Developing and Measuring A Robust Safety Culture

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Is Safety Culture a Process or Outcome?

- Our practice characterized in two different ways: **procedures** (“ways of doing” things) or **products** (“things”).

- We act based from our history (individual or collective practice).

- This becomes important when recognizing established methods or procedures which can be completely perfunctory (mechanical).

- We must conscientiously balance safety and productivity to achieve both the best “**way of doing things**” and the “**thing**” itself.

Process or Outcome?

Through establishing a positive safety culture as part of a rigorous Safety Management System, we can understand not only the product of safety, but the process as well.

Your safety management system *IS* your safety culture

NTSB Identification: DCA09MA027

Scheduled 14 CFR Part 121:
Air Carrier operation of COLGAN AIR INC

Accident occurred Thursday, February 12, 2009
in Clarence Center, NY

Aircraft: BOMBARDIER INC DHC-8-402, registration: N200WQ

Injuries: 50 Fatal (includes 1 on ground)

February 12, 2009

USA Today: A Continental Airlines commuter plane coming in for a landing in Buffalo, N.Y., dove into a house in snowy, foggy weather, killing all 49 people on board and one person on the ground.

ABC. Com: The crash of Flight 3407 sparked a fiery explosion. Firefighters worked through the night to douse the flames. “The whole sky was lit up orange," said Bob Dworak, who near the crash site. "There was a big bang, and the house shook.”

Reuters

FAA: It was the first fatal crash of a commercial airliner in the U.S. in 2 ½ years.

February 12, 2009

CNN.com: Witnesses heard the twin turboprop aircraft sputtering before it went down around 10:20 p.m. Thursday.

Reuters

AP

Aircraft Problems?

February 13, 2009

There was no distress call, according to a recording of air traffic communications captured by the website LiveATC.net.

ATC questions approach equipment at airport.

Harry Scull Jr., The Buffalo News via AP

Bombardier Dash-8 Q400 aircraft

Google

Street view: 6038 Long Street, Clarence Center, N.Y

February 14, 2009

Fox News: Ice suspected in fatal crash.

Federal investigators said doomed Continental Flight 3407 **experienced heavy ice buildup** and lurched violently moments before it dove into the house.

Weather and Icing?

February 14, 2009

WSJ: Data collected from the plane's two black boxes "shows a **series of severe pitch and roll excursions**" shortly before the recording ended and the commuter jet crashed.

Minutes earlier, the pilots reported "**significant ice buildup on the windshield and leading edge of the wings**," (NTSB). They had already activated the de-icing mechanism on the aircraft just prior to their comments about the ice.

AP

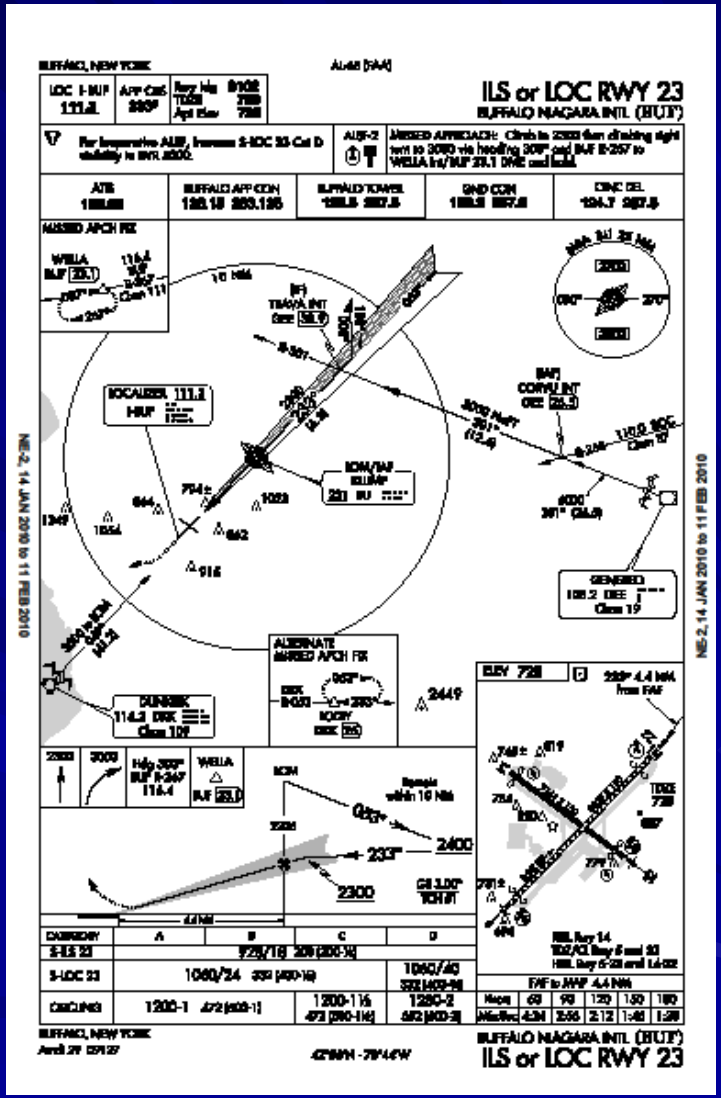
February 14, 2009

CLARENCE, N.Y. — The plane that crashed landed **flat** on the house and was pointed away from the airport where it was supposed to land.

"…Flight 3407 **did not dive into the house**, as initially thought.

The flight was cleared to land on a runway pointing to the **southwest**. But the plane crashed with its nose pointed to the **northeast**."

-Steve Chealander, NTSB



February 18, 2009

WSJ: Investigators examining last week's Continental Connection plane crash have gathered evidence that **pilot error -- not a buildup of ice on the wings and tail** -- likely initiated the fatal dive of the twin-engine Bombardier Q400 into a neighborhood 6 miles short of the Buffalo, N.Y., airport.

Pilot Error?

WHAT HAPPENED?

Captain Marvin Renslow

Age 47
With the airline for nearly 3 1/2 years
3,379 total flight hours
Airline Transport Pilot rated
Residence: Lutz, FL
Annual Salary: $ 55,000
(48,548 CHF)

Joined Colgan September 9, 2005 with
618 total flight hrs, incl
38 hrs actual instrument time, and
71 hrs simulator instrument time

CPT had been a commuting pilot since hired by Colgan.

First Officer Rebecca Shaw

Age 24
Joined Colgan January 16, 2008
With airline just over 1 year
2,220 total flight hours
772 hours in the Q400 aircraft

Annual salary: $16,000
(14,123 CHF)

FO joined Colgan with 1,470 total flight hrs, incl
6 hrs actual instrument time, and
86 hrs sim instrument time

Recently married, living with her husband.
In Jan 2009 they moved in with her parents in Washington to save for house.

FO had been a commuting pilot since hired by Colgan.

Colgan – The Crew – Professionalism?

- CPT: Commuted from Tampa the day prior to flight
- Evidence of being awake at 3:30 AM (logging into company system)

  - New upgrade to Captain
  - Fairly low hour ATP – very low hours in aircraft
  - Fairly weak piloting skill (failed check rides, over reliance on autopilot)

- FO: Commuted from Seattle day before – rides jumpseat on several carriers
- Into EWR ~6:30AM
- Chats w/co workers, texts, sleep a bit on couch
- Complaining of cold symptoms

- Crew:
- Engaged in idle chatter at the time of the accident, a violation of rules that ban cockpit chit-chat during takeoff & landing procedures, below 10,000 ft.
- Missed radio calls
- Missed checklist items
- Talking about ice build up and experience with icing operations
- Evidence of yawning (both) and congestion (FO)

Colgan – The Crew

Crew selects **landing gear down** and **flaps set at 15 degrees**. Immediately after flap selection the stick shaker activates.

Evidence suggests the captain pulled on the controls, further slowing the airplane, instead of pushing the nose forward to regain airspeed.

The plane struggles for about 25 seconds, during which the crew makes no emergency declaration.

A/C rapidly loses altitude and crashes into a private home about 5 miles (8.0 km) from the approach end of the runway, and nearly directly under its intended approach path, with the nose pointed away from the destination airport.

Colgan Air

Troublesome organizational (industry) issues:

- Chronic pilot fatigue
  - Sanctioned duty-time regulations = 7 hours between flights
  - Fatigue Policy?
  - Commuting policy – don't let it affect your timeliness to work, all expenses personally borne
- Low pilot pay
- Inadequate pilot training – e.g., Winter Ops Training video
- Poor resume-checking / grew too fast
- Cost-cutting pressure from the major airlines who use the regionals as subcontractors

NTSB Final Report

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was **the captain's inappropriate response to the activation of the stick shaker, which led to an aerodynamic stall from which the airplane did not recover.**

Contributing to the accident were

(1) Flight crew's failure to monitor airspeed in relation to the rising position of the lowspeed cue,

(2) Flight crew's failure to adhere to sterile cockpit procedures,

(3) Captain's failure to effectively manage the flight, and

(4) Colgan Air's inadequate procedures for airspeed selection and management during approaches in icing conditions.

WHY DID THIS HAPPEN?

Human Error and Accidents

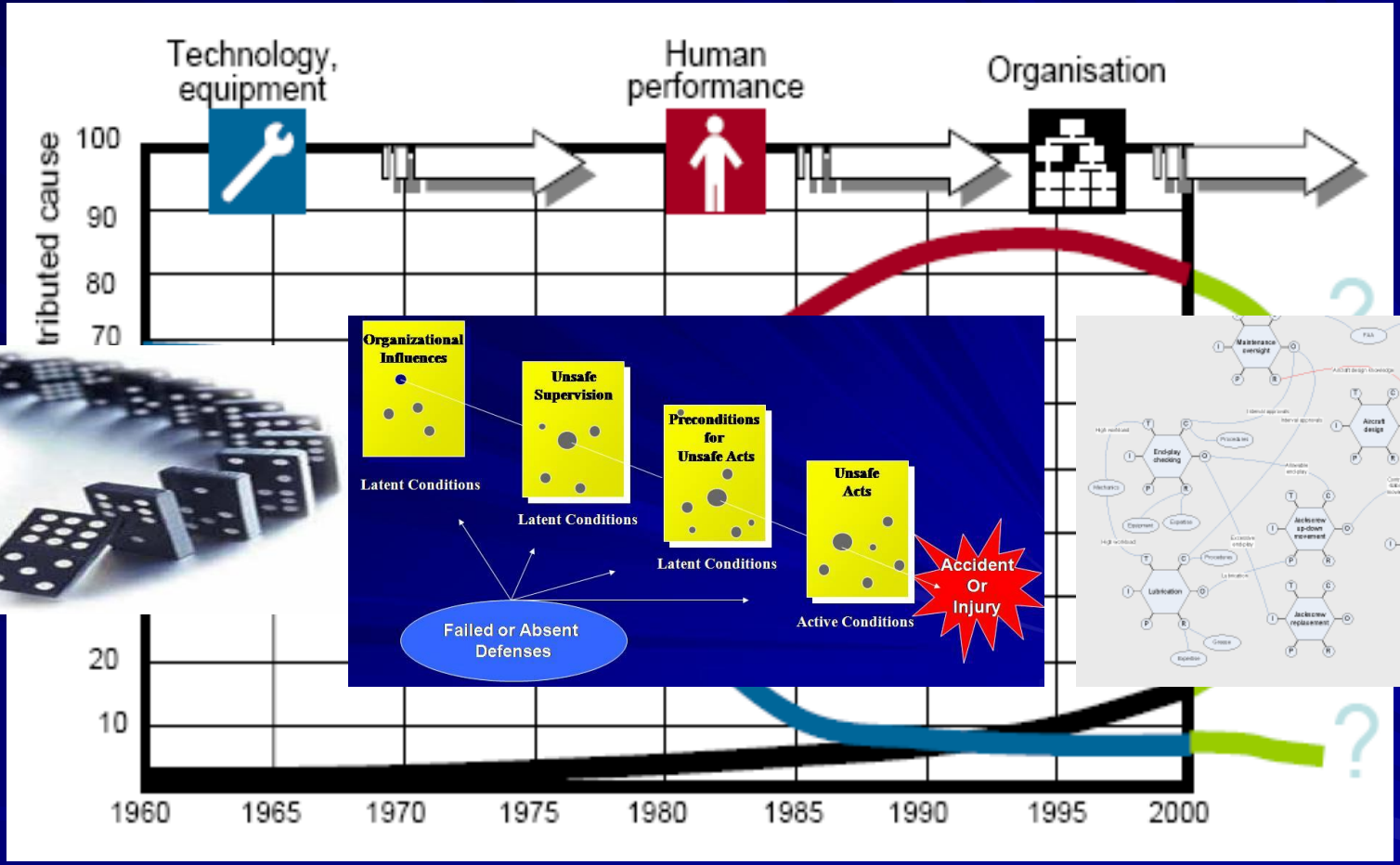
- **Human error has been implicated in 60-80% of accidents in aviation and other complex systems.**

