferences held prior to 2014. As a follow-up, the first Simulator Data Validation (SDV) exploratory meeting was then held in Dallas in 2014. Primary objective of the SDV was to explore and to open up discussions regarding potential alternative means of compliance and validation of FSTD's – plus to share and promote new ideas and ways of optimizing regular testing and checking methods.

Figure 2-2 below provides additional top-level historical information related to the SCQ WG, which was officially established in the Year 2016.

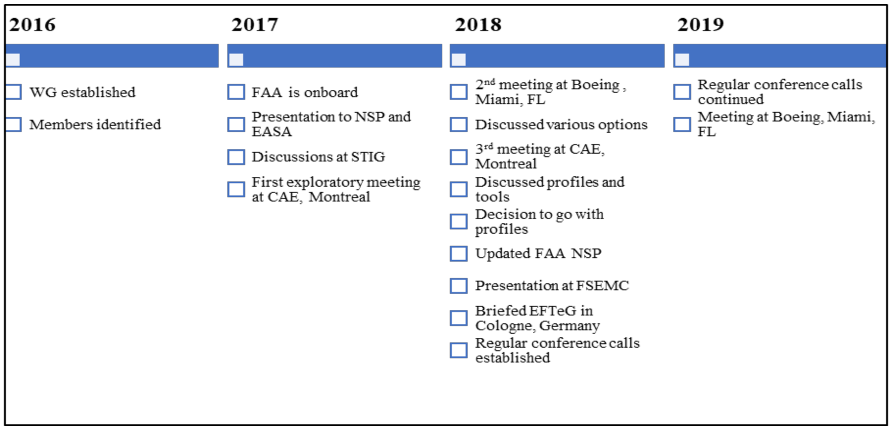


Figure 2-2 – SCQ WG Historical Information

2.3 SCQ Exploration

SCQ WG exploration to date has encompassed topic discussions and testing regarding:

- Dynamic flight profiles
- Reduction in the number of tests
- Analyzing objective results in the time domain

2.4 Profile and Other Testing

- Several Options discussed in some detail
- Load checksum …. No H/W involved, did not address the non-aero issues
- Birhle, TRU, CAE, Abbreviated, Profile Approaches

2.5 Tools

- Manual input capture (CAE)
- Currently available

2.6 Who is on-board

The list below identifies types and names of organizations presently supportive of the SCQ WG efforts.

- Operators — FedEx, United, Delta, Lufthansa
- TDMs: — CAE, FSI, TRU, L3, AXIS
- OEMs – Airframers — Airbus, Boeing
- Regulator(s) — FAA, EASA

2.7 Prerequisites

The following prerequisites apply to any FSTD (...older legacy and neer model FSTDs) planned for incorporation of the SCQ proposed flight profile testing.

Prerequisites include:

- The simulator already meets the fidelity requirements as evaluated per the appropriate regulatory criterion and is approved for flight crew training via a valid statement of qualification certificate
- FSTD shall be capable of front-end driving of flight controls positions and forces
- Configuration Control
- Approved Quality Management System
- Add Other Assumptions Here

2.8 Continuing Qualification (CQ) / Load Check Issues

2.8.1 Time, Cost, Effort

Initial concerns with the time and effort needed to execute entire QTG annually … included the cost from both operator and regulatory aspects (sim time)

EEI partially addressed certain aspects

Issues of quick checks (yearly) and assessment still remained

Load checks still involved entire QTG

2.8.2 Regulatory Assessment Issues

Uniformity of assessment …. Understanding QTG by CQ evaluators

Will the regulations accept this?

Mechanism for acceptance

Trial Period, incentives, etc.

3.0 OPTIMAL COMBINATION INPUTS AI: AL

3.1 Introduction

Optimal Combination Inputs (OCI) are simply a series of maneuvers taken to stimulate the FSTD and generate data for evaluation. The fidelity of the device can be ascertained against prior test results (or baseline data).

The test result can also be inserted back into the device and "re-run" for engineering purposes.

3.2 Profile Types

Text.

3.2.1 Profile 1 – Ground Handling and Takeoff

Text

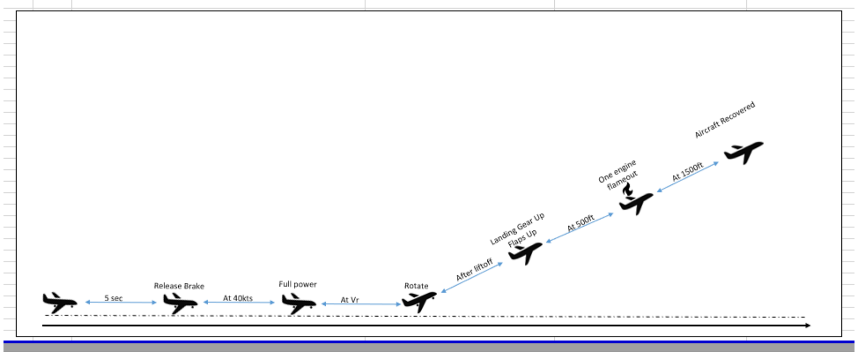


Figure 3-1 – OCI Profile 1

3.2.2 Profile 2 – Cruise and LOFT

Text

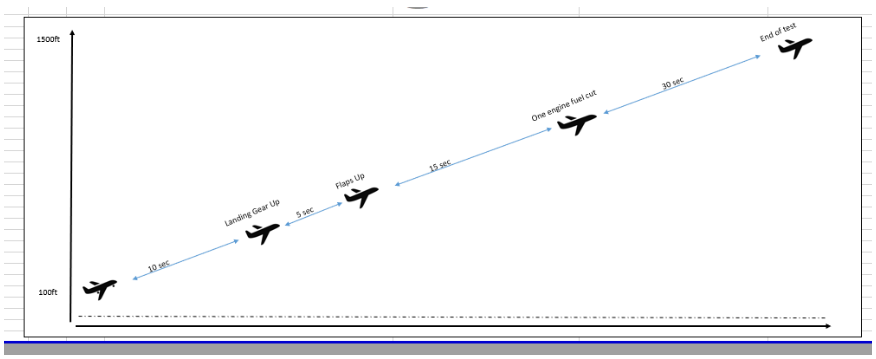


Figure 3-2 – OCI Profile 2

3.2.3 Profile 3 – Landing and Rollout

Text

Figure 3-3 – OCI Profile 3

3.3 Additional Information

None.

