# Calspan Loss-of-Control Studies Using In-flight Simulation

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# Overview

- Calspan URT Background and URT Studies
- General Observations From These Studies
- Recommended Loss of Control Training Characteristics
- One Study in Detail – the US Navy P-8 Program Study
- Conclusions

# Calspan Background in Loss-of-Control Training

- In 1960 began in-flight simulator based Test Pilot School training to demonstrate aircraft dynamics, stability and control, and handling qualities.
- Shortly after US Air Flight 427 crash near Pittsburgh on September 8, 1994 we were asked if we could simulate the initial aircraft responses of that event.
- Did not receive a contract from the NTSB or Boeing, but Calspan began to consider use of their programmable airplanes to research and train “Selected Event Training.” Developed an early training program using internal funds.
- Performed six studies and trained over 500 commercial pilots from 1998 to 2012.

# Calspan's Loss of Control Studies

- **Study #1: 1999-2002.** Funded by NASA Ames. Looked at different training methods with 5 groups of 8 airline pilots. Simulated 8 hull loss accidents. Measured reaction times and response errors.
- **Study #2: 2002-2006.** Funded by the FAA. Developed airborne training program and collected performance and training effectiveness data. Trained 294 airline pilots. Developed the Recovery Rating Scale.
- **Study #3: 2007-2008.** Funded by FedEx. Evaluated URT effectiveness for airborne training and FFS. Evaluations by 20 FedEx pilots.
- **Study #4: 2009-2010.** Funded by US Navy. Evaluated URT effectiveness for airborne training and FFS. Evaluations by 30 Navy P-3/P-8 pilots.
- **Study #5: 2009-2010.** Funded by NASA Langley. Performed initial look at URT re-currency issue. Re-tested 40 airline pilots.
- **Study #6: 2010-2011.** Funded by NASA Langley. Evaluation of the utility of the Calspan URT for regional airlines. Trained 30 regional airline pilots.

# Observations from 12 Years of URT and Research

- Loss-of-control needs to be more than “unusual attitude” recovery training. Usually LOC events are accompanied by a malfunction or change in an airplane’s flying characteristics.
- Training devices need to be able to induce these upset causing malfunctions.
- Loss of control events come from a diverse set of causes and cannot be solved by a single set of procedures.
- Rather the solution must depend on pilot ingenuity and skill when confronted with rare or unique events. Previous exposure to such events and problem solving practice improves these skills.
- The concepts of “measured response” and “alternate control strategy” need to be part of a pilot’s skill set.

# Some More Observations

- There can be issues with an FFS's aerodynamic data base that causes the simulation to be non-representative of the actual airplane for some maneuvers.
- Notwithstanding the above, most loss of control situations are well within the "linear aerodynamic" region for both a FFS or a training airplane.
- Handling qualities of the training device needs to be representative. Small aerobatic aircraft don't fly like "transports" and may lead to a negative transfer of training.
- Although FFS are very good for procedural practice, for dynamic events there are sensory cue limitations to what can be observed regarding recognition and recovery from a loss of control event.
- The "element of surprise" and the actual "airborne environment" are critical aspects of providing a correct and compelling learning experience.

# Recommended Ideal Upset Recovery Training Program

- It should consist of academics, simulator training, *and* flight training.
- The academics should cover aerodynamic principals, aircraft stability and control, maneuvering and aerodynamic loads, causes of upsets, unusual attitude recoveries, alternate control strategies, and measured response.
- The flight syllabus should precede and complement the simulator training. This will provide the full flight envelope experience to make the subsequent simulator training seem more real.
- Both the flight and simulator training should include both unusual attitudes and loss-of-control events.
- The element of surprise should be built into the training sequence.
- The training aircraft should have handling characteristics representative of the trainees' fleet equipment.
- There should be a 3-5 year re-currency training requirement.