(Kern, 1998; Wiegmann & Shappell, 2003)

- **These active failures are due, at least in part, to other latent failures such as supervisory issues &/or organizational causes.**
  - **(**March & Simon, 1958; Heinrich, Peterson, & Roos, 1959 ; Bird, 1974; Reason, 1990, ; Maurino, Reason, Johnston, & Lee, 1995 ; Reason, 1997; Perrow, 1999; von Thaden, Wiegmann & Shappell, 2006)

Developments in Causal Logic

Hollnagel (2002)



<u>Sequential accident model</u>
Probability of component failures

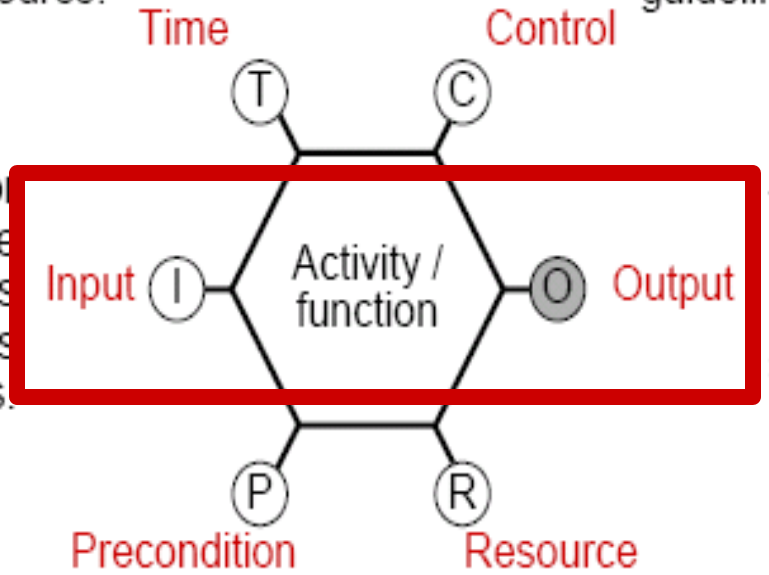
<u>Epidemiological accident model</u>
Likelihood of weakened defenses, combinations

<u>Systemic accident model</u>
Coincidences, links, resonance

Functional Resonance Analysis

Time available: This can be a constraint but can also be considered as a special kind of resource.

That which supervises or adjusts a function. Can be plans, procedures, guidelines or other functions.



That which is used or transformed to produce the output. Constitutes the link to previous functions.

That which is produced by function. Constitute links to subsequent functions.

System conditions that must be fulfilled before a function can be carried out.

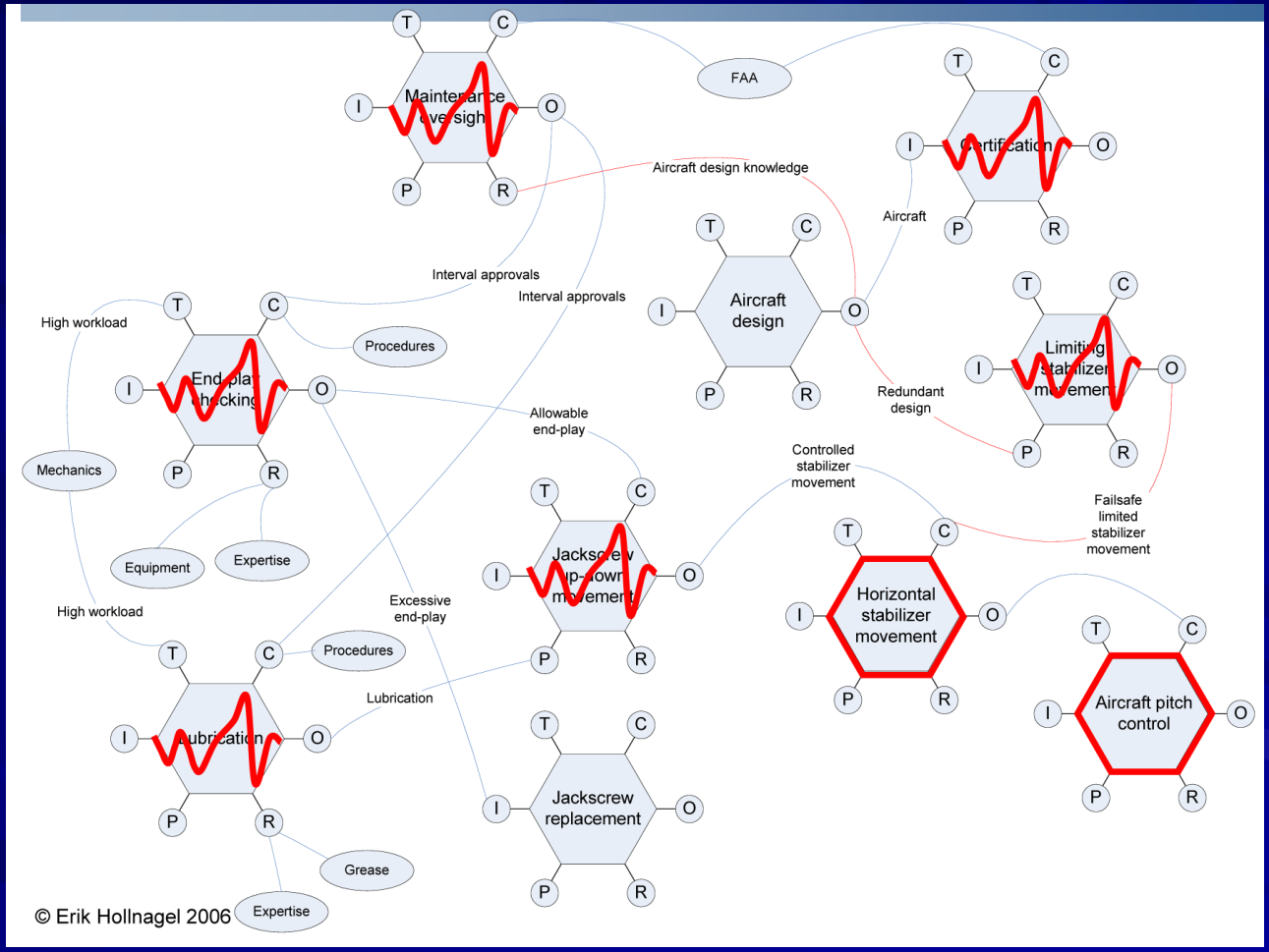
That which is needed or consumed by function to process input (e.g., matter, energy, hardware, software, manpower).

© Hollnagel, 2006

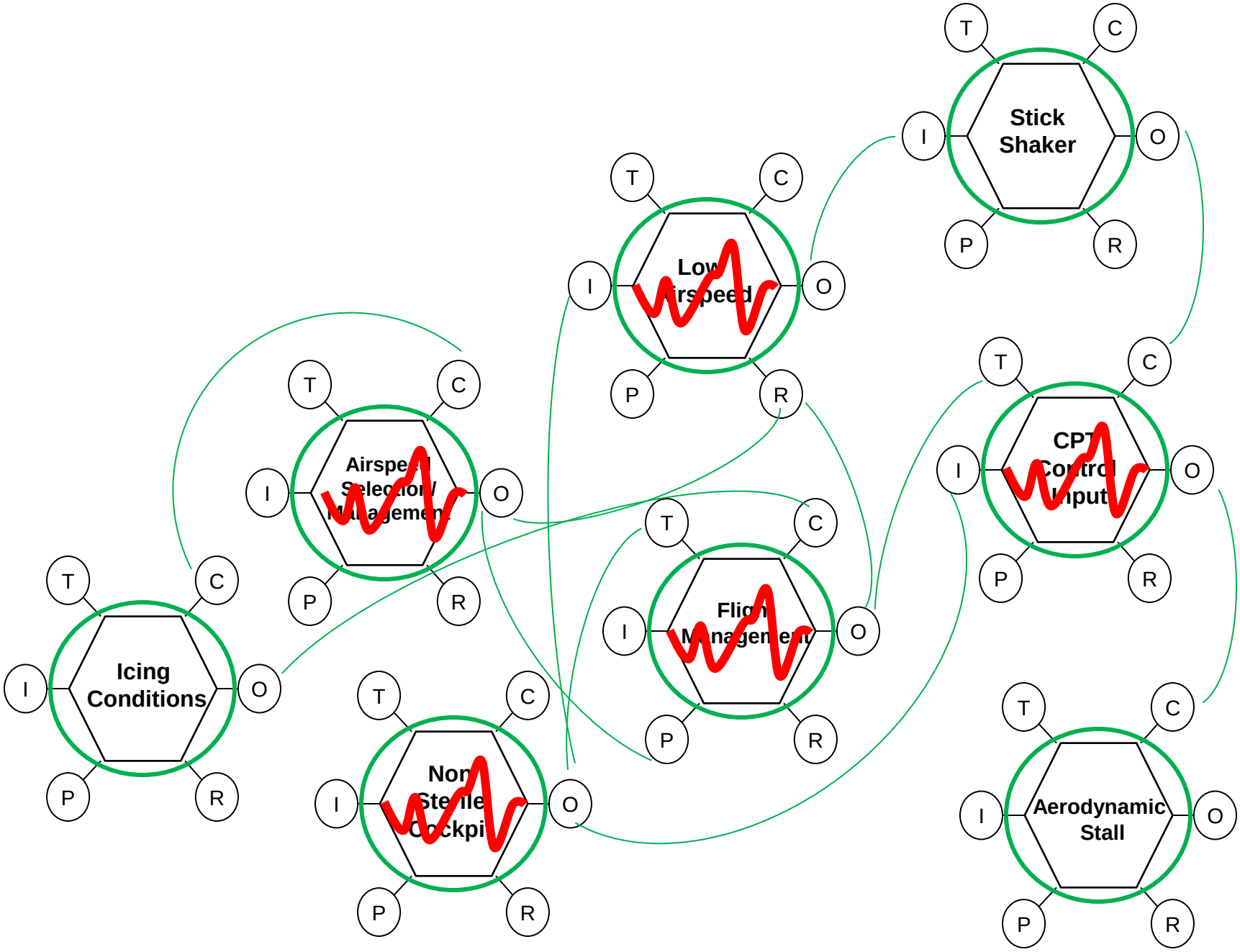
See: http://www.skybrary.aero/bookshelf/books/402.pdf