3.4 Discussion

Include excerpts from paper

The goal of the SCQ WG dynamic flight profile testing thus far has been to arrive at a concise number of flight profiles and associated tests that will do a comparable job of validating simulation regression more efficiently with the potential to add value using multiple FSTD's. In doing so, the following concepts have been evaluated and initially tested on several FSTD's:

Design, use, and test results analysis of three (3) separate engineering profiles that contain a combination of maneuvers or modes in a practical sequence

Note:

Segments of each test profile has to date represented trends or critical segments of certain combination of QTG tests.

3.5 OCI Flight Profile Descriptions

(Describe OCI 1, 2, and 3 here)

(Describe / add pictorial of FSTD test envelope used vs overall aircraft flight envelope)

3.6 OCI Flight Profile Use Benefits and Drawbacks

Table 9-1 identifies some of more significant Benefits (Pro's) and Drawbacks (Con's) regarding use of the proposed flight profiles.

BENEFITS	**DRAWBACKS**
✓ Quick and easy assessment ✓ Cost and effort towards initially ✓ No data ✓ Basics of profile can be replicated and adapted to various airplanes ✓ Should cover a majority of the aero tests ✓ Should be effective for load updates (Standard/Binary) ✓ In depth understanding not necessary ✓ No manual testing required	x May be difficult to implement in some legacy devices x Acceptance may take time x Does not cover entire QTG x Fool-proofing subject to IP issues

Figure 3-4 – Proposed Flight Profile Benefits and Drawbacks

3.7 FSTD's Used for OCI Flight Profile Testing

Initial SCQ WG flight profile testing included use of a variety of QTG tools on older legacy and newer FSTD's at flight training centers owned and operated by Boeing, CAE, FedEx, United Airlines, and Lufthansa Airlines. Among the FSTD's used at these training centers were:

Table 3-1 – FSTDs Used for OCI Testing

IN-SERVICE DATE	TDM	FSTD TYPE
1990	CAE	Boeing 737 CL
1997	THOMPSON	Airbus A320
2001	FlightSafety International	Boeing 737 NG
2014	Sim Industries/LM/CAE	Boeing 767-300F
2018	CAE	Airbus A 320

3.8 OCI Flight Profile Examples

(Insert OCI 1, 2, and 3 plotted diagram examples / test results, descriptions, and FSTD used here)

The figure below is an early whiteboard version of potential flight profiles generated at the Boeing Miami SCQ WG meeting in January 2014. The profile consisted of takeoff and landing profiles wherein fourteen (14) overall maneuvers were embedded into these test profiles. The test was later flown manually using a pilot-in-the-loop procedure and subsequent data was collected. At that time, it was decided that the specific profiles were too difficult to implement using the QTG tools available at that time.

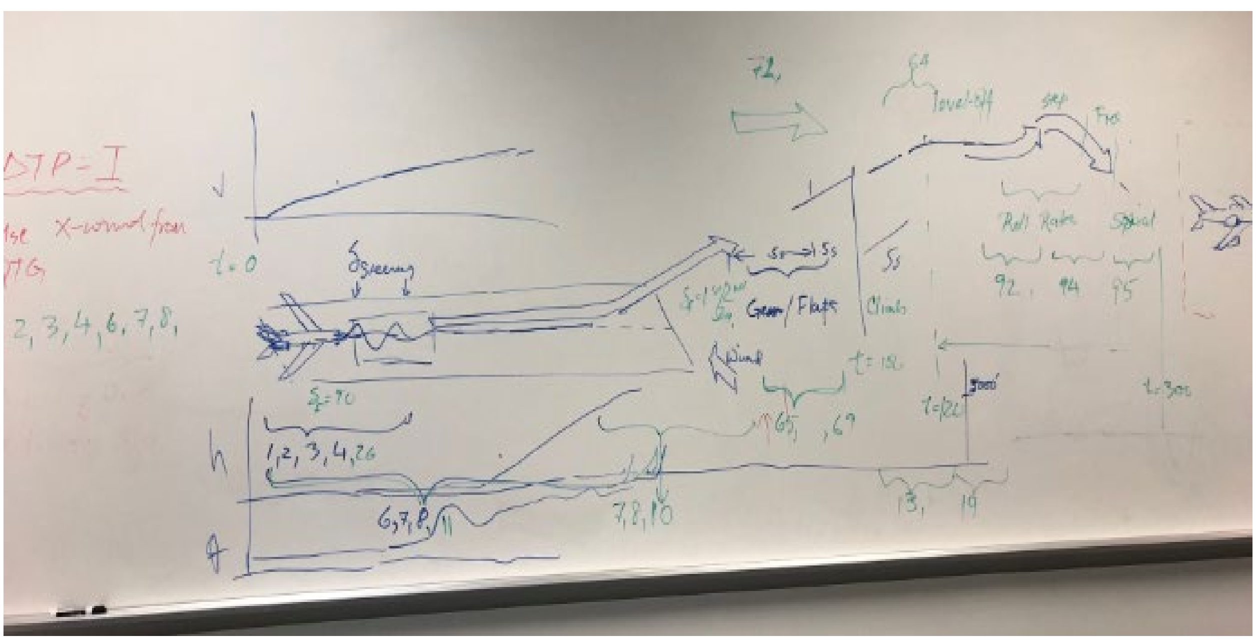
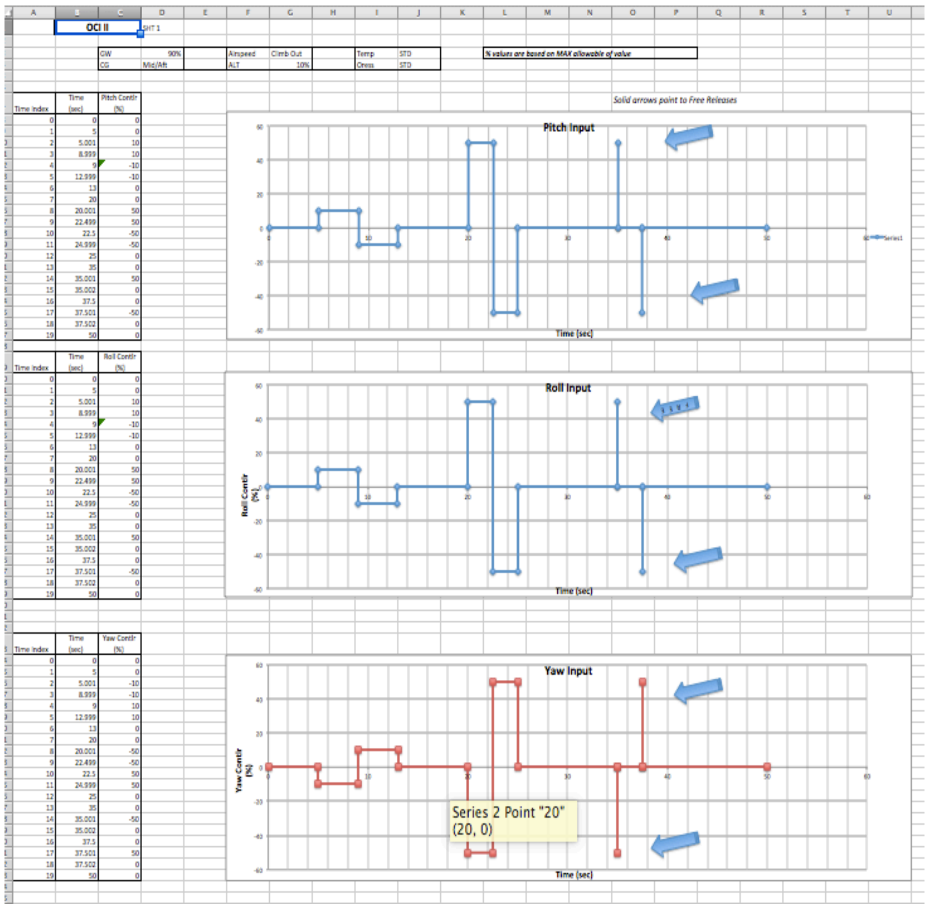