# One URT Study in Detail

## Study #4: US Navy Study for P-8 Training

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# US Navy Study - Test Methodology

- Thirty US Navy pilots served as research subjects.
  - All were P-3 A/Cs and instructors
  - 10 of the 30 were test pilots
- Divided into 3 groups of 10:
  - All would receive academic training
  - Group 1 would receive URT training in an FFS.
  - Group 2 would receive URT training in Calspan Lear IFS.
  - Group 3 was a control group and would not receive URT.

# US Navy Study – Sequence of Events

- All three pilot groups were evaluated in Lear IFS using four events.
- All three pilot groups received URT academic training.
- Group 1 received URT using the Aeroservice LLC Training Center 737-800 FFS with an expanded aerodynamic model.
- Group 2 received URT using the Calspan Learjet 25 IFS.
- Group 3 received no further URT.
- All three pilot groups were re-evaluated in the Lear IFS using same events but in a different order.

# US Navy Study - Academics

| AM URT Academic Training | |
|---|---|
| Aerodynamic Principals | Dihedral effect, adverse yaw, envelope (speed vs. g) corner speed, Dutch roll, and crossover speed. |
| Aircraft Control & Maneuvering | Primary and secondary controls, control of flight path and pilot induced oscillations. |
| Aircraft Stability | Aerodynamic center, effect of cg shift on aircraft response, and specialized control techniques for unstable aircraft. |
| Aerodynamic Loads | Rolling pulls and effect of rudder on tail loads. |
| Causes of Upsets | Pitch axis, roll axis, and yaw axis disturbances. Aircraft damage assessment and controllability considerations. |
| Unusual Attitude Recovery | Nose high, nose low and close to terrain. |
| Upset Recovery | Alternate control strategy and measured response. |

# US Navy Study – Evaluation Maneuvers

| Maneuver | Description |
|---|---|
| UAR | Nose low automatically flown setup to initial condition:<br>[Pitch = -20°, Bank = ±90°] |
| UER Pitch | Pitch axis upset (ramp input) implemented simulating trim runaway to 100% maximum command |
| UER Roll | Roll axis upset (step input) to 100% maximum command simulating a spoiler jam. Roll control from ailerons remain active. |
| UER Yaw | Yaw axis upset (step input) to 100% maximum command. Roll due to sideslip equivalent to maximum roll command. |

# Rudder Hard-over Event Video

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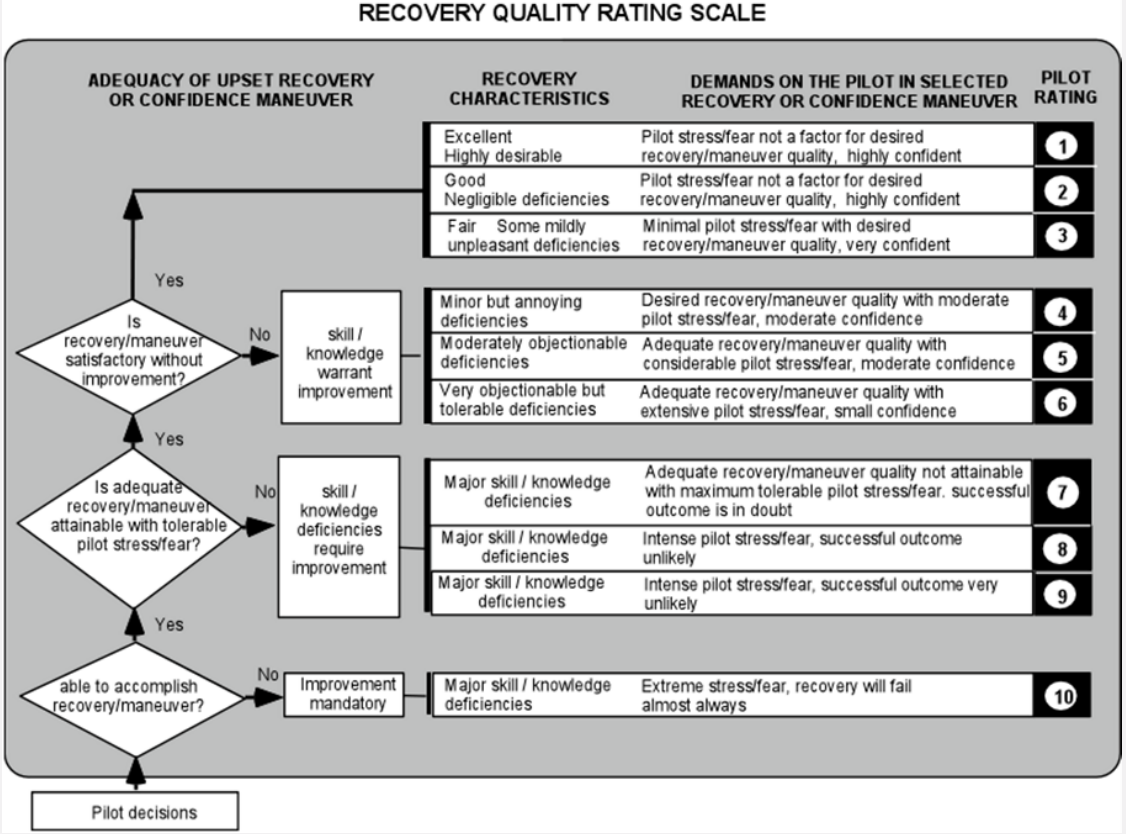
# US Navy Study – Data Collected