Study Variable Performance

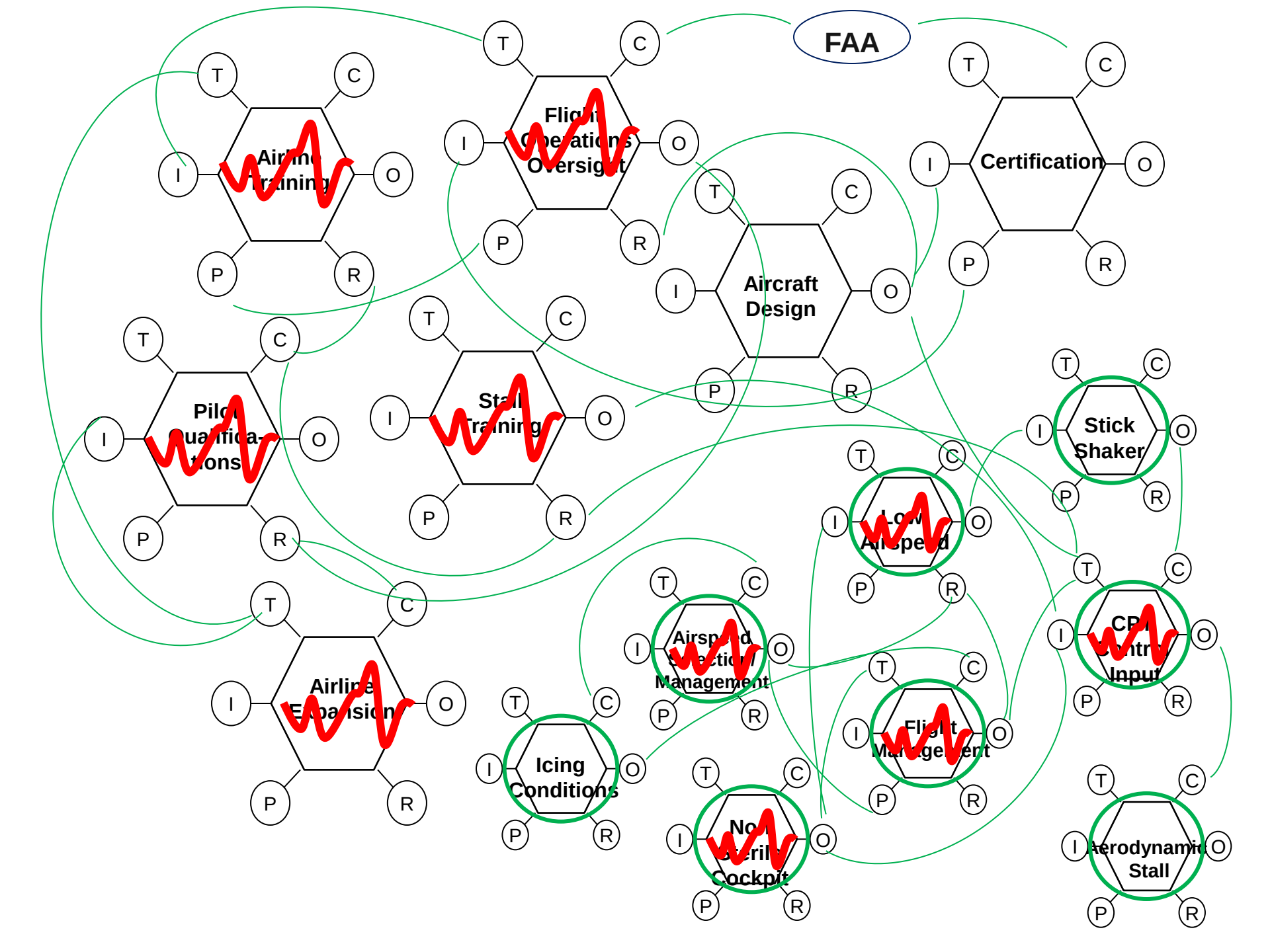
- If we study the variability of normal performance and discover under which conditions it combines in unwanted ways, we can then build in preventions.



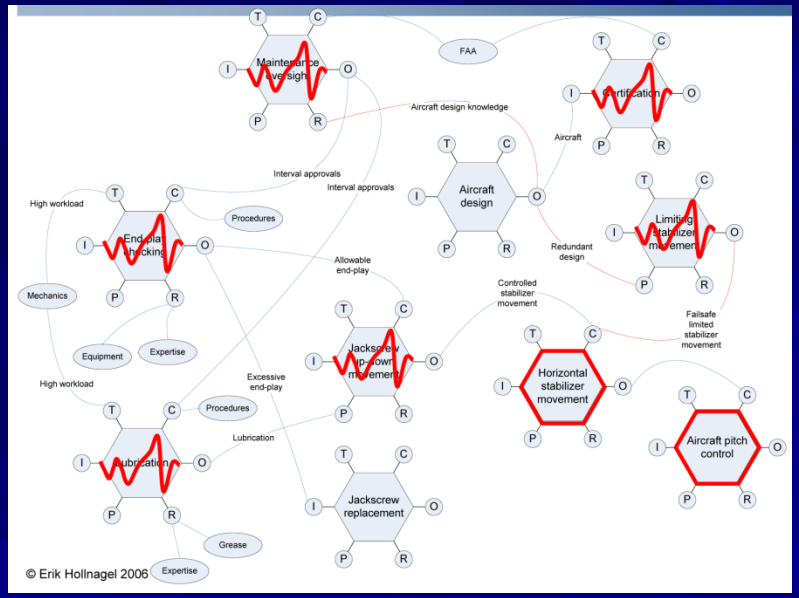
Look for coincidence, links, and resonance


T
C
I
O
P
R
Stick Shaker
Low Airspeed
Airspeed Selection/ Management
CPT Control Input
Icing Conditions
Flight Management
Non-Sterile Cockpit
Aerodynamic Stall

What about looking beyond the Crew?


FAA
T
C
I
O
P
R
Airline Training
Flight Operations Oversight
Certification
Aircraft Design
Pilot Qualifica-tions
Stall Training
Stick Shaker
Low Airspeed
Airline Expansion
Airspeed Selection/ Management
CPM Control Input
Icing Conditions
Flight Management
No Sterile Cockpit
Aerodynamic Stall

How to Describe System in Terms of Whole?



Study the culture

Look at the normal operations of the organization

Humans are Creatures of Habit

The focus of risk analysis should be **normal human performance**

(von Thaden, 2008; Hollnagel, 2009)

- Accidents occur as a consequence of a series of trade-offs we make between **efficiency** and **thoroughness.**

- **T**rade-offs / workarounds are not random; they are
  - Regular
  - Effective
  - Learned

- Can we measure tradeoffs as part of normal operations?

Status of the "Safety Culture" Concept

- Numerous studies have attempted to measure and assess safety culture in a variety of industries. (see Wiegmann, Zhang, von Thaden, Sharma, & Mitchell, A. (2002). A synthesis of safety culture and safety climate research.)
- There is lack of consistency in concepts and definitions (i.e., safety climate/safety culture).
- Efforts to study safety culture have remained "unsystematic, fragmented and in particular under-specified in theoretical terms" (Pidgeon, 1998).

What is a Safety Culture?

- Committed to proactive safety activities – *shared information*
- Non-punitive – *shared information*
- Recognizes inevitability of error & learns from it – *shared information*
- Strongly influenced by upper-level management, but influences the behavior of everyone in the organization.

(Wiegmann, Zhang, von Thaden, Sharma, and Gibbons, 2004)

GOAL:

- Identify safety problems <u>before</u> they result in an accident or incident. <u>Share information so it is appropriately meaningful to everyone involved in the organization.</u>

What is a Safety Culture?(Definition)

The enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization.

It refers to the extent to which individuals and groups will:

1. Commit to personal responsibility for safety;
2. Act to preserve, enhance and communicate safety concerns;
3. Strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes; and
4. Be held accountable or strive to be honored in a manner consistent with these values.

(Wiegmann, von Thaden, Mitchell & Sharma, 2001; von Thaden, Kessel, Ruengvisesh, 2008)

Common Themes

- **Safety culture exists on a continuum**

  An organization may have a positive, negative, or neutral culture with regard to safety.

- **Multidimensional**

  There are several organizational indicators of safety culture. It has several **subcomponents** that **combine** to create the overall safety culture of an organization or industry.

- Proactive

  Must be continually measured and assessed to generate safety.

Assessing Safety Culture How Do You Measure It?

- Can we assemble and model collected data and information to inform the culture in a meaningful way?
- Are there universals in culture?
- Are there areas that are culturally specific?

Assessing Safety Culture
How Do You Measure It?

- **Variety of Methods**
  - Interviews
  - Observations/Ethnography
  - Simulation/Lab Studies
  - Organizational Data: ASAP, FOQA/FODA, LOSA, IOSA…..

Some Examples of Data for a Safety Culture

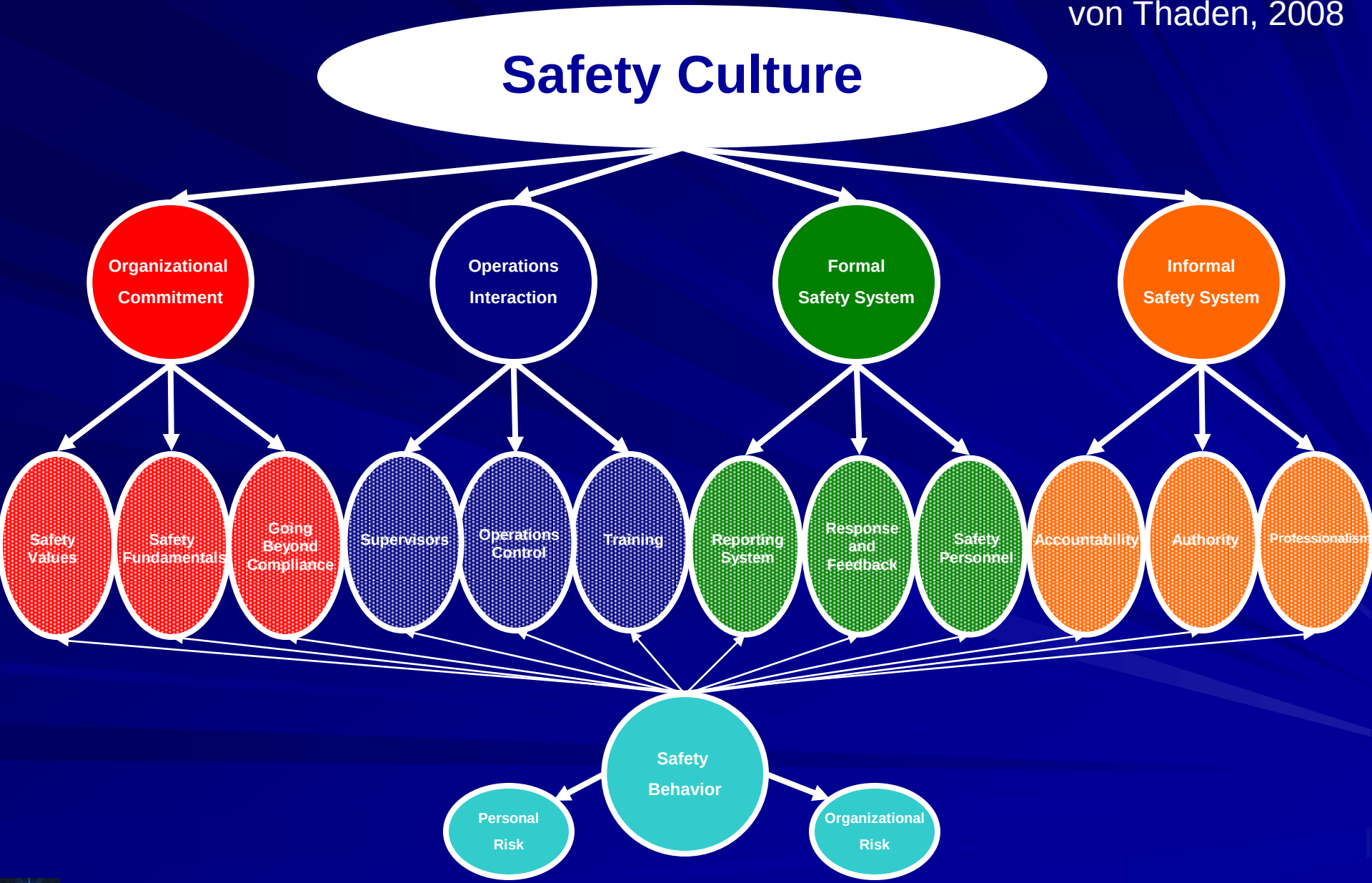
- **Accident investigation**
  - *Accidents are rare events and represent a system failure*
- **Incident reports – ASAP/ASR**
  - *Data slanted to events resulting from system and operator failures*
- **Line checks**
  - *Data show crew proficiency and procedural knowledge*
- **Flight Data Recorders – FOQA/FODA**
  - *Data show "what happened" in terms of flight parameters*
- **Observing normal flights – Line Operations Safety Audit (LOSA)**
  - *Gives data on why things happen and how they are managed*
  - ***May/may not** provide a realistic baseline of safety*

Assessing Safety Culture How Do You Measure It?