Figure 3-5 – Initial Whiteboard Flight Profiles

Figure 9.2 below illustrates an additional potential flight profile description and associated identification details.



OCI II | SHT 1

GW	90%	Airspeed	Climb Out	Temp	STD
CG	Mid/Aft	ALT	10%	Dress	STD

% values are based on MAX allowable of value

Time Index	Time (sec)	Pitch Contlr (%)
0	0	0
1	5	0
2	5.001	10
3	8.999	10
4	9	-10
5	12.999	-10
6	13	0
7	20	0
8	20.001	50
9	22.499	50
10	22.5	-50
11	24.999	-50
12	25	0
13	35	0
14	35.001	50
15	35.002	0
16	37.5	0
17	37.501	-50
18	37.502	0
19	50	0

Time Index	Time (sec)	Roll Contlr (%)
0	0	0
1	5	0
2	5.001	10
3	8.999	10
4	9	-10
5	12.999	-10
6	13	0
7	20	0
8	20.001	50
9	22.499	50
10	22.5	-50
11	24.999	-50
12	25	0
13	35	0
14	35.001	50
15	35.002	0
16	37.5	0
17	37.501	-50
18	37.502	0
19	50	0

Time Index	Time (sec)	Yaw Contlr (%)
0	0	0
1	5	0
2	5.001	-10
3	8.999	-10
4	9	10
5	12.999	10
6	13	0
7	20	0
8	20.001	-50
9	22.499	-50
10	22.5	50
11	24.999	50
12	25	0
13	35	0
14	35.001	-50
15	35.002	0
16	37.5	0
17	37.501	50
18	37.502	0
19	50	0

Figure 3-6 – Additional Flight Profile Description and Details

3.8.1 B737 NG and A320 Flight Profile Test Results

Figure 9.3 contains flight profile tests results using:

- Left Side Plots: B737 NG FFS (see 40 second test results)
- Right Side Plots: Airbus A320 FFS (see 100 second test results)

