Simulator Training for Flight Inspection

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BIOGRAPHY

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Work on automatic code generation and quality management systems.
With Aerodata since 2006 as Software Engineer, Customer Support and Project Manager
- Software Design and implementation
- Configuration Tools
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- Calibration software
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- Training
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Dipl.-Ing. for Measurement, Control and Energy Technics at Technical University of Braunschweig
Work with computer controlled transport systems
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- Project Manager for flight inspection and mission systems
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ABSTRACT

Flight simulation tools have grown up from simple programs with low demands for realism and graphics to autonomous serious products. Professional flight simulation tools are used worldwide for supporting any kind of flight aspects. Learning in simulators has become an important part for every pilot.
Sophisticated flight inspection systems provide already the possibility to simulate flight inspection aspects. Normally these are limited to a small number of predefined flight procedures, which cannot be modified or influenced.
Professional flight simulators, coupled to a flight inspection system, provide much more realistic behavior and expand the possibilities of training.
The proper communication and understanding of the crew members, a precondition for successful and save performance, can be trained or reproduced as well as realistic situations inside real simulator cabins, especially during night operation or difficult weather and traffic conditions.
Modified data of ground facilities under inspection allows a preparation for difficult situations and increase the knowledge for later missions.

INTRODUCTION

Simulation can be defined as an "imitation of a real-world process or system".
Simulation comes into use if real systems or means are
- Not yet existing
- Not available or only once

- Too fast or too slow
- Expensive
- Dangerous
- Not feasible due to time, location or other reasons

There is a difference to other supporting means like replay/reprocessing/recalculation, which repeat an already recorded event with same or different parameters and conditions.

Simulation is already in use at many different avionic areas, e.g.
- Procedure validation (there are recommendations to perform a simulation before the real flight inspection)
- Pilot training
- Antenna calculation and simulation
- Effects on GND RF signals (shadowing, reflection) by nearby obstacles (large aircrafts, buildings, terrain constellations) – already shown on the IFIS in different presentations
- Performance of engines, wings etc.

Simulations normally have – beside they only "copy" the reality – some advantages. They can be
- stopped or paused at any time/position
- accelerated, slowed down, may be shifted fore and back
- special parts can be skipped
- repeated as often as requested
- different views or settings can be arranged, while the general situation remains the same.

The basic function of flight inspection software simulation was implemented in our company around 1992 and since then continuously improved by special requirements, further functions and levels.
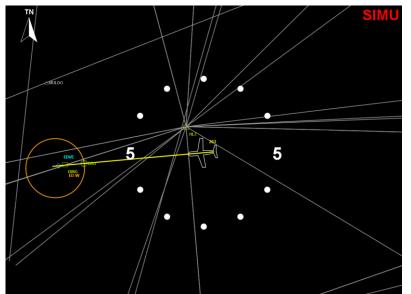
Realization

This lecture describe four major levels of simulation in flight inspection, which have been implemented so far:
1. Simulation of general flight inspection procedure paths
2. Modification of the simulated signal
3. Involvement of additional flight simulation SW
4. Connection to professional flight simulator

1. Simulation of general flight inspection procedure paths
Started as a SW development tool, then used for verification and training, the first level of simulation was integrated very early in our flight inspection software.
It provides procedures often used for flight inspection, selectable by the user.
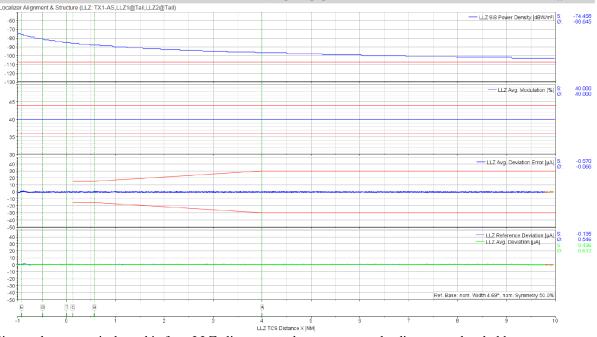

Picture shows a moving map, with a centerline approach (e.g. for LOC alignment and structure)

The SW assumes an ideal functionality and an availability of all parameters and devices:

RTS Status	Alive	
No of failed plug in cards	0	
Radio Altimeter	Alive	
Semi Real Time System	Alive	
NAV1	Ok	Self Test
NAV2	Ok	Self Test
DME1	Ok	Self Test
DME2	Ok	Self Test
ADF	Ok	Self Test

Typical picture of the status page (build-in test) of the FIS equipment

Following the results are straight, smooth and always inside the tolerances:

Picture shows a typical graphic for a LLZ alignment and structure over the distance to threshold:
- first row indicates the signal power,
- second row the signal modulation in %,
- third row deviation error,
- fourth row the reverence deviation and the average deviation.
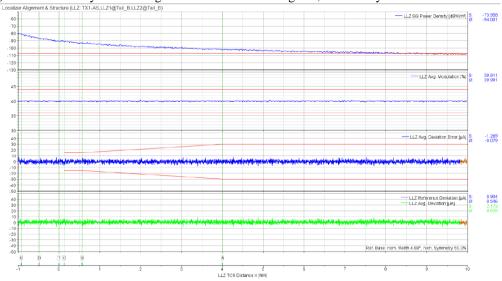
With this simulation the general functionality and performance check of
- FIS SW
- Hardware (computer)
- Connection and performance of special equipment like cameras, altimeters etc.
is possible. It serves further as training tool and comparison means for ideal (computer generated) and real (recorded) data.

2. Modification of the simulated signal

To expand the possibilities of the functionality further effects can be added:

a) Enhancement by a noise or generator on dedicated signals, which may violate tolerances:

Picture shows simulated approach signals with added noise
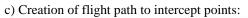
This function supports checking of:
- margins
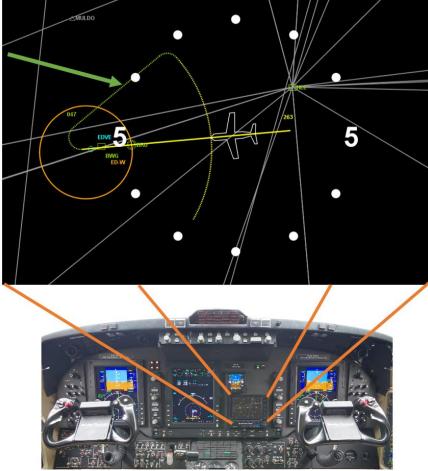- Out of tolerance indications
- Graphics
- Reports

b) Simulation of external (cockpit) signals:

Cockpit events / switches are used during inspections, where the decision or indication from the pilots are needed, e.g. VASI, PAPI.

Picture shows a cockpit and the according FIS simulation control window

c) Creation of flight path to intercept points:

Picture shows a cockpit guidance map

Here the functionality of the FIS software, a cockpit map / guidance and autopilot signals can be tested and shown.

d) Further control buttons for
- Simulation speed, reset
- Pause, Auto mode (for repeated and long time tests)
- Pre-selectable course, ground speed, altitude
- Event and update buttons;

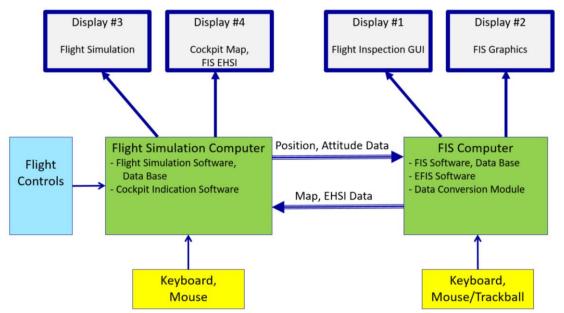Picture shows a typical FIS simulation control window

All these features improve the possibilities for trainees and can help to show and test the functionality of the FIS SW.

3. Replacement of the way generator and position module by flight simulation SW

If position, attitude and flight path of the simulated flight shall not be pre-defined, the according SW modules can be replaced by a dedicated flight simulation SW.
The flight inspection SW must be open to accept external data, and the flight simulation SW must be able to output the required data to external devices. Data conversion might be necessary. The integrity of both data bases (Flight Simulator and FIS) need be compared and verified.

Connection of modern computer systems is easy, and the setup can be realized like the following:

Picture shows a block diagram for flight inspection simulation setup

Pictures shows Flight Simulator PC next to Flight Inspection PC (office installation)

Picture shows a Flight Simulation System with
- Flight simulation computer with sufficient graphic power; keyboard, mouse
- Large display or projector for cockpit view (left)
- cockpit map / EHSI, interfaced by the FIS (right)
- Controls:
  o Yoke (for helicopter FIS simulation we use a joystick)
  o Quadrant levers
  o Switching panel
  o Pedals
- Sound system
- Software:
  o FAA certified Flight Simulation SW, data base
  o Cockpit guidance map
  o Network SW

The Flight Simulator is coupled to the Flight Inspection System Simulator:

Picture shows a training set for flight inspection:
- Flight Inspection simulation computer, keyboard, trackball or mouse
- One or two displays according customers installation
- Network installation (switch)
- Software:
    o FIS simulation SW, data base
    o Network SW

The connection is realized by high speed Ethernet. The following parameters are required from the flight simulator:
- position, attitude (in x, y, z direction)
- speeds, accelerations (x, y, z)
- events, switching
- cockpit indications

This installation provides – beside the already described features – the following benefits:
- New procedures can be tested (origin idea to couple the flight simulator), e.g.:
    o Radar (vector) based flight guidance
    o Land mark based flight guidance
- Behavior of "strange" positions / flight paths
- Reaction on special flight maneuvers / failures
- Cockpit performance / work load check e.g. with recording of runway marking light (failures)

Picture shows a simulated approach during night conditions

A couple of FIS simulation computers (we use up to five) can be connected via a network to one flight simulation "master", so several trainees can perform their task simultaneously and compare/discuss their results in behind.