- **Variety of Methods**
  - Interviews
  - Observations/Ethnography
  - Simulation/Lab Studies
  - Organizational Data: ASAP, FOQA/FODA, LOSA, IOSA…..
  - Surveys/Questionnaires
    - Allow broad assessment
    - Faster validation of initial ideas

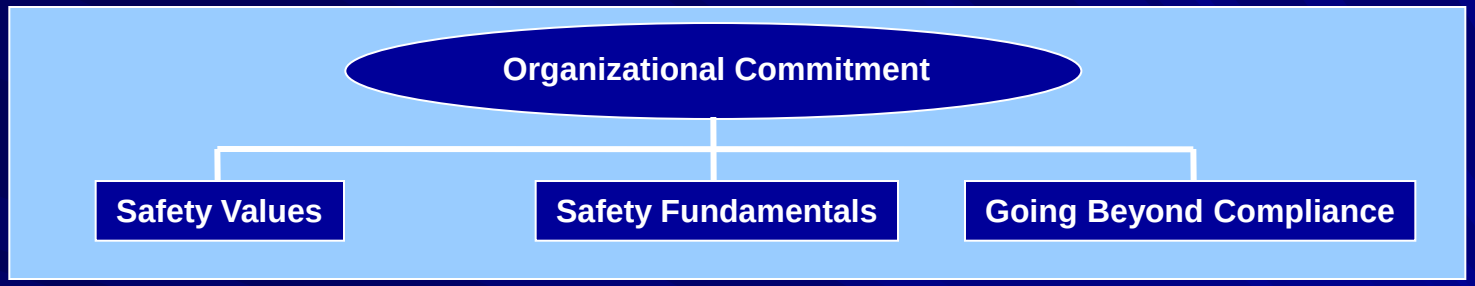
Organizational Indicators of Safety Culture

von Thaden, 2008



Organizational Commitment

The degree to which an organization's leadership prioritizes safety in decision-making, and allocates adequate resources to safety.



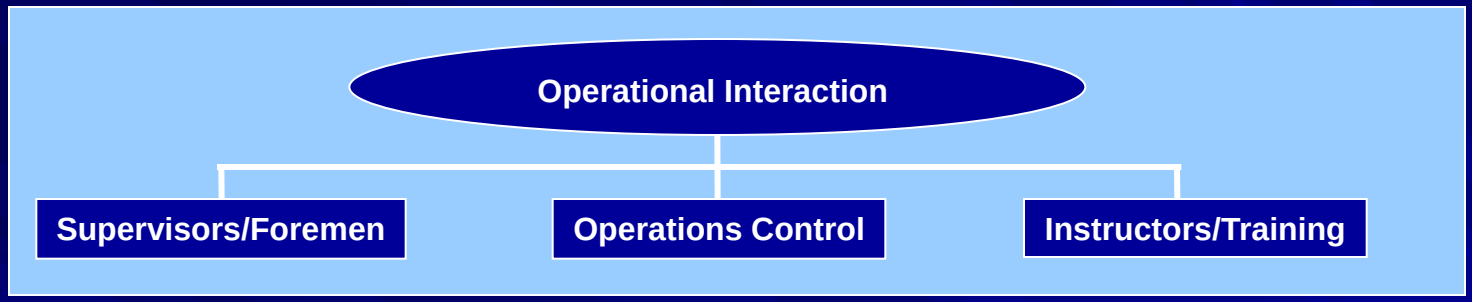
Safety Values – Attitudes and values expressed (in words and actions) by leadership regarding safety.

Safety Fundamentals – Compliance with regulated aspects of safety (e.g., training requirements, manuals and procedures, and equipment maintenance), and the coordination of activity within and between teams/units.

Going Beyond Compliance – Priority given to safety in allocation of company resources (e.g., equipment, personnel time) even though not required by regulations.

Operations Interaction

The degree to which those directly involved in the supervision of employees' safety behavior are actually committed to safety and reinforce the safety values espoused by upper management (when these values are positive).



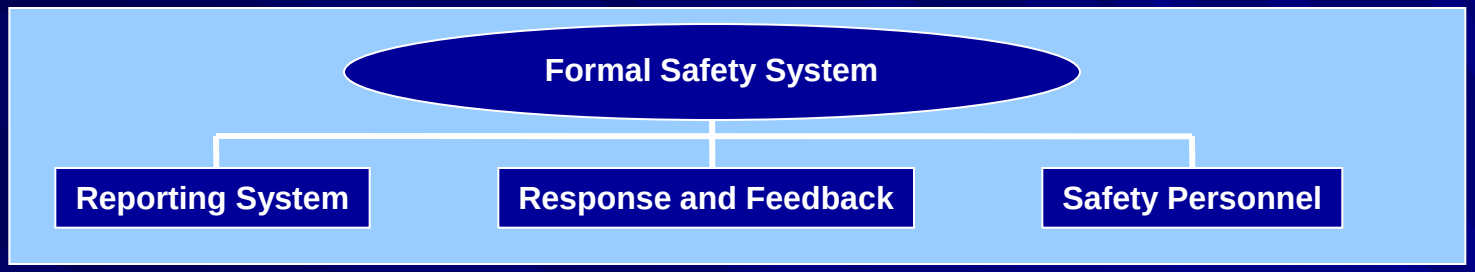
Supervisors/Foremen– Their involvement in and concern for safety on the part of supervisory and "middle" management at an organization (e.g. Chief Fleet Pilot).

Operations Control – Effectively managing, maintaining, and inspecting the safety integrity of the equipment, tools, procedures, etc. (e.g. Dispatch, Maintenance Control, Ground Operations, etc.).

Instructors/Training–Extent to which those who provide safety training are in touch with actual risks and issues.

Formal Safety System

Processes for reporting and addressing both occupational and process safety hazards.



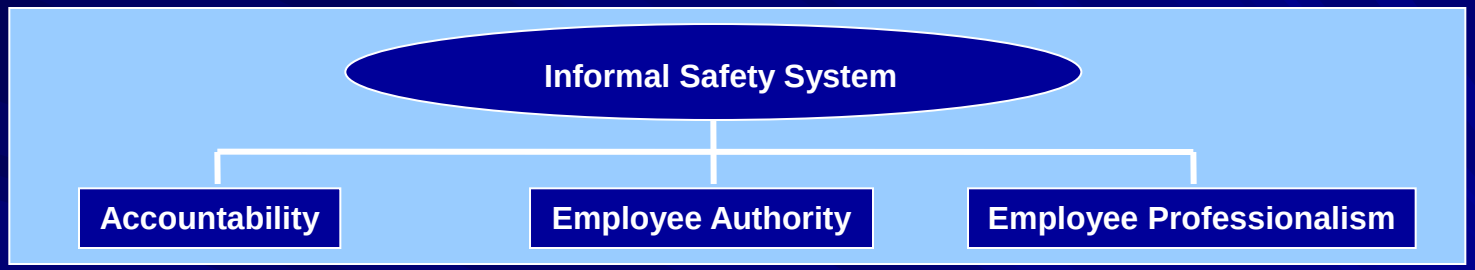
Reporting System– Accessibility, familiarity, and actual use of the organization's formal safety reporting program.

Response and Feedback– Timeliness and appropriateness of management responses to reported safety information and dissemination of safety information.

Safety Personnel– Perceived effectiveness of and respect for persons in formal safety roles (e.g., Safety Officer, Vice President of Safety).

Informal Safety System

Includes unwritten rules pertaining to safety, such as rewards and punishments for safe and unsafe actions. Also includes how rewards and punishments are instituted in a just and fair manner.



Specifically, the informal safety systems include such factors as:

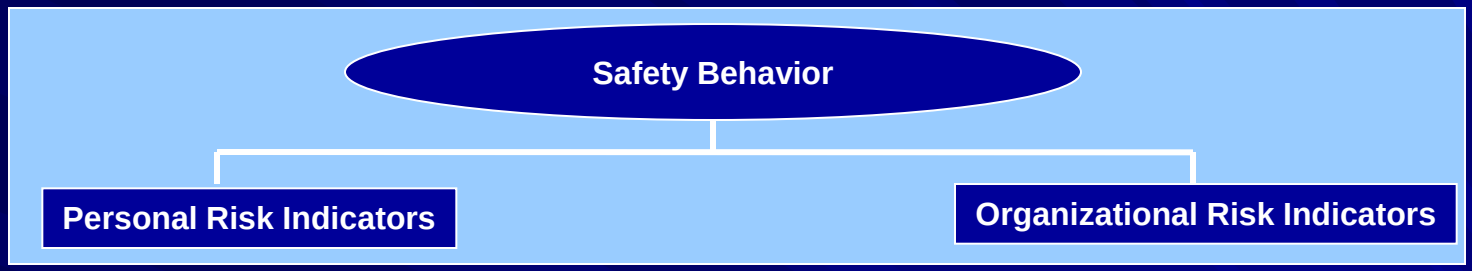
Accountability– The consistency and appropriateness with which employees are held accountable for unsafe behavior.

Employee Authority– Authorization and employee involvement in safety decision making.

Employee Professionalism– Peer culture employee group norms pertaining to safe and unsafe behavior.

Safety Behavior

Reflects personal and organizational perception of safety; attitudes and beliefs.



Specifically, safety behavior involves:

Personal Risk– The personal level of acceptable risk on behalf of each employee. Reflected in the employees' actual safety practice and the their perception of how others in the organization practice safety.

Perceived Organizational Risk– The perception of the likelihood that the organization will be involved in an accident or incident.

Surveying Safety Culture
SCI/SMS
Safety Culture Indicator

- Survey originally developed in 2000.
- Questions psychometrically developed to reveal **objective** & **subjective** indications of safety culture.
- Body of survey specifically worded to engage respondents to answer as **observed at the organization**, not from personal point of view.
- Risk items specifically worded to engage respondents to answer from **personal point of view**.

Safety Culture Is Not Only Numbers

- Both **Qualitative** and **Quantitative** data make up the study of Safety Culture.
- Ask closed and open ended questions
  - What do people say about their organization?
  - Respondent comments reveal underlying factors in the perception of safety culture.

Safety Culture Survey Process

- Third Party Research - optimal
- Accountable Executive / Union agreement
  - Line through Leadership positions
- Lead time
  - Survey adaptations to organization specific terms
  - Organizational promotion and rollout
- Participation voluntary, responses anonymous, anonymity assurance (*protection of human subjects*)

SCI/SMS

Since 2000 the instrument has been repeatedly tested and validated with excellent statistical reliability (Alpha consistently over .80)
(Scores over .70 considered reliable)

Organizations engaged in the process (circa 2010,180+):

Part 121, Part 135, Part 145, & Part 91(K) Operations
Domestic, International and Foreign Carriers
Passenger and Cargo Operations
Maintenance Facilities
Emergency Response

Survey has been translated into Chinese and Thai with reliable results.
Future translations in process (French, Spanish).

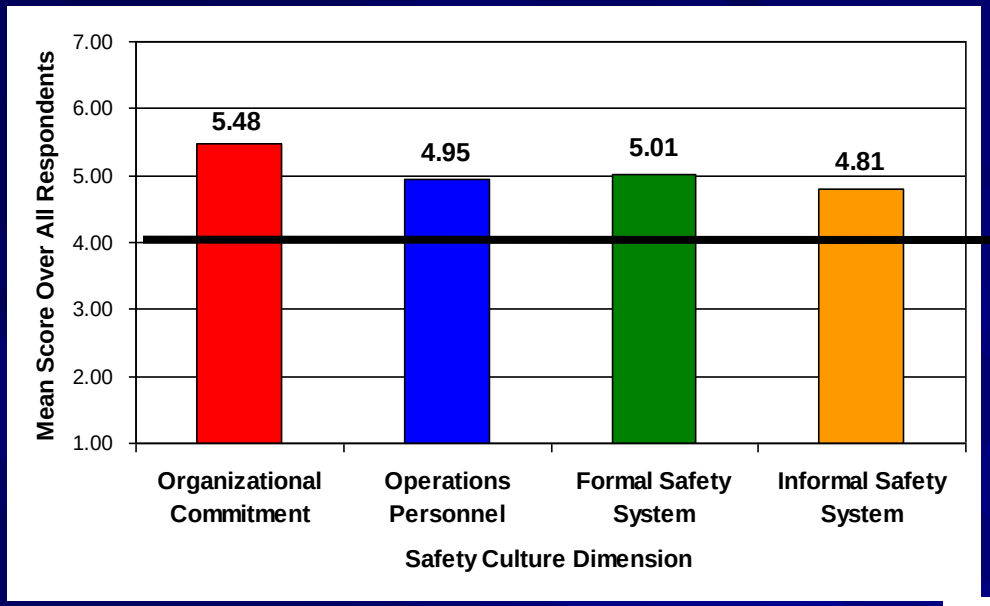
Example - Scale Reliability

Scale	# of items	Alpha
Organizational Commitment	20	**0.91**
Operations Personnel	60	**0.95**
Formal Safety System	17	**0.83**
Informal Safety System	16	**0.82**
Total Reliability	113	**0.97**

A value of 0.7 and above is considered acceptable, a value of 0.8 is considered a reliable measurement.