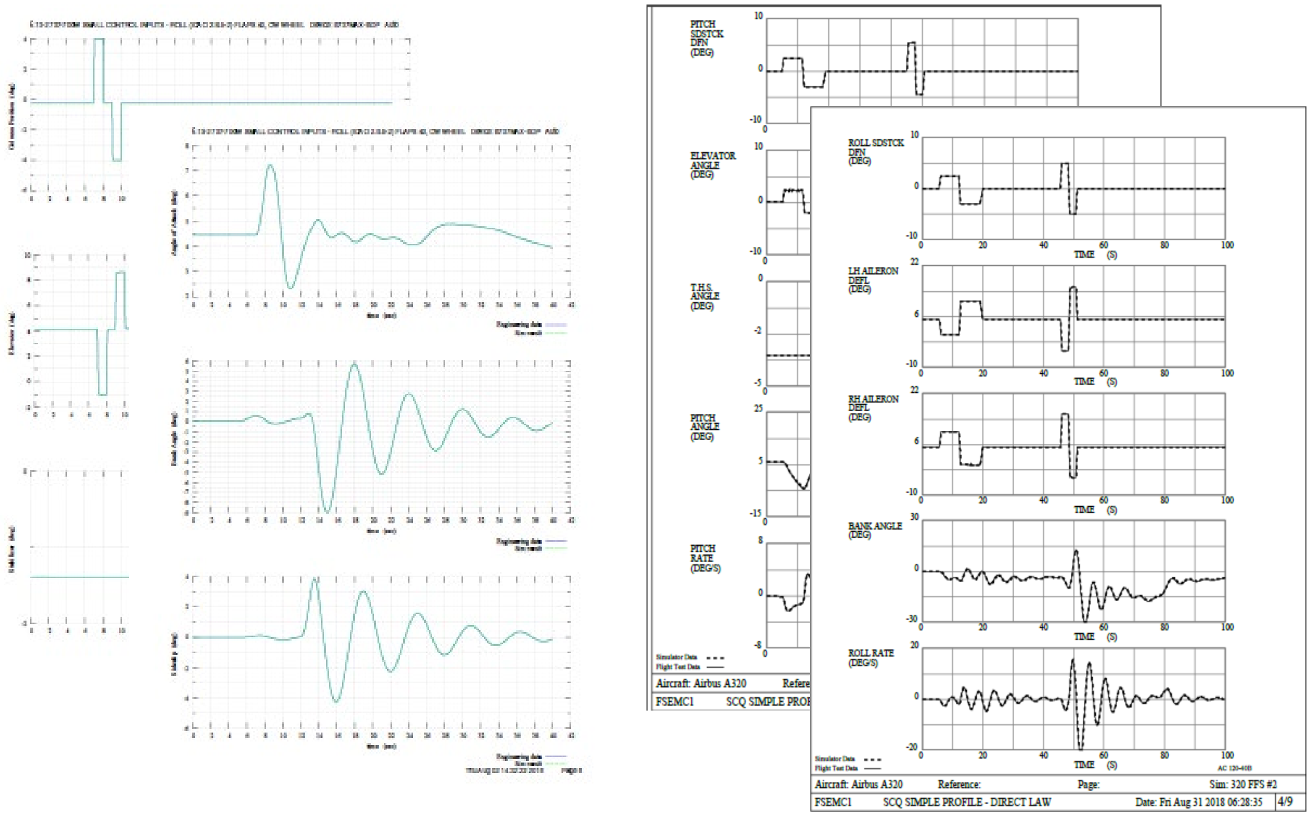


Figure 3-7 – B737 NG and A320 FFS Flight Profile Test Results

3.8.2 CAE A320 Flight Profile Test Results

Figure 9.4 below contains flight profile tests results using CAE's new DTP software QTG tool set on a CAE Airbus A320 FFS.

The CAE developed new tool set:

Provides:

Provides the ability to create tests that can quickly and comprehensively validate the simulator behaviour to identify flight simulation modelling (software/hardware) potential regression

Benefits Offered:

As easy as 1,2,3: Record, Replay Instantly, and Compare

Drastically decreasing the engineering set up … From 3 weeks to negligible

Note:
The results in the figure depict the test being run twenty-five (25) times with each test result over plotted on top of the previous test result plot.

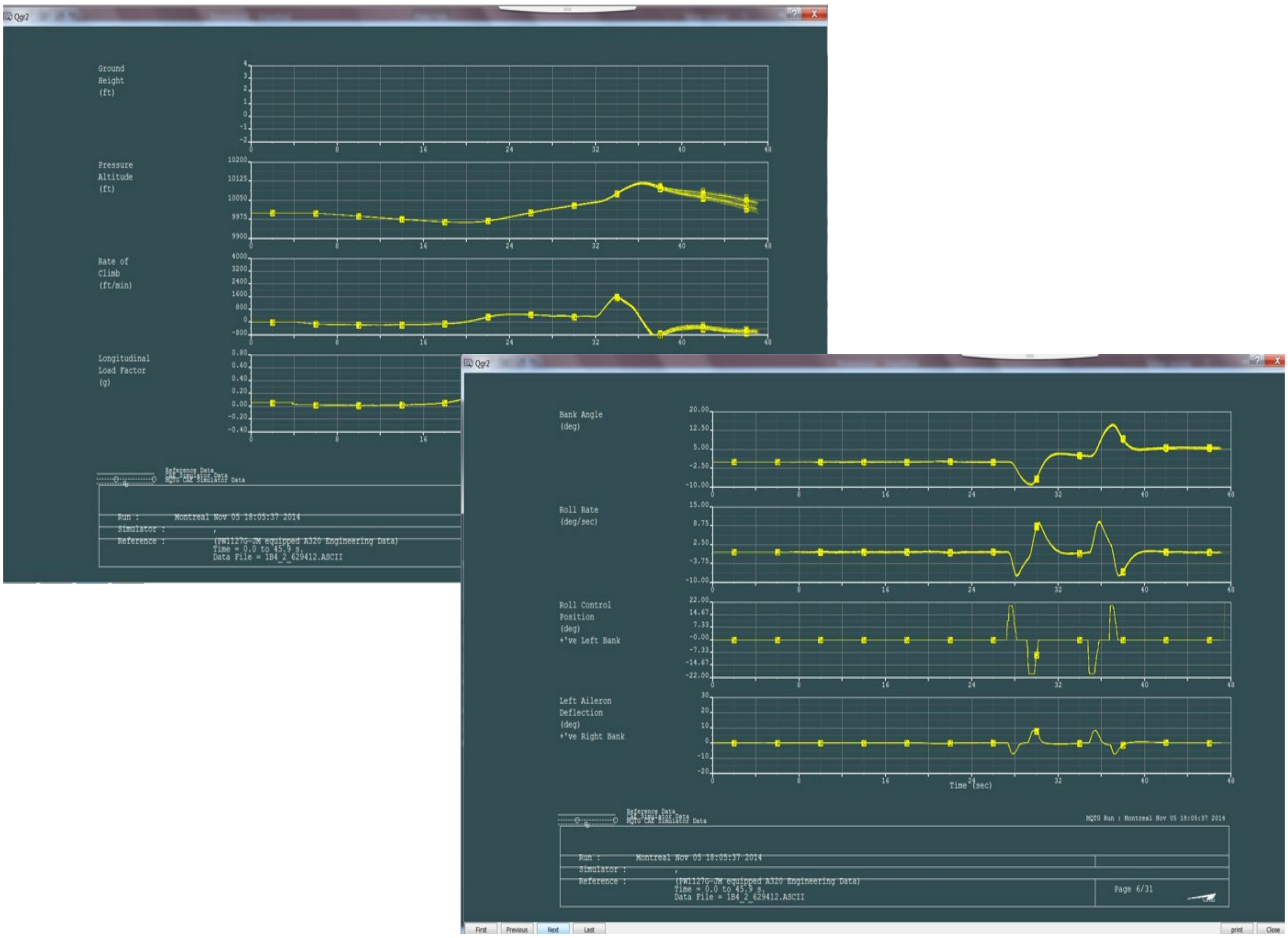


Figure 3-8 – CAE Montreal B737 NG and A320 FFS Flight Profile Test Results

3.9 Test Set Up

Include excerpts from test set up

4.0 TESTING METHODOLOGY AI: BOEING AND FSI

4.1 Introduction

Text.

