# Measuring the Effectiveness of Error Investigation and Human Factors Training

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# Error Reduction in Aviation Maintenance

- Gore Commission Report (1997): continuing error reduction in aviation needed
- NTSB: human errors continue to be major factor, particularly in maintenance
- Concentration on removing Active Failures has shifted to addressing common Latent Failures, e.g. poor procedures, poor communication
- People in aviation maintenance have certain consistencies in attribution of incidents (Marx, 1998)

# Incident Investigation

- How to improve aviation maintenance performance? most programs in airlines and repair stations include training in HF (largely CRM-based) and better incident investigation.

- If enough incidents available, can find patterns to guide interventions: e.g. Wenner and Drury for ground Damage (2000)

- But need to have confidence in the data!

# Job Aid

- Job aids have been developed to improve incident investigation beyond blaming the person at Reason's "sharp end"

- Earliest and most widespread, is Boeing's Maintenance Error Decision Aid (MEDA)

- Also others: Aurora MMS (Marx, 1998), Human Factors Accident Classification System (HFACS: Schmidt, 1998), Five Rules of Causation (FRC: Marx, 2001)

# Typical Incident Investigation Model (from literature)

# Phase I Goal

- Developed and validated a methodology that would be suitable for measuring operationally how well people in various positions investigate incidents

# Phase II Goal

- Used the incident investigation methodology to measure the effectiveness of two specific Human Factors training programs

- Does CRM-type training in HF help people investigate incidents better?

# Phase III Goal

- Extended the methodology to evaluate the effectiveness of incident investigation tools and job aids

- Nobody seemed to actually USE the job aids in our first two years, even though they had been trained to. Would people do better when instructed to USE their job aid?

# Methodology

- Using incident scenarios to elicit simulated investigation (Woodcock and Smiley, 1999; Torell and Bremberg, 1995)

- Investigator required to ask experimenter for data until the incident has been satisfactorily investigated

- Six incidents were chosen and developed into scenarios based on existing incident reports at partner airlines

# Procedure

- A typical trigger statement:

**Missing Cockpit Door**

**During the preflight check on aircraft #6833, Flight #1141, the crew found that there was no cockpit door in place. The cockpit door had been removed and not reinstalled during overnight maintenance to locate an under-floor leak.**

- Experimenter supplied answers from master fact sheet with 55-119 facts

- Asked for verbal report on findings (synopsis) when investigator said enough data collected

| Fact # | Date/Time | Fact |
|---|---|---|
| 571010 | 6/12 0630 | Donald Southgate writes logbook entry that #2 IRU replaced and tested satisfactorily |
| 572010 | | Donald Southgate leaves E&E bay, closes access door |
| 573040 | | Donald Southgate does not notice disconnected pitot static lines |
| 574010 | 6/12 0650 | Donald Southgate replaces logbook in ready room |
| 574011 | 6/12 0650 | Donald Southgate clocks out |
| 580010 | 0700 | Aircraft 1263 taxied to Gate 27 for flight 371 to Washington IAD |
| 580110 | 0730 | Pilot taxis from gate towards runway and notices velocity and air temperature in error from #2 ADC |
| 580210 | | Pilot returns to gate 27 |
| 580310 | | AMT troubleshoots #2 ADC and finds pitot static lines disconnected |

# Participants

## Participants pool:

- Aviation Maintenance Technician (AMT)
- First-line Supervisors and Managers
- Quality Assurance Investigators
- Professional Aviation Incident Investigators

| | Phase I Baseline Study | Phase II Human Factors Training | Phase III Job Aids | Population data from Bureau of Labor Statistics (BLS, Washington, 1991) |
|---|---|---|---|---|
| Mean Age (yr) | 43.5 | 41.7 | 42.5 | 36.2 |
| Mean Experience (yr) | 17.5 | 18.3 | 15.8 | 9.4 |
| Total Participants | 37 | 32 | 15 | / |