Alpha scores reveal highly reliable instrument as surveyed at [Airline].

Example Overall Scores

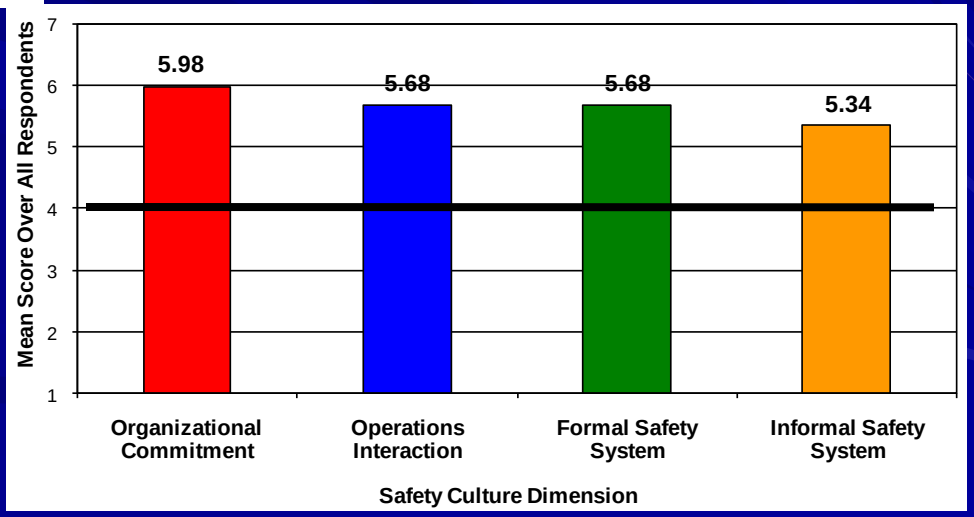


1-7 Lickert scale

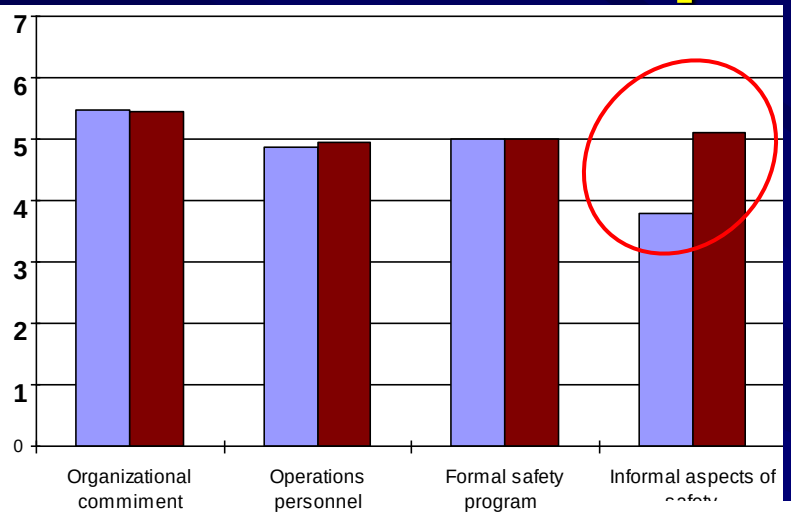
Disagree Strongly/Agree Strongly

The scale midpoint is 4.

Scores are considered positive when above 4 and negative when below 4.



Example Comparisons

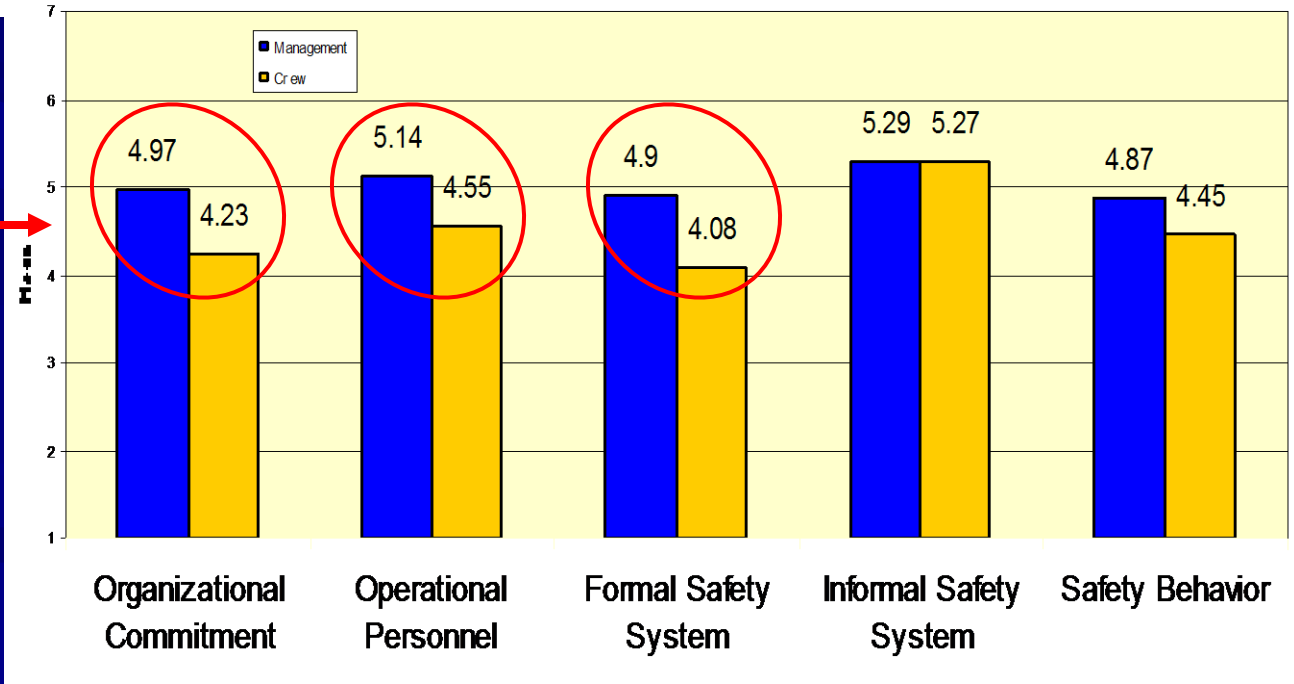


Significant differences

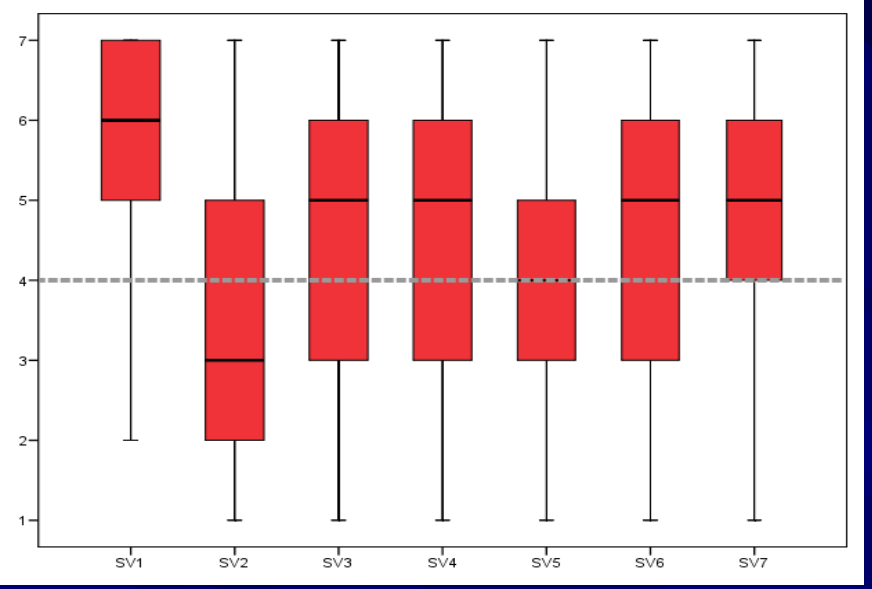
Between
Flight and Maintenance

Significant differences

Between
Line and Leadership

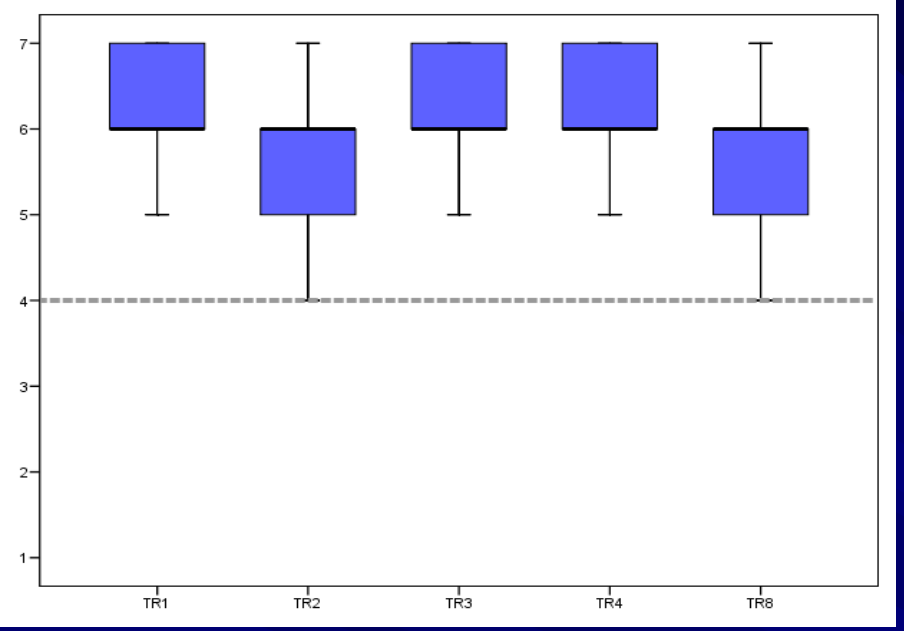


-Organizational Culture-
Safety Values



Item	* Reverse coded (high scores are good)	Mean
SV1	Safety is identified as a core value at [Airline].	5.84
SV2	*[Airline's] leadership is more concerned with making money than being safe.	3.73
SV3	*[Airline's] leadership expects pilots to push for on time performance, even if it means compromising safety.	4.76
SV4	*[Airline's] leadership doesn't show much concern for safety until there is an accident or incident.	4.68
SV5	[Airline's] leadership does not cut corners where safety is concerned.	3.96
SV6	Leadership at [Airline] would rather see a flight canceled than take a chance with safety.	4.47
SV7	Leadership views safety in flight operations as critical to the overall safety record of the airline.	4.97

-Operations Interaction- Instructors/Training



Item	* Reverse coded (high scores are good)	Mean
TR1	*Instructors/trainers teach shortcuts and ways to get around safety requirements.	6.31
TR2	*The training program/materials at [Airline] are dull and trivial.	5.53
TR3	Safety is consistently emphasized during training at [Airline].	6.14
TR4	Instructors/trainers have a clear understanding of risks associated with flight operations.	6.06
TR5	Instructors/trainers prepare pilots for various safety situations, even uncommon or unlikely ones.	5.69