4.2 Baseline Generation

Pilot flown

Engineering data (Math pilot)

Test Running

4.3 Open Loop vs. Closed Loop

Text.

4.3.1 Open Loop

Engineering value

Troubleshooting

4.3.2 Closed Loop

Succinct testing

May mask problems (tolerances, latency, etc.)

4.3.3 Hardware Effects on Testing

During testing, one should consider how (i.e., driving controls/surfaces, etc).

4.3.3.1 Driving Controls

Text

4.3.3.2 Driving Surfaces

Text.

4.4 Input Condition Considerations

For each OCI profile, an airline or operator should apply consistent input conditions. The initial setup becomes important for repeatability, and equally important in comparison of one or more test results.

4.5 Repeatability

While important to an airline or operator, repeatability is not the primary goal for a regulatory recurrent qualification. The primary goal is faithful fidelity of any training device to the aircraft it represents.

Depending on the type of input/output, tolerance criteria can vary to suit the criticality. Sources of non-repeatability include:

- Turbulence
- Runway contamination
- Trim with hardware in the loop

- Hysteresis
- Deadband
- Trim related
  - Slight numerical differences between each trim
    - Partially inevitable
    - Partially caused by non-optimized trim gains and parapeters
  - Wrong trimming method for requested condition causing some axes to be untimed
- System related
  - Flight controls, engines, or ancillary systems not optimized to catch up backdrive commands during trims – causing discontinuities
  - Non-seamless backdrive switches after the trip/reposition (e.g., EFCS of Flight Controls no providing requested backdrive commands)
  - Flight controls deadbands/hysteresis causing several control positions possible for one surface deflection
    - Initial control position may be different each time a scenario is re-run
    - In some cases, control position may be closer to the deadband threshold with can eventually affect the surface response
- Synchronization related
  - Not starting a test in the same dispatcher leg in which it was started
  - In cases where we are running OEM simulations it may be impossible to perfectly synchronize it with our simulation
  - 3
  - 4

4.6 Repeatability

Re-run issues

Modifications of inputs

4.7 Procedural

Introducing into standard testing

4.8 Compiling Results

Include selected results

4.9 Loads

Discussion on Load Standards, Binary

5.0 TOLERANCES AND DEVIATIONS AI: CAE

5.1 Introduction

Text.

5.2 Tolerance Considerations

Tolerance criteria should be applied to OCI data evaluation for consistency and reasonable fault identification. Considerations include:

- Data collection over time (sample size).
- Standard deviation over sample size.
- Hardware vs. Software tolerance expectations.
- Acceleration and displacement

Tolerance criteria can be a singular point of pass/fail, or perhaps in a range of deviation. The difficult item to discern is high tight of a range would still provide benefit to data evaluation and test scoring.

An airline or operator may also find that a tolerance parameter is not necessary and provides no value by setting a pass/fail point or range.

5.2.1 Version 1 – Monte Carlo Method

Text

5.2.2 Version 2

Text

5.2.3 Version 3

Text

5.2.4 Version 4

Text.

5.2.5 Version 5

Text.

5.3 Parameters

Text

- Parameter 1
- Parameter 2

6.0 OCI VALIDATION (PROOF OF CONCEPT)

6.1 Introduction

6.2 Error Introduction

6.3 Forced Errors

- Aero coefficient errors
- Control hardware errors
- System errors

Figure 11.1 below illustrates a study conducted by United Airlines to show the effect of errors in the profile, versus error in the QTG. The profile validated that it will catch the same types of errors that fail QTGs.

The method used included injection of a calibration error into the accelerometer signal going to the ELAC.

Summary of results in the figure were:

- Left Side Plots: QTG test 2C2A: Flap change dynamics
- Right Side Plots: Profile test run with same induced error