During training sessions we experienced the following:
- Familiarization of the system is more "interactive"
- General interest is higher
- Technical discussion inside the crew start
- Positions are exchanged
- Understanding / acceptance of the others job increases
- External effects (weather, failures …) are simulated and discussed
- Several possible scenarios of a flight inspection task are repeated:
  o Different approach angles for localizer / glidepath
  o Different parameter of ground NAV aids under inspection
  o Alarm condition
  o Special CAT III requirements, weather conditions

As already shown for the flight inspection simulation software, modification of data bases can be done, like
- Simulation of data base failures, e.g.
  o Wrong runway data (length, threshold)
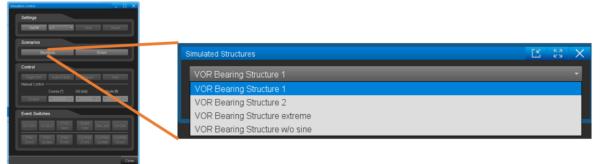 o Wrong position coordinates
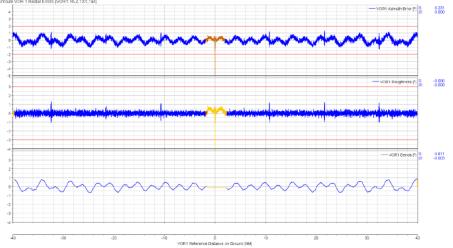
- Simulation of failures of GND facilities

Picture shows a view of a modified facility during approach.

- Simulation of failures of GND antenna signals.
  The software provides an interface for user implemented structure and error scenarios. Noise and other waveforms can be added by prepared functions to be parametrized e.g. by an ASCII setting file. Data like distance, azimuth, elevation and frequency are simulated and available.
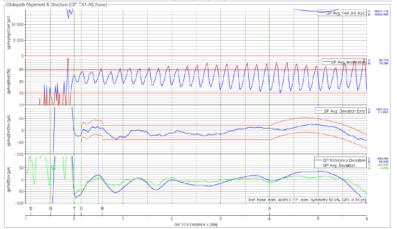

Resulting graphic of VOR Radial shows the selected scenario:_

Picture shows VOR Azimuth Error, Roughness and Bends analysis of the FIS.

The modifications are selected and activated by an user defined GUI.
Following the same principle, multiple scenarios like
- Facility errors:
  - Wrong GPz
  - Wrong promulgated Width
  - Coordinate errors
  - Alignment errors
- FI system failures or special situations at
  - antennas
  - receivers
  - receiver 1 to top antenna, receiver 2 to bottom antenna
  - not (proper) calibrated receivers
- Simulation of position reference system failures
  - Space based failures
  - GND based failures
- Simulation of flight guidance failures
- Simulation of A/C related failures
  - Propeller modulation / interference
  - Influence of gear up / gear down position / gear doors
  - Weather radar modulation / interference
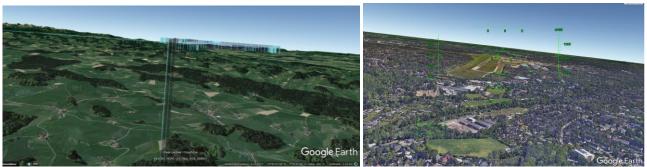

Picture shows a weather radar modulated signal

can be activated.

In addition the system supports customer acceptance procedures. The handling and general functionality during different situations, SW reaction time, FI computer performance, different tolerance settings, pre-definitions, graphics and report generation can be tested.
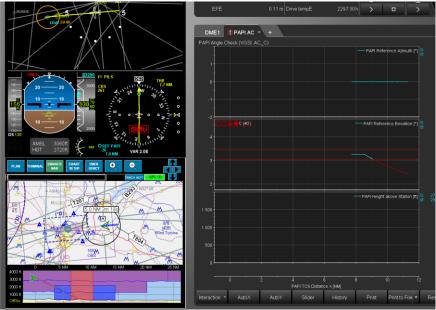
For post-flight evaluation the data direction can be turned; the real recorded data is used then to view the aircraft behavior / position during inspection flight:

Picture shows the simulated A/C during a replay run in the according attitude

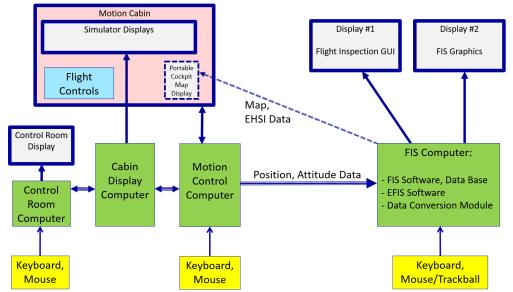KML export to google earth or other map systems is possible as well.