Overall Scores – Flight Operations

Correlations between Major Factors and Safety Behavior

Major EU Carrier

	Correlation (*r*)
Organizational Commitment	0.58
Operations Interaction	**0.65**
Formal Safety System	0.59
Informal Safety System	**0.66**

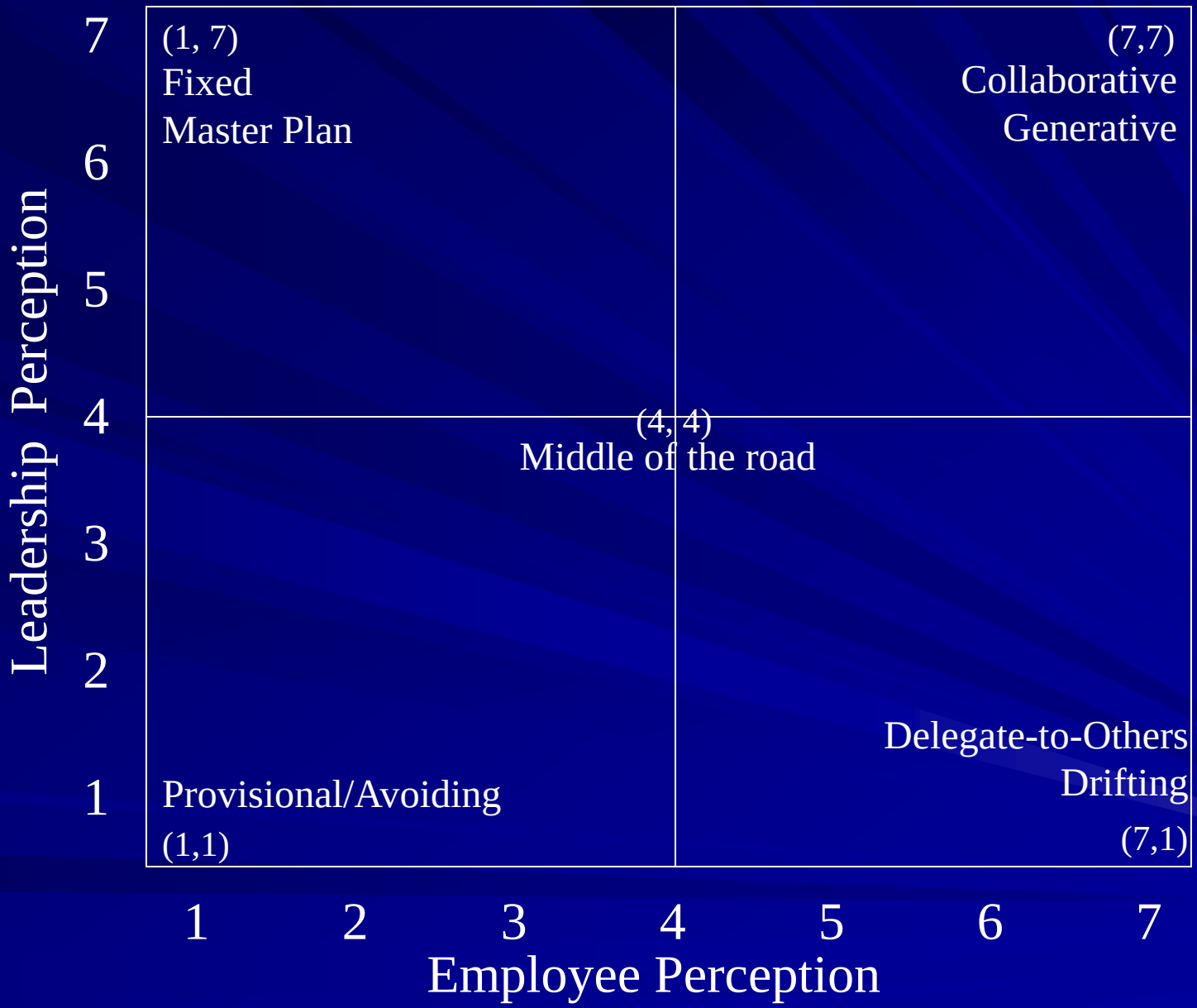
Major US Air Carrier

	Correlation (*r*)
Organizational Commitment	**.68**
Operations Interaction	.53
Formal Safety System	.59
Informal Safety System	**.64**

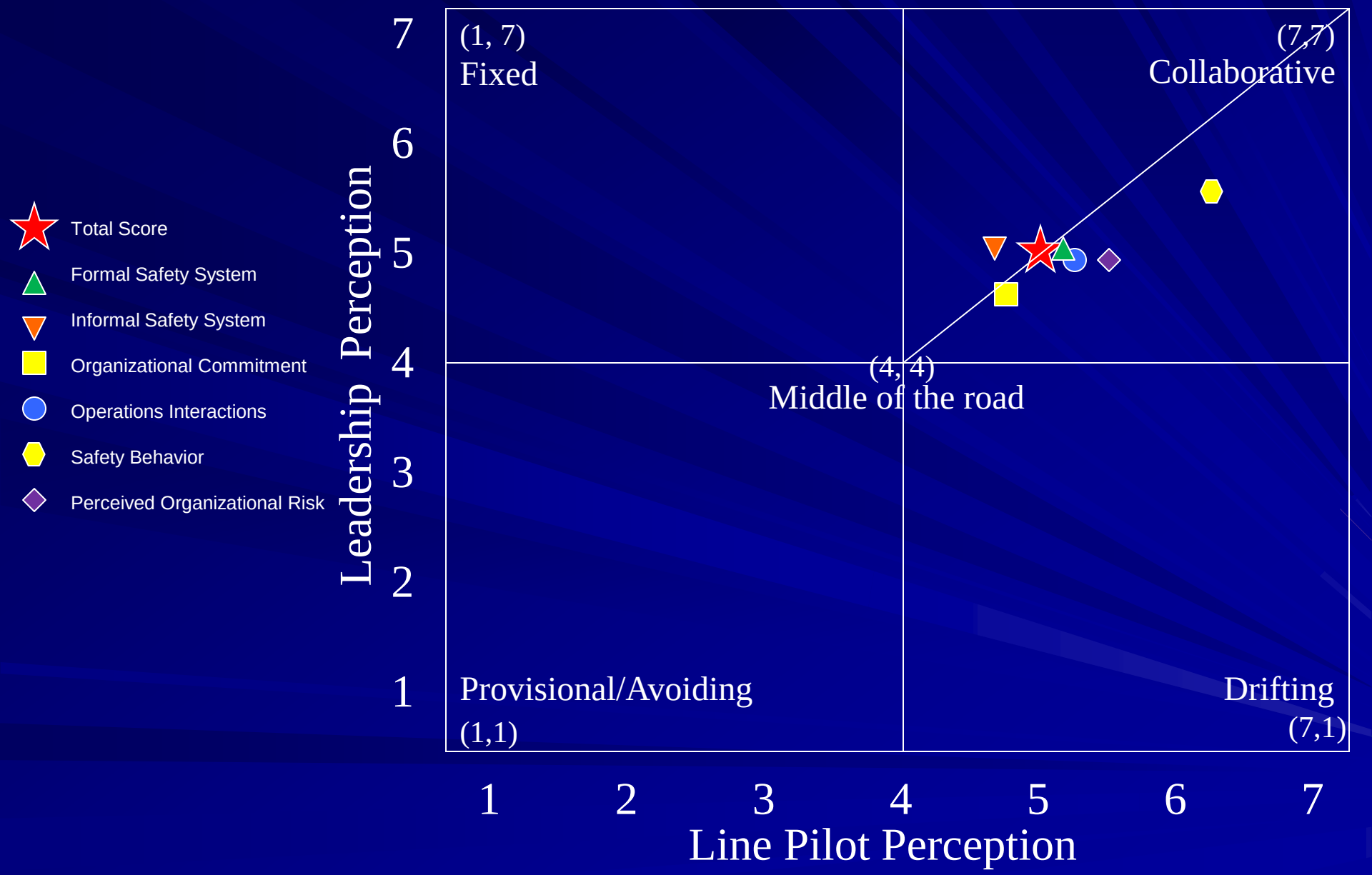
All correlations are significantly different from zero ($p<0.01$).

Approaches to Organizational Safety Culture—The Culture Matrix

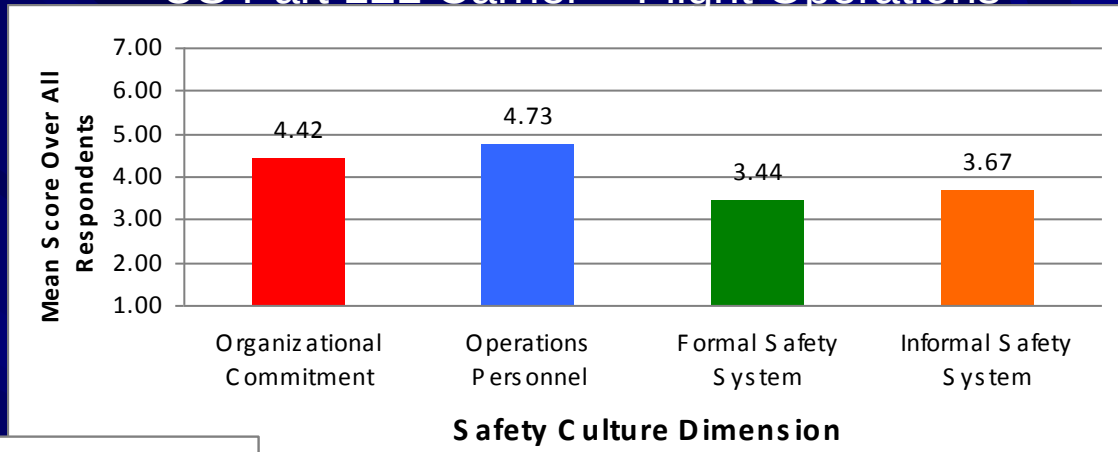
von Thaden (2006)



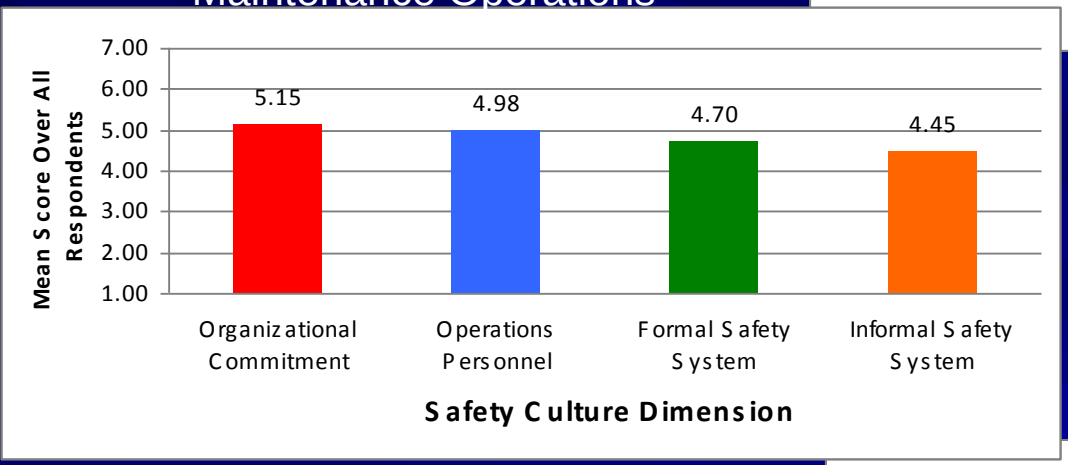
Airline Culture Matrix – Flight Operations