- After upset events, the instructor pilots rated four elements of the recovery:
  - Event recognition/reporting
  - Surprise/unexpectedness of the event
  - Processing time
  - Recovery execution
- Each element was rated between 1 and 5, with 1 being "essentially incorrect" to 5 being "correct and well executed".
- Post flight an additional rater reviewed the video and independently graded the events.
- Subject pilots also rated themselves using the Recovery Quality Rating Scale (1 is excellent and confident; 10 is recovery will fail).

# Recovery Quality Rating Scale

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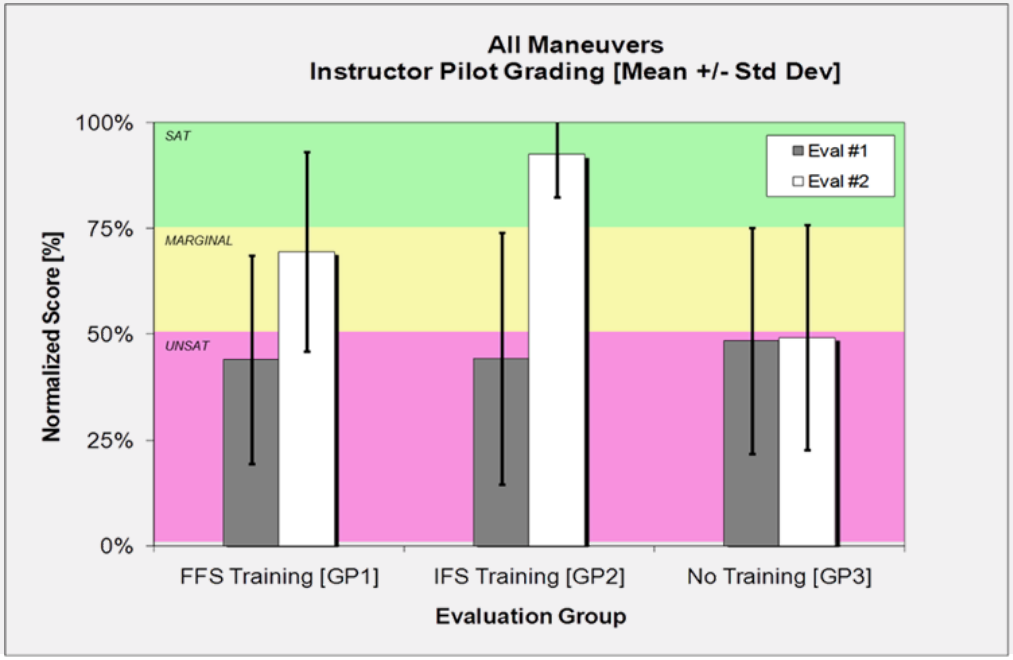
# US Navy Study – The Results

- Instructor Pilot Grading for all maneuvers shown below.
- Detailed results for each of the 4 events is in the report.