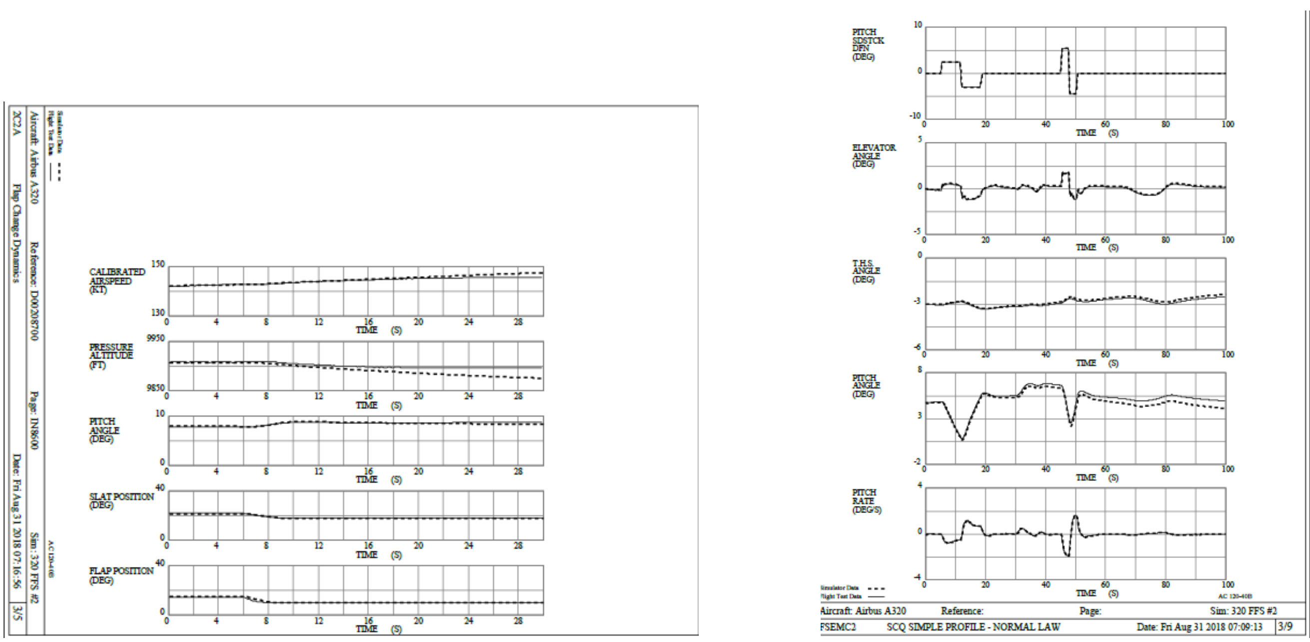


Figure 4-1 – Error Introduction Flight Profile Test Results

6.4 Deviations

Allowable Study

6.5 Criticality

6.6 Definition and Interpretation

6.6.1 Defining Testing

(Add description here)

6.6.2 Define Regression

(Add description here)

6.6.3 Parametric identifiers

(List identifiers here)

6.6.4 Quick/In depth Analysis

(Add description / define method used here)

7.0 REGULATORY CONSIDERATIONS AI: AL AND AIRCREW TRAINING

7.1 Introduction

7.2 Alternate Means of Compliance

What is in the regulations (FAA, EASA)

How to ask for an exception (FAA in DC)

Process to submit OCI results in place of QTG results

https://www.skybrary.aero/index.php/Alternative_Means_of_Compliance

By definition, and in the case of flight simulation training device (FSTD) qualification, an acceptable Alternate Means of Compliance (AltMOC) is considered a method wherein compliance with a specific aviation regulatory requirement or rule is satisfied via an established means other than that typically expected by an aviation regulatory and approving agency. An example, if an acceptable data set is not available for use is qualifying an FSTD as part of an Acceptable Means of Compliance (AMOC)

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APPENDIX A ACRONYMS

A	Airbus
ABC	Alpha Beta Charlie
AltMOC	Alternate Means of Compliance
AMOC / AMC	Acceptable Means of Compliance
ARINC	Aeronautical Radio Incorporated
B	Boeing
CAE	Canadian Aviation Electronics
CQ	Continuing Qualification
DO	Document from RTCA
EASA	European Aviation Safety Agency
EFCS	Electronic Flight Control System
FAA	Federal Aviation Administration
FAQ	Frequently Asked Questions
FFS	Full Flight Simulator
FSEMC	Flight Simulator Engineering and Maintenance Conference
FSI	FlightSafety International
FSTD	Flight Simulation Training Device
ICAO	International Civil Aviation Organization
LOFT	Line Oriented Flight Training
NG	Next Generation
OCI	Optimal Condition Input
OEM	Original Equipment Manufacturer
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automotive Engineers
SCQ	Simulator Continuing Qualification
SDV	Simulator Data Validation
STIG	Simulator Technical Interest Group
QTG	Qualification Test Guide
WG	Working Group

APPENDIX B GLOSSARY

Alpha

The first. If you aint first, you're last.

Monte Carlo

James Bond parties there.

Optimal Combination Input

APPENDIX C OCI TESTING EXAMPLES

7.3 Heading 2

The topics below are awesome.

The topics are not in a stratified order, and include:

- Bullet 1
- Bullet 2
- Bullet 3

APPENDIX D FREQUENTLY ASKED QUESTIONS

7.4 Heading 2

7.5 Frequently Asked Questions (FAQ)

Note:

Click on a specific question below to show answer. To close answer click on question again.

- Q1: What fidelity level must an FSTD meet prior to implementation of the proposed flight profiles?
- Q2: If an operator chooses to use the proposed flight profile method will it replace the current aviation regulatory required QTG testing?
- Q3: If an operator chooses to implement the proposed flight test profile method can they choose to implement only some of the profiles or do all of the profiles have to be implemented on the designated FSTD
- Q4: What is the required aviation regulatory agency (FAA, EASA, TC, etc.) approval process for an operator to implement and use the proposed flight profiles as an alternate means of compliance for recurrent / continuing qualification evaluations?
- Q5: What aviation regulatory agencies have pre-approved and accepted the use of the proposed flight profiles?
- Q6: Is manual QTG testing still required if an operator chooses to implement the proposed flight profiles?
- Q7: Will aviation regulatory agency functions and subjective testing still occur if an operator chooses to and is approved for use of the proposed flight profiles as a means of compliance during recurrent / continuing qualification?
- Q8: How frequent must the proposed flight profiles be performed by a sponsor / operator on the designated FSTD if an applicable aviation regulatory agency approves the use of the flight profiles?
- Q9: Are the proposed flight profiles only useful for QTG related testing from a training perspective or can they also be used as a form of early detection preventive maintenance and/or problem discrepancy troubleshooting-fault isolation-fault analysis-fault resolution-fault resolution regression testing by the sponsor's / operator's simulator maintenance team?
- Q10: Would the proposed flight profiles have to be retested and/or re-baselined if a change or update occurs to the simulator load?
- Q11: If implemented will the proposed flight profiles detect and identify all occurrences where the simulator load has changed since the last run of the profiles? If so, how will the change be identified to the sponsor / operator?
- Q12: Can an sponsor / operator choose to revert back to only running the individual MQTG tests without disqualification of the FSTD?
- Q13:
- Q14:

- Q15:

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APPENDIX E WHITE PAPER MATERIAL

Simulator qualifications have often been somewhat of a contentious exercise in the pilot training industry. Despite fairly well laid out regulations, informed and involved personnel (stake holders), reliable high-technology equipment and techniques, proven system configurations, the process of evaluation is wrought with pitfalls that consistently defy reason and sometimes even logic. Rarely are qualification or evaluations carried out without a hitch.