# Phase I Results - Overview

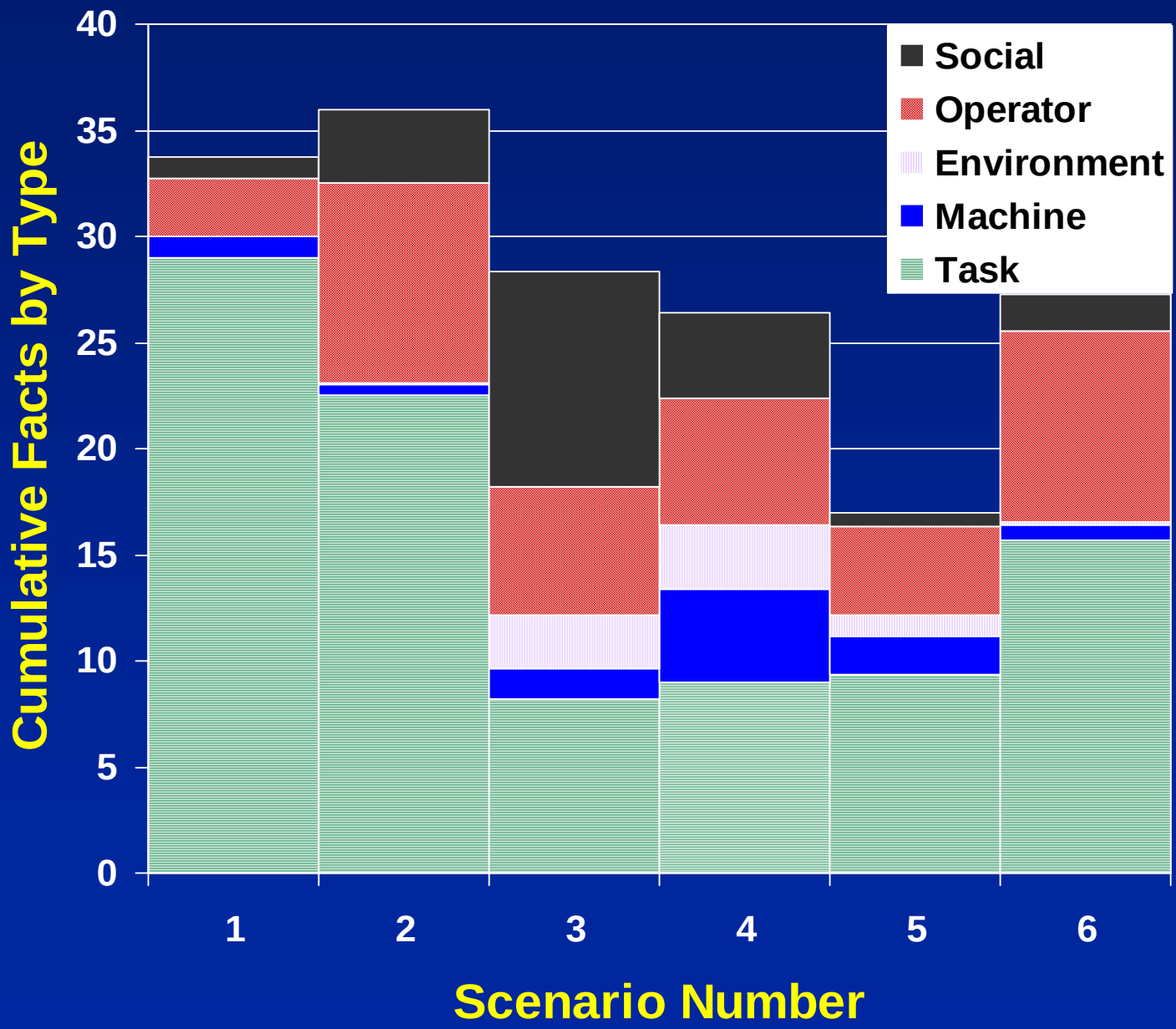
- GLM ANOVA of Number of Facts Requested

| Model | F value | P value |
|---|---|---|
| Fact Type | F (4,149) = 85.7 | < 0.001 |
| Scenario | F(5,149) = 4.5 | = 0.001 |
| Fact Type x Scenario | F(20,149) = 8.1 | < 0.001 |
| Job Type (as covariate) | F(20,149) = 8.1 | = 0.036 |

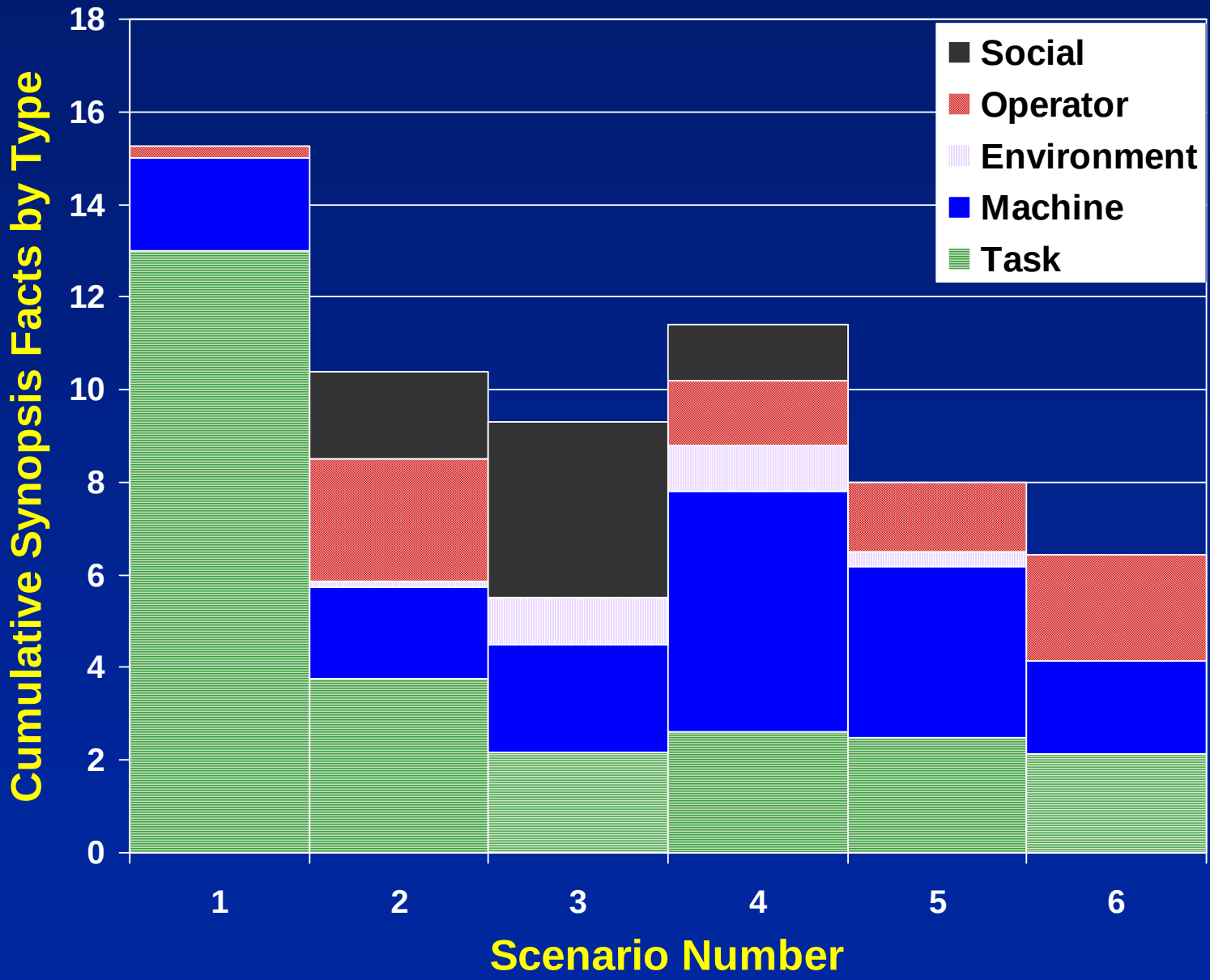
- Except for professional investigators, the size of “Job Type” effect was small