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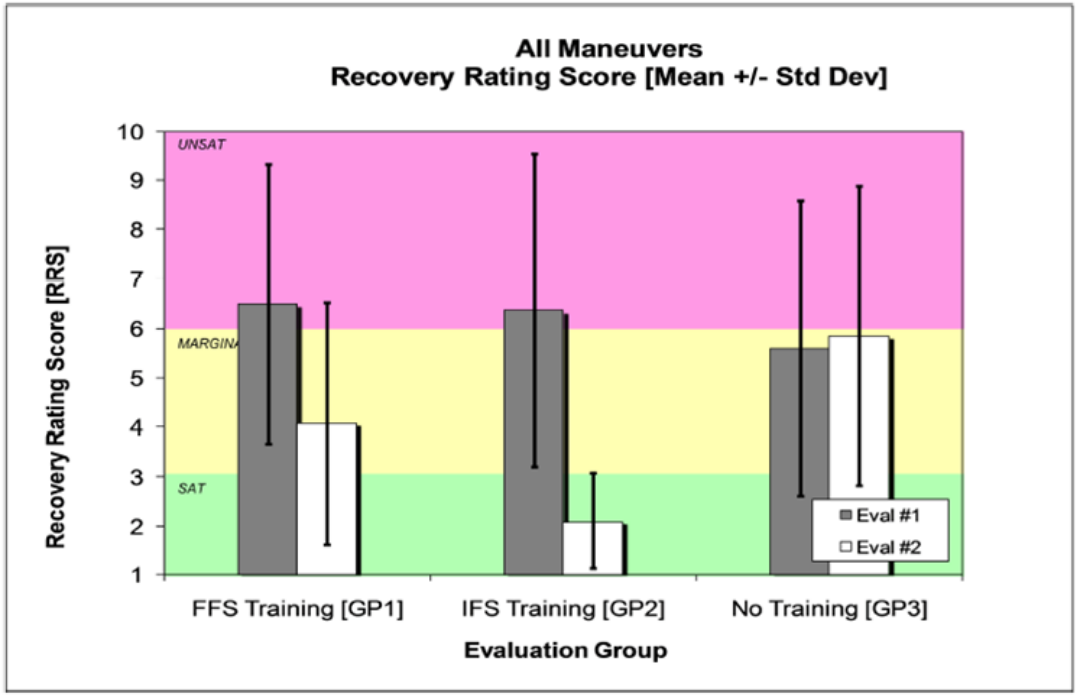
# US Navy Study – The Results

- Recovery Quality Rating results shown below.

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# Calspan's Current Position Regarding URT

- After 12 years of experience in teaching/researching, we feel we know what is needed to improve pilot skills to deal with LOC.
- The technology currently exists to improve training in this area; it has been used by the flight test community for over 50 years.
- We feel that industry and the regulatory agencies are not seriously interested in improving pilot skills in this area - if it changes the status quo or costs more.
  - For example, the recent FAA NPRM specifies *ALL* training to be done in a ground-based FSTD. "Airborne training allowed by exception only."
  - A rigorous URT program for *every* US airline pilot (including a flight in a programmable training aircraft) could be paid for by less than $0.25 per ticket.

# Conclusions

- What is needed to improve pilot loss-of-control event skills is known.
- It's a matter of ***will and funding*** to implement, regulate, monitor the solution.
- So, the choices are to:
  - Do nothing and LOC will remain the # 1 cause of accidents in an very safe industry.
  - **Or**, implement a best practices training solution starting with the most at risk segments of the industry and as part of ab initio pilot training. Over time this will prepare all pilots to deal with unexpected loss of control events.
  - **Or**, with the ever increasing reliability of aircraft, allow the industry to remove the pilot from the manual control loop for these type of un-commanded events and deal with the issues using automatic control.

- Thank you!
- Questions?


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