In order for a simulator to be used for training and a pilot to receive “credits” in accordance with training regulation outlines, a simulator is required to be “qualified” or “certified”. The difference is not necessarily of semantics but quite targeted.

Qualifications fall essentially under three broad categories- first, there is the crucial “initial” and then the ongoing “continuing” or “recurrent” qualifications.

In between are also qualifications for upgrades, updates, moves, re-qualifications (reinstatements) and various others that may be termed as “specials”.

An examination of the different types of qualifications will show that they all fall under the giant umbrella of the “initial”. The other types of qualifications are all subsets of the “initial”. The processes for each are treated differently but the “approach”, the tools and techniques utilized have much in common. The manner of all the testing has a basis on the “initial”.

During an initial qualification, the regulations specify in detail the requirements needed to be accomplished in order to establish the assessment of a good training tool and a sound validation of the fidelity level of the simulator. From then onwards, at certain intervals, the simulator is required to undergo a subset of the initial qualification in order to prove that the original assessment made during the initial remained valid. This is more or less a simplistic view of the process!

In general, the initial, recurrents and most of the other types of qualification require the presence of the regulatory authorities as witnesses. The authorities may, in certain cases and under circumstances, allow some special qualifications to be accomplished by other designated personnel. These involve matters of confidence and credibility and sometimes personnel logistics.

Every qualification check consists of two parts- a subjective and an objective. During an initial, the subjective checks encompass fly-out’s, system checks, checks on “abnormals”, handling and operational aspects and require the expertise of qualified personnel (pilots) and engineers. The objective checks (tests) are all mainly contained in a Qualification Test Guide (QTG) and are specific to the applicable regulatory document. The tests are very detailed in nature and obtaining supporting references can be a very expensive proposition. Complete data packages have soared in pricing and retesting of questionable data may turn out impractical. The regulations also deem that all of objective tests be conducted as a pre-requisite to a qualification and presented as part of the qualification. Once the simulator undergoes the initial qualification, the cycle for continuing/recurrent qualification begins.

During recurrents, the simulator undergoes both subjective and objective checks in a much-abbreviated fashion to the initial. The idea is to sample-verify. In rare cases and especially for special qualifications, some objective portions may be dispensed with.

If the simulator has been under strict configuration control and properly maintained, subjective or objective checks should not reveal any problems during subsequent recurrents- at least in theory. The entire QTG is required to be executed and presented to the authorities on a yearly basis. This process can become tedious, repetitive and time-consuming. And, based on current methods of validation, the process may not unveil the true picture of the state of the simulator, which would be contrary to the goal for a recurrent.

Since a recurrent is an abbreviated initial and hence a subset, a case to be made that many of the problems discovered may have emanated from the initial as they can be passed down. However, tackling the “initial” issue, in spite of all sound arguments, has to be relegated to another discussion. The scope of this paper will concentrate only on the “recurrent” objective testing aspects since the possibilities of streamlining the process would be far more manageable and benefit the entire industry. Since the subjective testing does not require any such pre-tests, the effort involved is minimal.

Again, the intent of a continuing or recurrent qualification is to ascertain whether the original assessment of a simulator has been maintained. The typical recurrent involves the execution of the entire list of tests as contained in the QTG at designated intervals (normally on a yearly basis) and is accomplished by the operator. The regulatory authorities then require the witnessing and sample testing of the simulator as well as evaluating the voluminous results.

A fresh execution of the entire QTG may require a few contiguous days, even when run automatically. Since a regulatory requirement is to have the runs spread over the year, a specific quarter of the QTG is run during each quarter. Due to training times/slot constraints, runs may have to be conducted sporadically over the quarter. The process has to be repeated another three times during the year. This takes a toll on the training schedules as well as the revenue.

Hence, some means of establishing the integrity of an original assessment without imposing undue burden on the operations would be a welcome alternative to spending the time and effort (and the financial implications) for the operators. Plus there is value to helping maintain the standards. If the regulatory authorities can be convinced to the utility of such an alternative then their reassurance can be guaranteed- always with the option that, if demanded, the entire QTG would be still available for examination in its usual format.

As airplanes become more complex, more sophisticated and more computer-controlled, many of the conventional tests as specified in the regulations are delivering lesser valuable information towards validation (or revalidation) from a traditional sense. Alternative approaches will need to be considered. It is conceivable that one can come up with one or few tests which when conducted, hopefully in an integrated fashion (involving the various systems in a simulator), will deliver a result(s) that would be far more meaningful towards establishing the integrity of the entire configuration. Such a test or tests would efficiently reveal crucial factors of the simulator configuration and in a far speedier and efficient manner. The test(s) may involve a flight pattern that may incorporate various key regimes in the flight envelope and include maneuvers and important abnormal conditions. Since, under normal circumstances, such a representative flight test may not be available as reference data for validation purposes, such a test would have to be designed judiciously and would be categorized as a “footprint” type test and subsequently evaluated in the usual fashion.

Tests may also be constructed purely from a software basis whereby the integrity of the configuration would be checked. The idea would be the use of a computational utility that would execute logic checks throughout the computational software to flag any differences from an established baseline. Such types of checks are often conducted in other computational fields and can be very quick and reliable. However, including some of the hardware in the loop, because of permissible drift or wear, may pose a challenging proposition. The basis of any such testing would be an attempt to include the entire system or as much as practical so that a good representative of the simulation- both hardware and software is checked out in an integrated fashion.

For the naysayers, it would be prudent to realize that some degree of similar “integrity” tests have already being implemented but in a micro scale and is evident per the current regulations on motion and sound systems e.g. Motion System Repeatability/Cueing Signature, Frequency Response, etc. Their utility may be debatable, but the intentions are sound. The tests are intended as a check of part of these systems from an operational standpoint and establish degrees of system integrity.

Consider some of the pluses that such tests could deliver. If set up properly with diligence and designed to cover the gamut of the simulation, one or more of these test profiles may be accomplished within hours in lieu of days and run more conveniently during available time-slots and can be repeated over months. The tests would then provide, if not the same, a much deeper insight at the integrated model for analysis. A separate discussion on the implications of frequency of running and validity would be in order and is deemed outside the scope of this paper. All this would vastly reduce the time and effort currently being expended to meet regulatory requirements. A step further would be the possibility that such tests would also aid the authorities in obtaining a better preliminary assessment of the qualitative state of the simulator. If a more in-depth investigation into the objectivity were warranted after such a run, the regular options again would always be available.