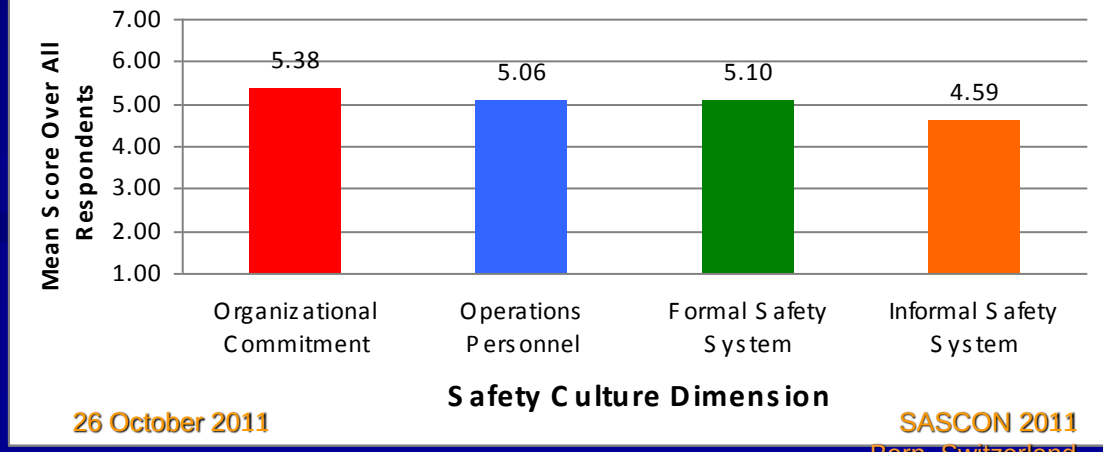
US Part 121 Carrier – Flight Operations



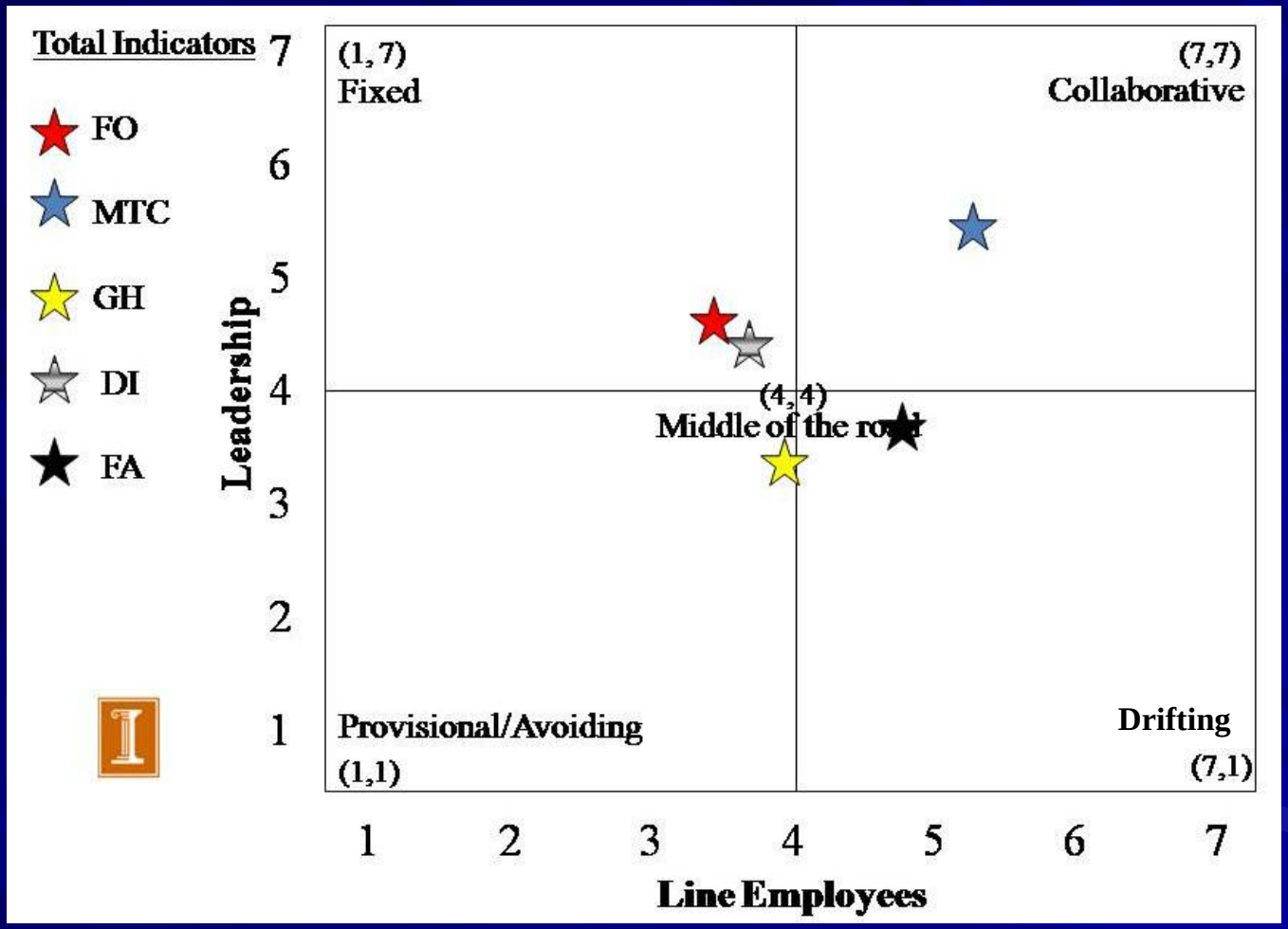
US Part 121 Carrier – Maintenance Operations



US Part 121 Carrier – Ground Operations

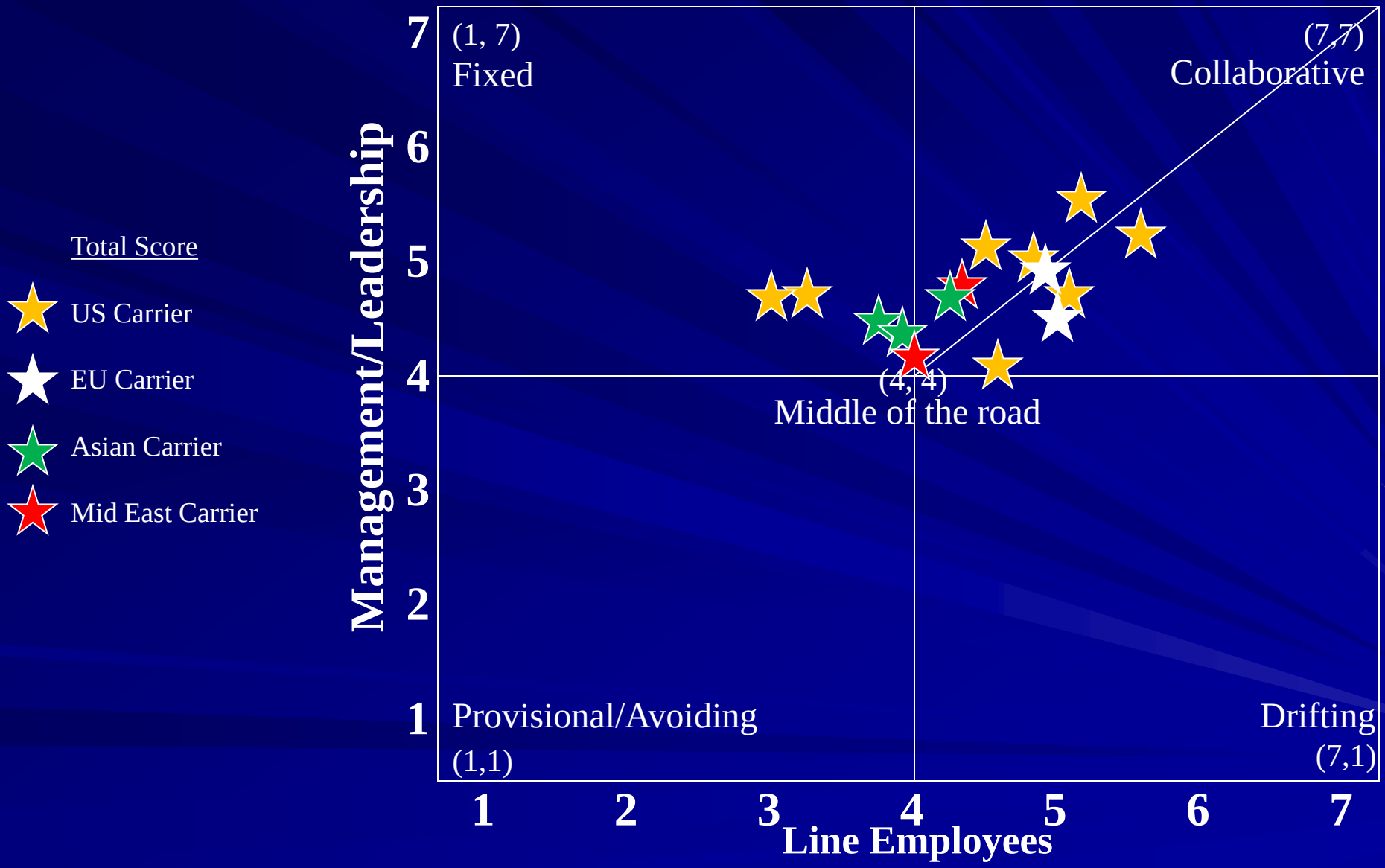


Airline Total Safety Culture Score Indicator plots - each operational department /US Part 121 Air Carrier

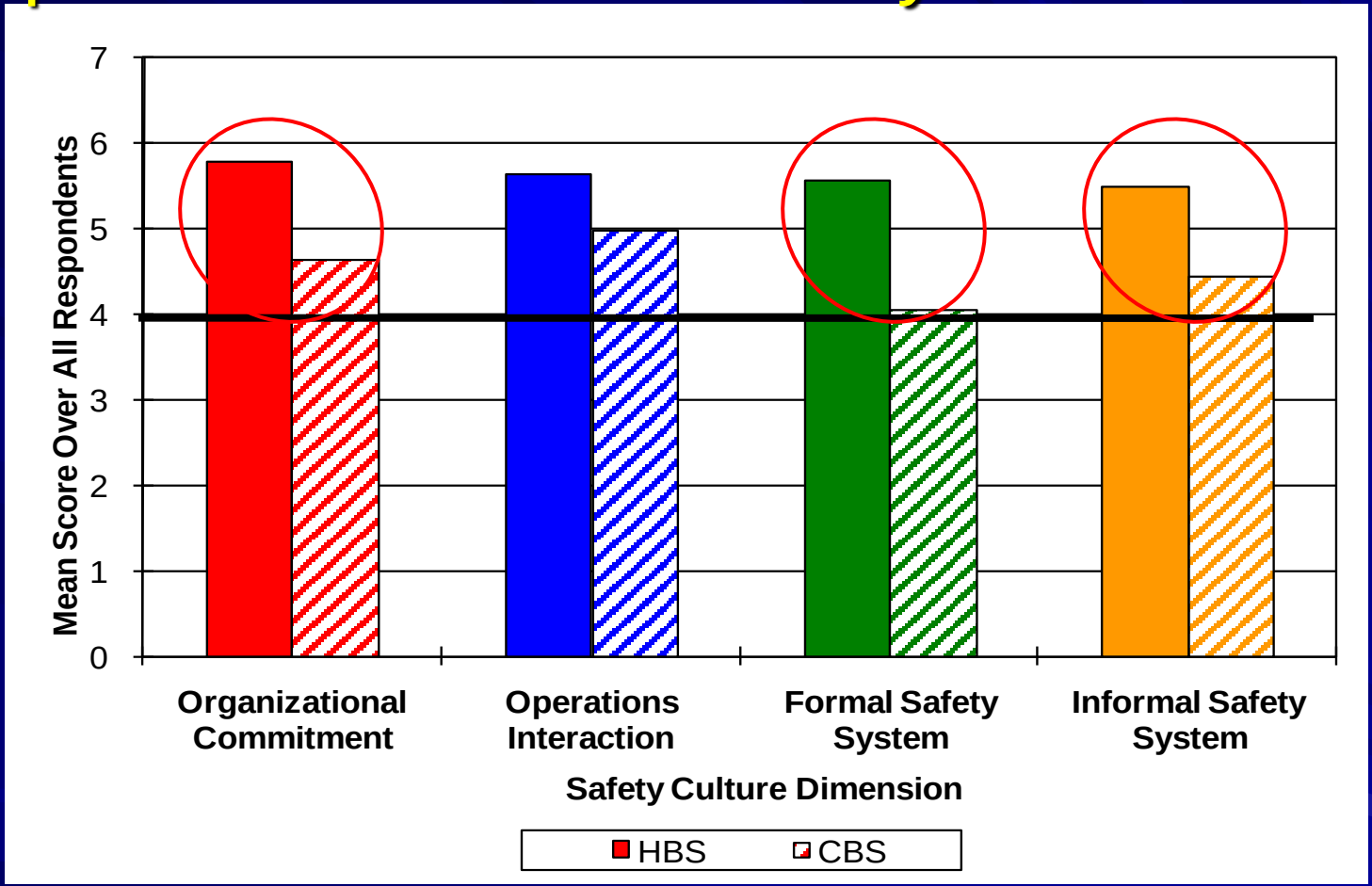


FO = Flight Operations, MC = Maintenance Operations, GH = Ground Handling Operations, DI = Dispatch Operations, FA=Cabin Operations