- A t-test of the correlation coefficient: the mean (0.31) of the distribution was positive (t=4.7, p=0.001)

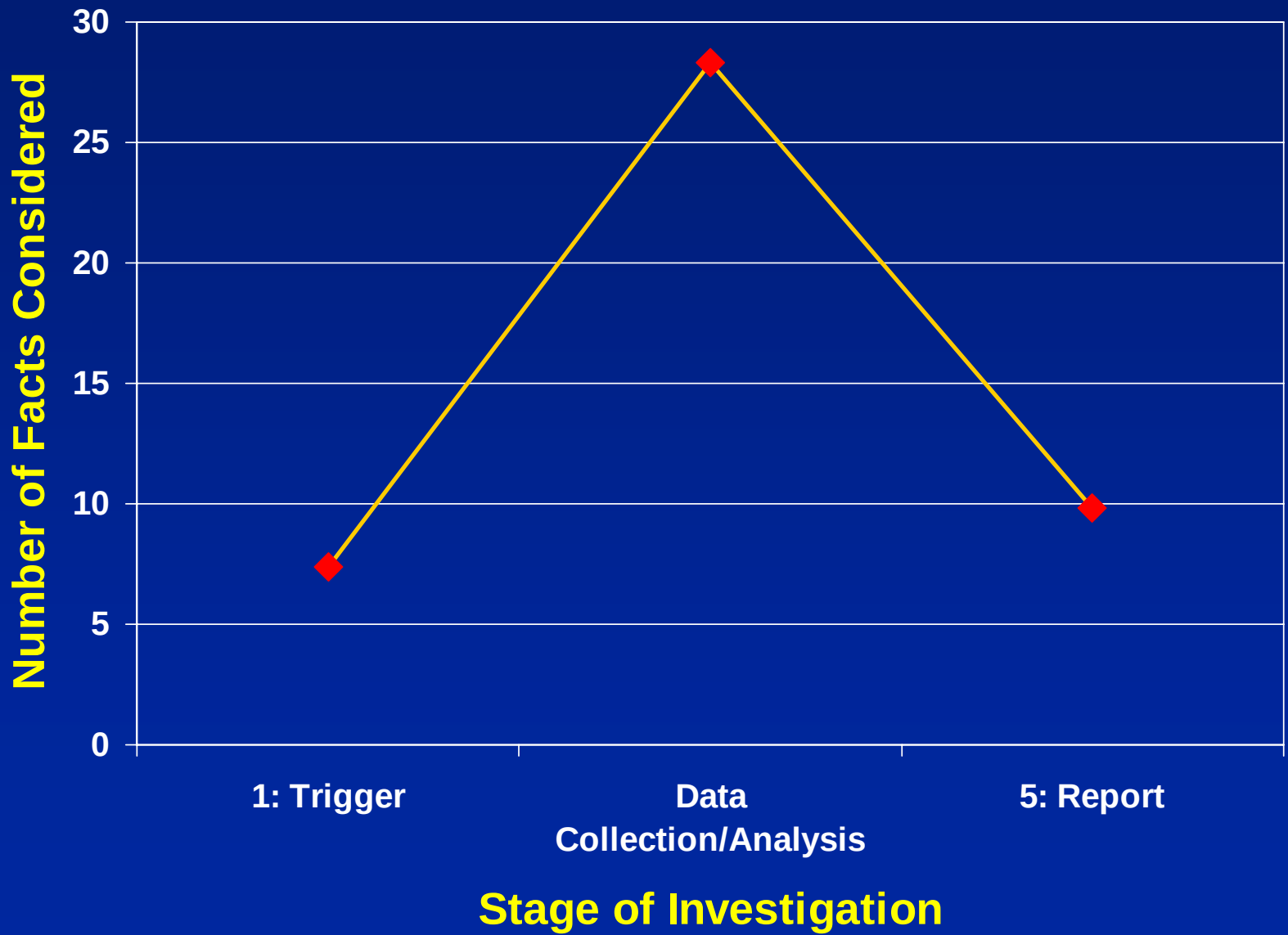
# Phase I: Facts Requested



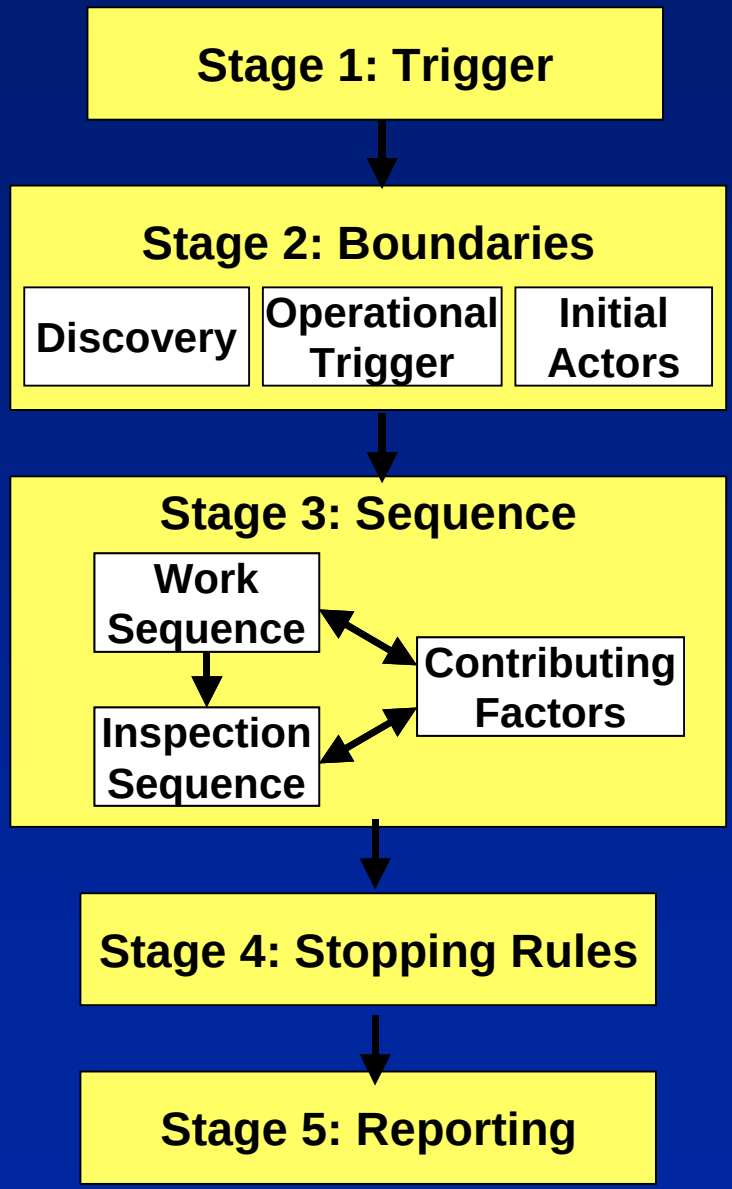
# Phase I: Facts in Synopsis



# Phase I: Facts being Considered



# Model of How People Investigate



# Phase II: Does Training Help?

- Tested people before/after either company HF training or no intervention
- 16 people in each group, mainly AMTs
- Measured number of facts requested during the investigation and in synopsis as in Phase I
- Used only 3 scenarios