A typical basic QTG may contain anywhere around 100 – 200 tests. And this is not even taking into account simulators with different engine fits, augmentation modes, acceptable variants, etc. As airplanes become more complex, this set may increase dramatically in number. If the assumption is that all the tests in an average QTG can be executed correctly and without any repeated attempts in approximately 24 hours of contiguous run time (an experienced assumption), in reality, the practical time involved could be over 5 times or more and even this assumption may still be conservative.

Consider certain realities and requirements that directly affect testing run time and effort:

- Tests have to be run in a quarterly basis spread over a year.
- Certain tests may require repeated attempts to obtain proper results.
- Time is expended in preparation and post-testing clean up.
- Some tests would require special testing setups including equipment setup.
- Pilot training logistics impact on time availability.
- Efficiency in time management of test conductors (personnel).
- Time required to making sensible evaluation of the results. May induce re- runs.
- Unforeseen issues which crop up and are the inevitability (Murphy's Law).

The tests in the QTG are spread judiciously over the various systems of the simulator with the obvious concentration on the flight modeling (aero, controls, engines, etc.). The sampling nature of these tests is intended to give the evaluator a clear objective overview of the fidelity of the entire system. Unfortunately each test is implemented almost in a standalone fashion. Each has its own unique "initial conditions" and tests are grouped to address specific regimes of the simulator operational envelope. There is very little crossover in addressing the transitions between the various phases of flight in a realistic and integrated way. There are minor exceptions and very few at that. Each test address validation in a discrete manner e.g. takeoff's, dynamic engine-cuts, climbs are basically all discrete tests and each usually with different initial conditions.

It is conceivable that one or more test profiles may be able to cover the majority, if not all, of these regimes in one continuous flow- starting from one initialization. After all one is still dealing with the modeling one ("average") airplane and obtaining real world data for such profiles may not be a practicality or even necessary. A well executed footprint profile covering each intended test regime could certainly provide the same information needed for re-validation. Without assigning any focused responsibilities, inputs from simulator manufacturers, aircraft manufacturers, operators, regulators and other interested parties should be seriously considered. Issues of weight and CG changes would need to be addressed and so would different tests that are conducted in similar flight phases. It is important to understand that these kinds of profiles are not intended to replace existing QTG tests but being generic in nature, to be used only during recurrents as a quick check in identifying problem areas. And such profiles may be approved either in conjunction or after a "classic" qualification.

Another interim idea floated was the use of an abbreviated list of test from the QTG. This selected list would be less cumbersome to handle on a recurrent. The idea does have its merits but really is a stopgap measure and, in the authors' opinion, can lead to much confusion. The tests have to be selected based on airplane, vintage, hardware and software architecture and systems and the individual problems they may generate. Persistent failing tests would still be the issue. The feasibility of such an endeavor would create a parallel mini-QTG, which would be an impractical long- term solution.

The visual system is one that has no true objective tests (vis-à-vis the real world) from an operational angle. The system does have tests that are termed objective but are mostly “capability” in nature while others are evaluated subjectively (even the Visual Ground Segment Test which is set up with very “hard” numbers!). Of importance in operation (training) are training scenarios (airport scenes) and issues of color balance, focus, aliasing distortion and others and again, are subjectively assessed. Some motion tests are similar as well and these would require separate analyses.

This paper is intended to stimulate (no pun intended!) the thought processes related to repeated evaluations and ensuing inefficiencies during recurrents. The paper will hopefully generate innovative options and means of streamlining the process. As this industry expands, efficiency and cost-savings become primary drivers. Informed discussions and practical studies are needed. Each option considered would need to be examined on its merits.

Before embarking on any in depth study, the authors would like to caution any researcher against some pitfalls and trends in the thought processes that seem to crop up persistently. It is a common belief that there are tests that take longer to set up, do not give consistent correct results, are difficult to execute or require too

much effort in set-up equipment and result-interpretation. One has to be remindedthat there are too many variables at stake- the operator, the simulation engineers, the airplane, the simulator manufacturer and more so the aerodynamic model, software architecture of the system and of course the test drivers. The problem may lie in any one or a combination of these variables.

If a test is inconsistent throughout the industry, the requirements for the test may need to be re-evaluated. Inconsistencies, upon careful examination, generally can be narrowed down to certain groupings or variables as mentioned. They then have to be dealt with within their respective scopes. It may point to issues in design, methodology or quality in the software or hardware. It may also point to issues with maintenance or lack in expertise.

Some of the propositions in this paper may require eventual regulatory changes. However, if a proposition is sensible then one should not waver from pursuing for change. As a reminder, all changes to the regulations over the years have been instituted from the outside (because of issues or problems). It is imperative that any changes proposed happen within the framework of the regulatory process. The regulators should be involved at all stages and proposed changes should follow a “buy-in” from them because the final benefits are equitably translatable. The current mood in the industry may be conducive to regulators in their willingness to promote such ideas towards value and efficiency.

Considerations have to be allocated to other facts as well. There are a very large number of simulators of various aircraft, vintage and manufacturers that are currently active. Certain aircraft designs may lend themselves well to an integrated check of its systems (model), others may not. Provisions have to be made to encompass the different nuances that exist. In the spirit of streamlining and efficiency, attention needs to be paid to all budding ideas ensuring that they do not result in undue burdening of existing or future operations.

It is a fact that in the past, such adventurous concepts have not been given their due. The bias towards what seem to be working rather than what can be done better should not be held as an excuse for the status quo. The effort towards proactivity is far more beneficial on the long run. In conclusion, the perceived value- as the outcome should be tempered with the effort and cost associations keeping in mind that the final goal is to benefit all parties involved. All these efforts may eventually lead to a new RQTG or RvQTG (Re-validation QTG!).

Maybe, one day there will be an “app” for such recurrents…..