Indicators of Safety Culture
Comparison of Major Air Carriers - Culture Matrices



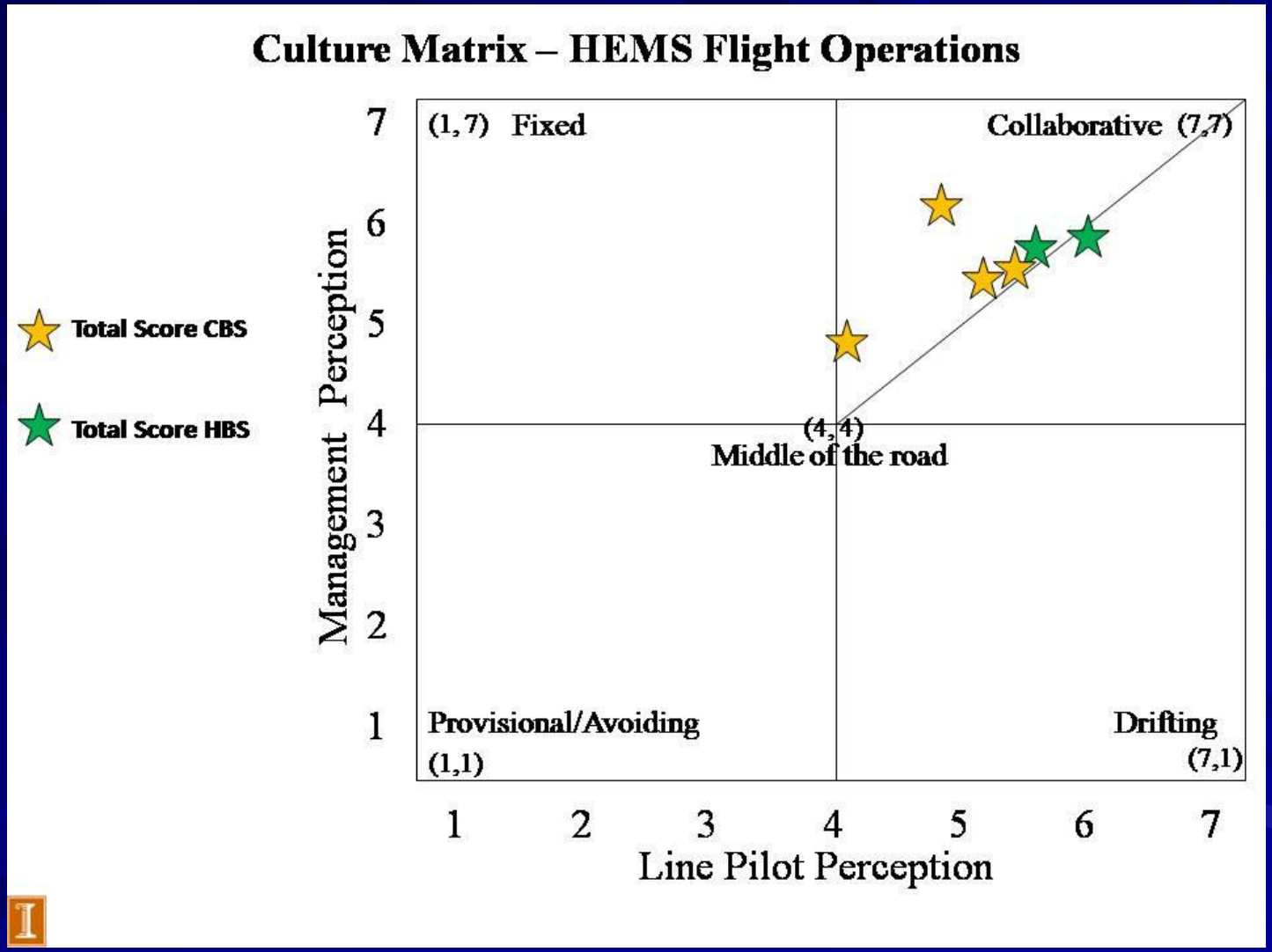
Mean Comparisons – Hospital-Based v. Community-Based Service



HEMS Operations

2009 Study

Comparison Culture Matrices – HEMS Flight Operations

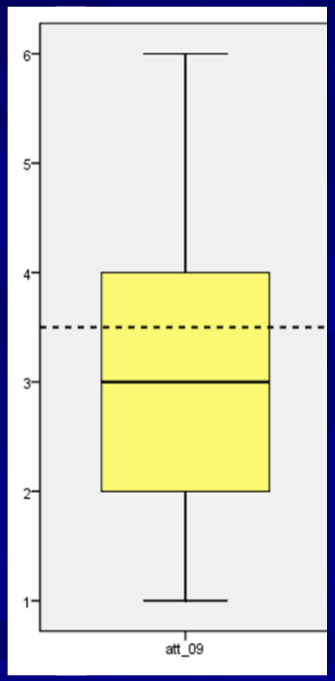


2009 Study

Negative Risk Perception Items

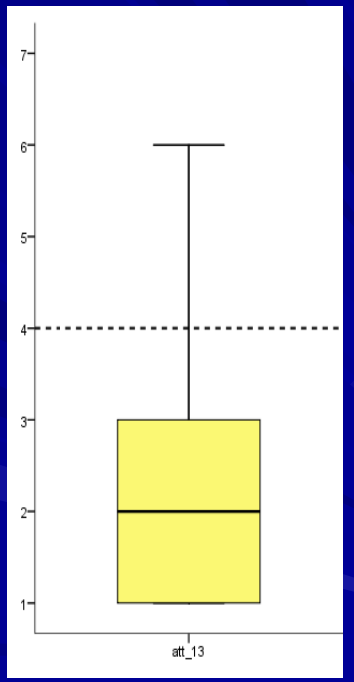
***Accidents will happen, no matter how careful we are.**

mean = 3.00



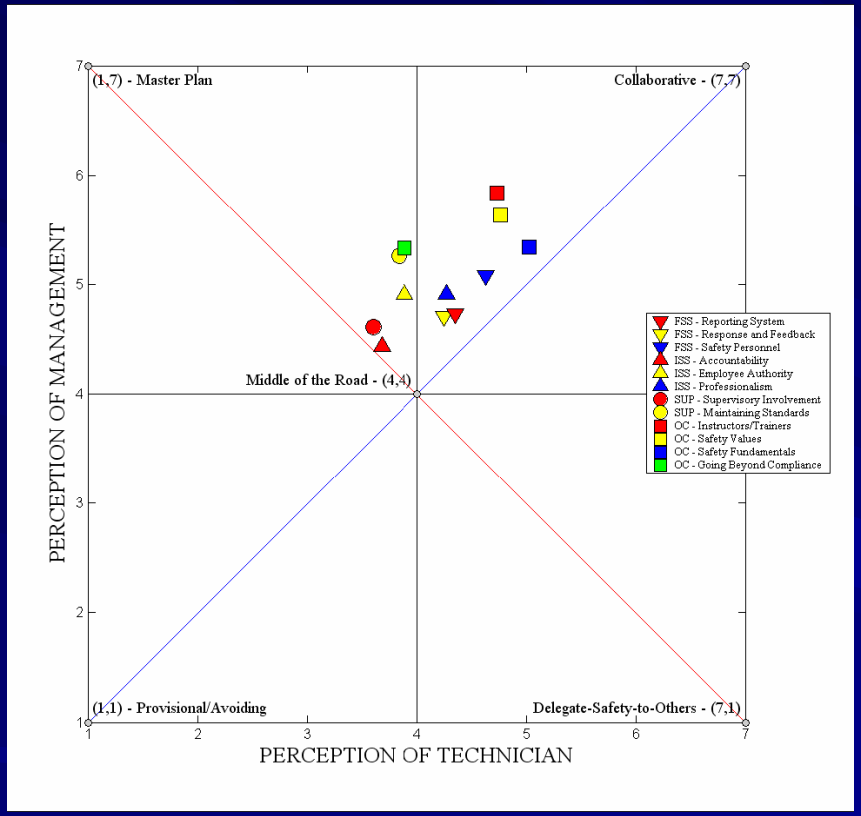
***As a HEMS pilot, I accept personal risk as part of the job.**

mean = 2.36

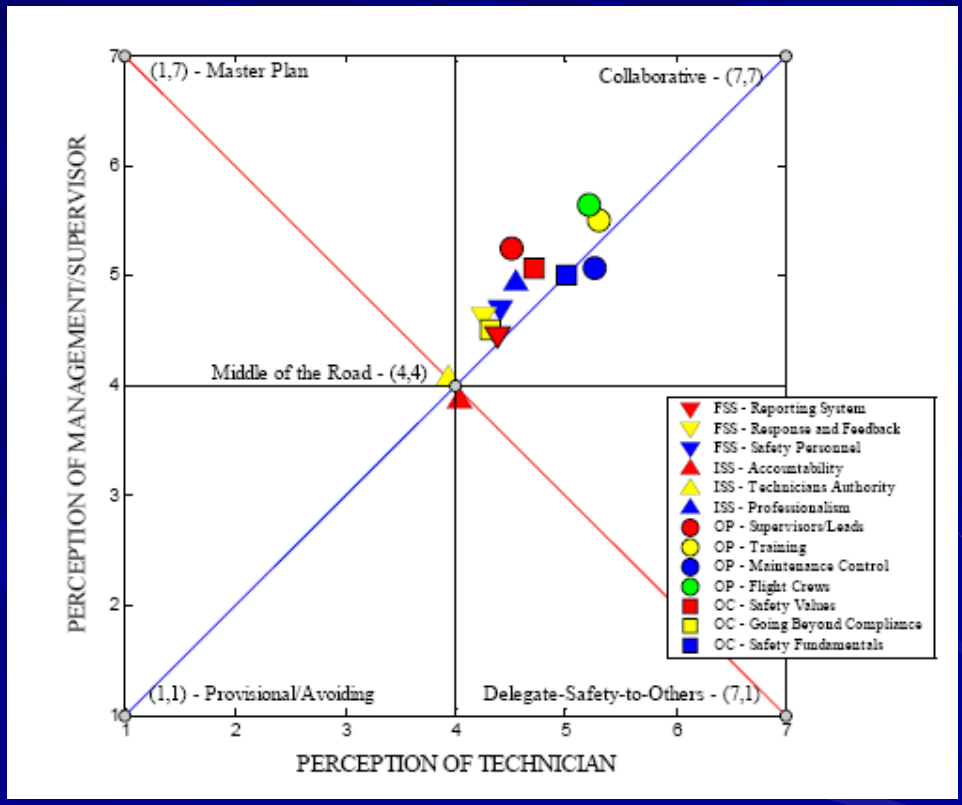


* Reverse coded (high scores are good)

Example: Part 145 Maintenance Station Change can be measured over time



Year 1 study



Year 2 study

Conclusion/Issues

- Differences in National Culture
- Differences in Job/Professionalism
- Alignment/Gaps in Culture – reduce silos
- Can measure demonstrable change over time
- Internal/External Adaptability
- Global Scores – Industry Average

Conclusion

- Safety Culture can be measured.
- Safety Culture can be changed over time.
- Understanding how humans perform their normal operations in complex environments allows us to build on successes and develop interventions to change and align poor performing areas.

VIELEN DANK

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