# Phase II Results - Overview

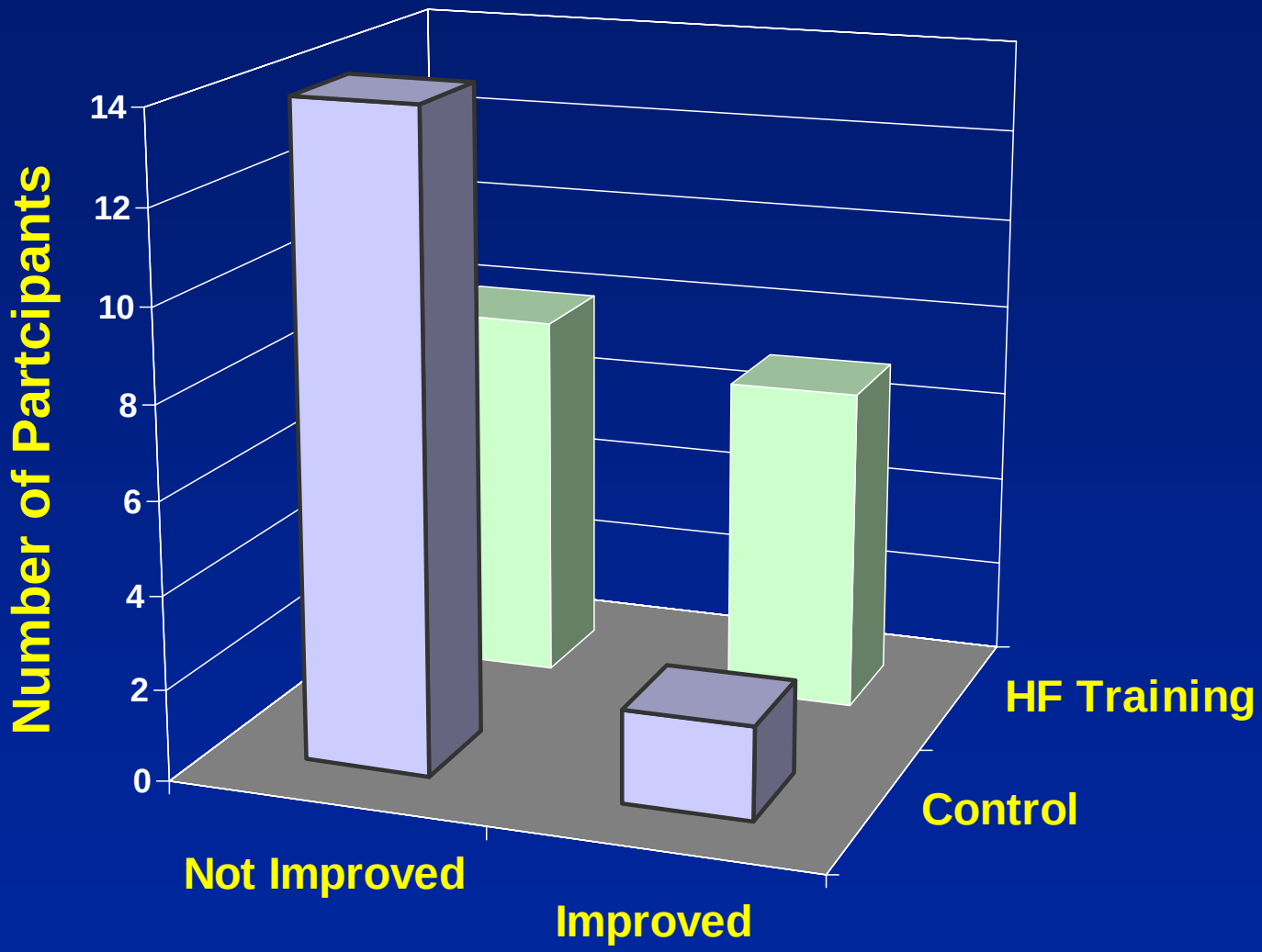
- Direct count of how many participants improved after training or no training

- Fishers exact probability test (P = 0.044): after training the training group found 3.1 more facts (training group) vs. 0.3 for control group

- GLM ANOVAs