Integration of flight data into Jeppesen Flight Deck

Again, it is very important to compare and verify the integrity of both data bases (graphical / map program and FIS). For many programs it must be understood that the displayed landscape is a "shot" at a certain date and time, which normally is different to the time of the recorded flight.

4. Coupling to professional Flight Simulators

Some professional flight simulators simulate mainly cockpit control and indications, while others provide full motion simulator with closed cabin arrangements. These are flight simulators are typically computer controlled; the control computer is often connected via network to the motion cabin.

At best case this computer interface contains already all required data and can be expanded to a FIS simulation computer (e.g. by Ethernet or WLAN). Sometimes also links to GPS receiver, (which typically have a serial interface), transferring data which can be used. If not, some information (labels) may need to be added.

Block diagram shows the connection between a full motion simulator and the FIS simulation computer

If the data protocols of the computer systems do not match, either the control SW of the full motion simulator may be modified or a data conversion by flight inspection simulation data computer is established.

Many trained profiles are approaches, which are needed for flight inspection, too.

The space inside the cabin of a full motion simulator is limited, so an original size Flight Inspection Demonstrator is easier to be installed outside.

FIS installed outside of the motion cabin

If the flight inspection system size can be reduced, and the relevant signals are also available inside the cabin, a participation inside the cabin is possible:

FIS simulation computer inside the motion cabin

If the installations allow, the cockpit inside the simulator cabin can be enhanced by a portable moving map, controlled by the FIS SW. This allows a flight procedure training with the visual FIS guidance, the "closed to reality" mode available.

Picture shows a portable cockpit moving map display with procedure guidance

Costs

The more possibilities, advantages and technics are realized and implemented, the more the according effort and costs are rising.

Picture shows the relationship between technics and costs

Normally the costs of full motion simulator hours are less than the comparable flight hours, but still quite high. A coupling of pilot and FIS operator training at a full motion simulator makes sense, when anyway simulator hours are required/ordered and can be used in connection with flight inspection training.
Adaptation of motion simulator software need to be evaluated due to its complexity.
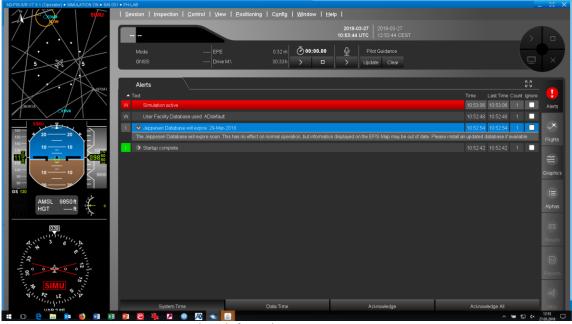
Summary

The simulation of flight inspection provides several advantages, especially during training sessions:
- Reduction of flight hours -> costs
- Available at all times, especially during daily working times
- Location is the office or classroom; acceptable level of noise, temperature, space etc.
    o Typically more than one system available
    o More people can be trained at the same time with comparable data
- Training becomes more interesting, different views are possible
- The understanding / crew resource management is supported
- Simulation SW normally have a "pause", repeat and speed control function (which are difficult to realize in reality)
- Modification of data enhance the training effect

Limits of (these) simulations
- Simulations are programmed; behaviors show the expected reaction
- Real reflections from ground, obstacles, buildings, surfaces or similar are yet not implemented (special programs available)
- Emergency cases cannot be sufficiently simulated
- It does not replace flight inspection, as real world scenarios and influences are not covered by the programs
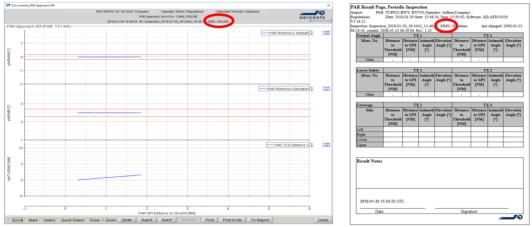-

So it is necessary to indicate clearly the usage of simulated data:

The FIS GUI gives the according "Alert" information

The situation awareness displays indicate the active simulation

Indication on all graphics and reports

ACKNOWLEDGMENTS