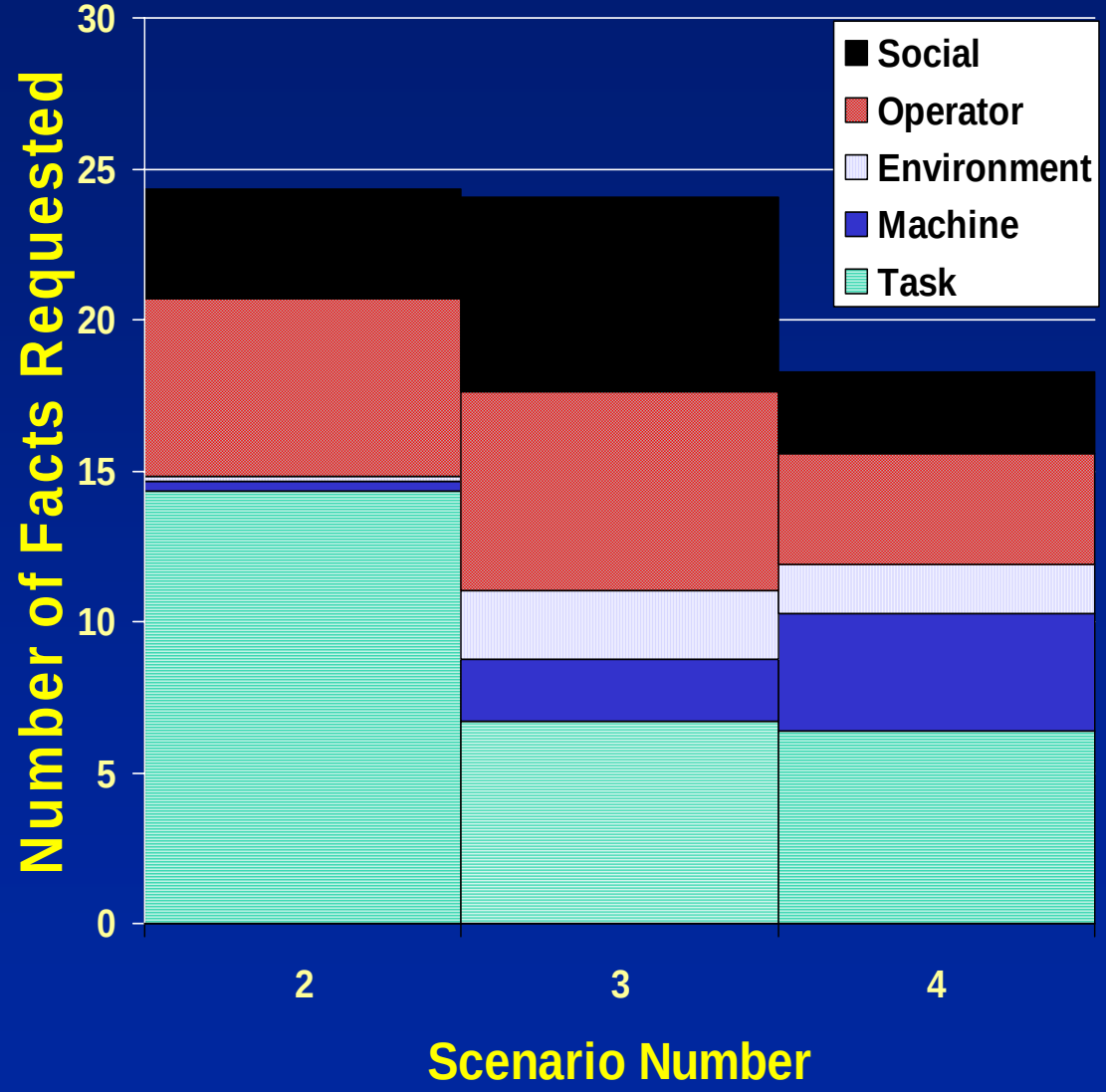
| Model | F value | P value |
|---|---|---|
| Before/After Test | F(1, 249) = 4.47 | 0.035 |
| Fact Type | F(4, 249) = 36.60 | < 0.001 |
| Scenario | F(2, 249) = 3.23 | = 0.041 |
| Fact x Scenario | F(8, 249) = 10.01 | < 0.001 |
| Training x Before/After x Scenario | F(2, 249) = 4.41 | = 0.013 |

# Phase II: Effectiveness of Training




**Fishers exact probability test showed the HF training course was clearly beneficial (p=0.044)**

# Phase II: Number of Facts Requested




(F(4,249)=36.60, p<0.001)

# Phase III: Does Job Aid Help?

- Tested people using two investigation job aids
  - MEDA
  - Five Principles of Causation

- All participants had been trained to use the job aids – we just provided them

- 15 trained participants in 3 organizations

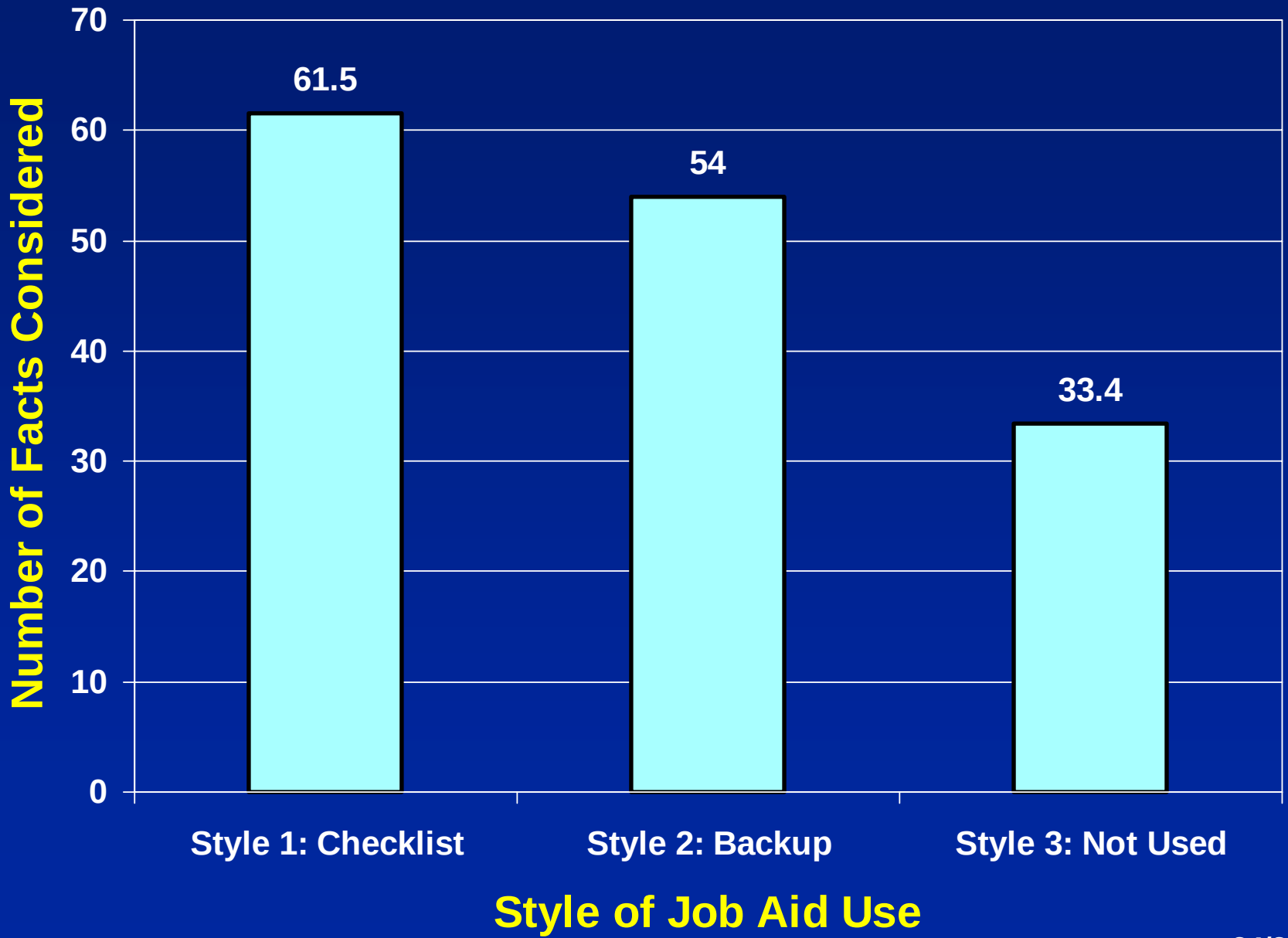
# Phase III Results - Overview

- Three different styles of using the job aids were observed. The effect of Style was highly significant (F(2,30) = 7.68, p =0.002).

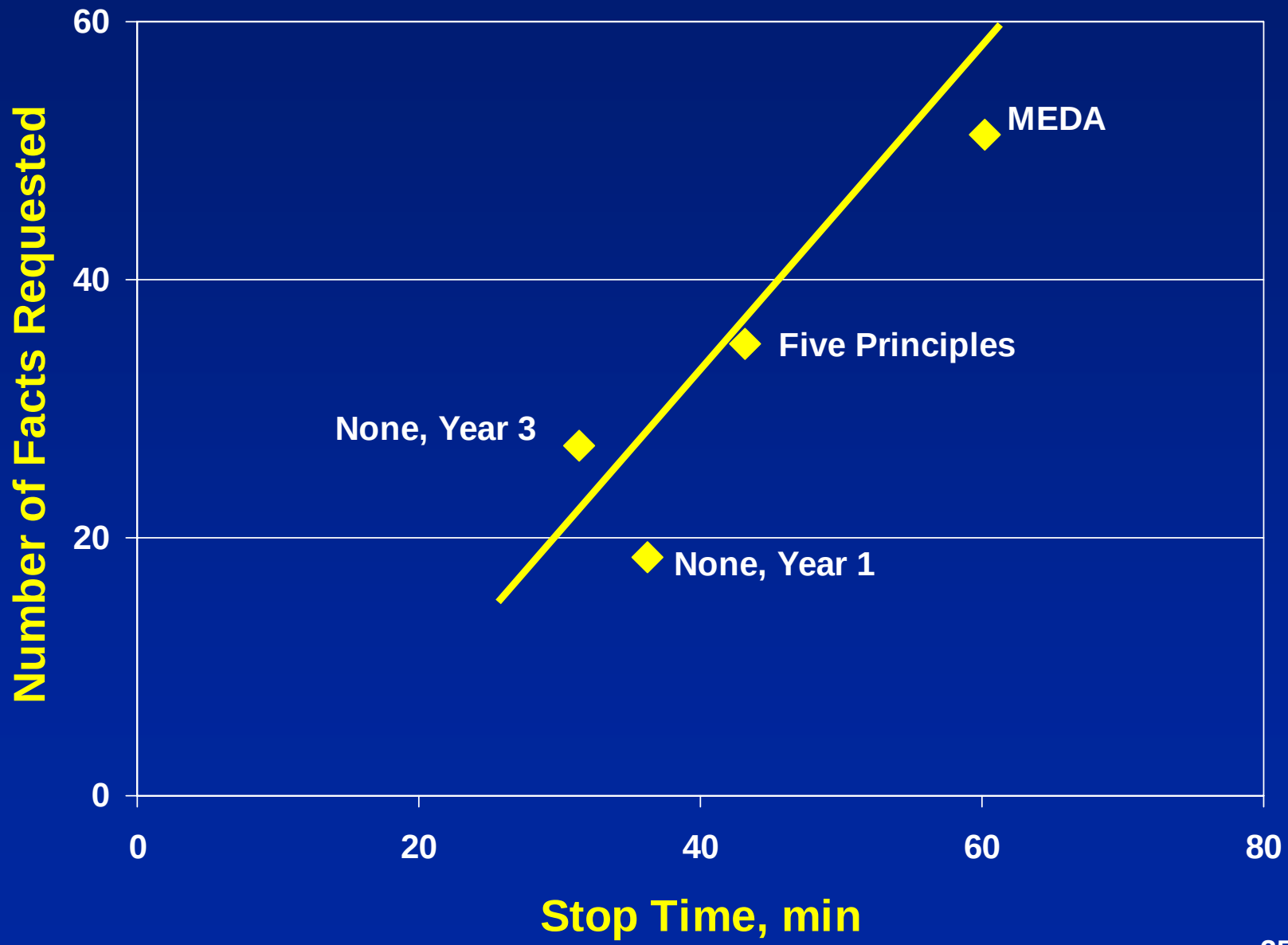
- Analyses of Covariance (ANCOVAs) since high correlation (0.645, p= 0.009) with experience.

| Model | During the Investigation | | In Synopsis | |
|---|---|---|---|---|
| | F value | P value | F value | P value |
| Fact Type | F(4, 29) = 15.91 | < 0.001 | F(4,29) = 5.10 | = 0.003 |
| Scenario | F(8, 29) = 3.40 | = 0.007 | F(8,29) = 1.97 | N.S. |
| Number of Incident Investigated (as covariate) | F(1, 27) = 4.10 | = 0.052 | / | / |

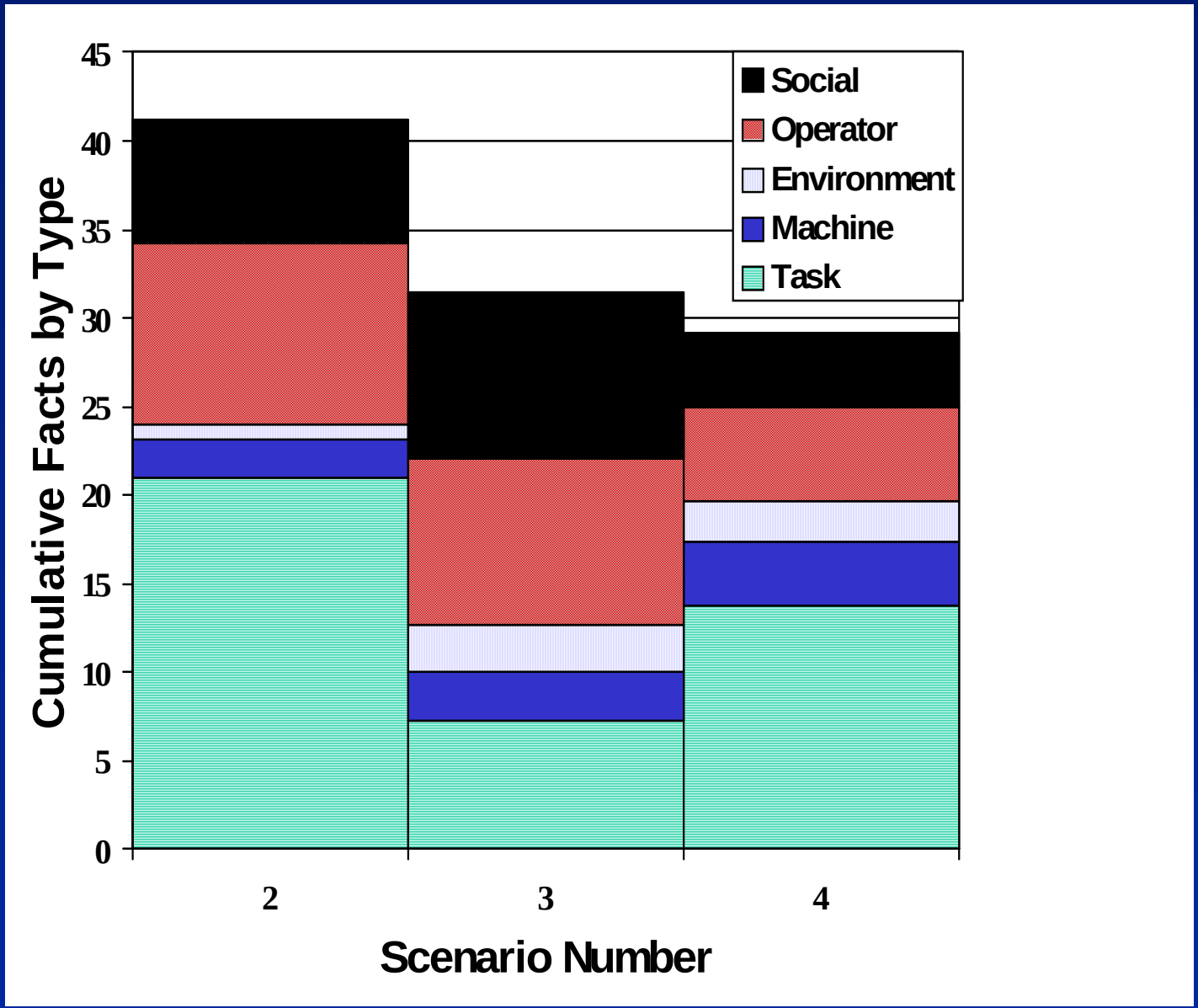
# Phase III: Effect of Style



# Phase III: SATO



# Phase III: Number of Fact Requested



# Discussion

- Revised the earlier four phase model to give more accurate representation of what actual investigators do.

- The Human Factors training programs did measurably improve a person's ability to investigate incidents (i.e. thoroughness).

# Discussion (cont')

- The current methodology was not a good match to the evaluation of a training program populated by largely inexperienced investigators.

- The job aids did improve performance

# Next Steps: Testing our Model

- Refining Event Tree for Scenario 1-6

**Branches**

**Sub-branches**

**Twigs**

**Stems**

- Test sequence of Level 1 requested
- Transitions made between different Level and TOMES Type
- Classify into Boundary Events and (Maintenance + Inspection) Events
- Testing sequence of (M + I) facts requested