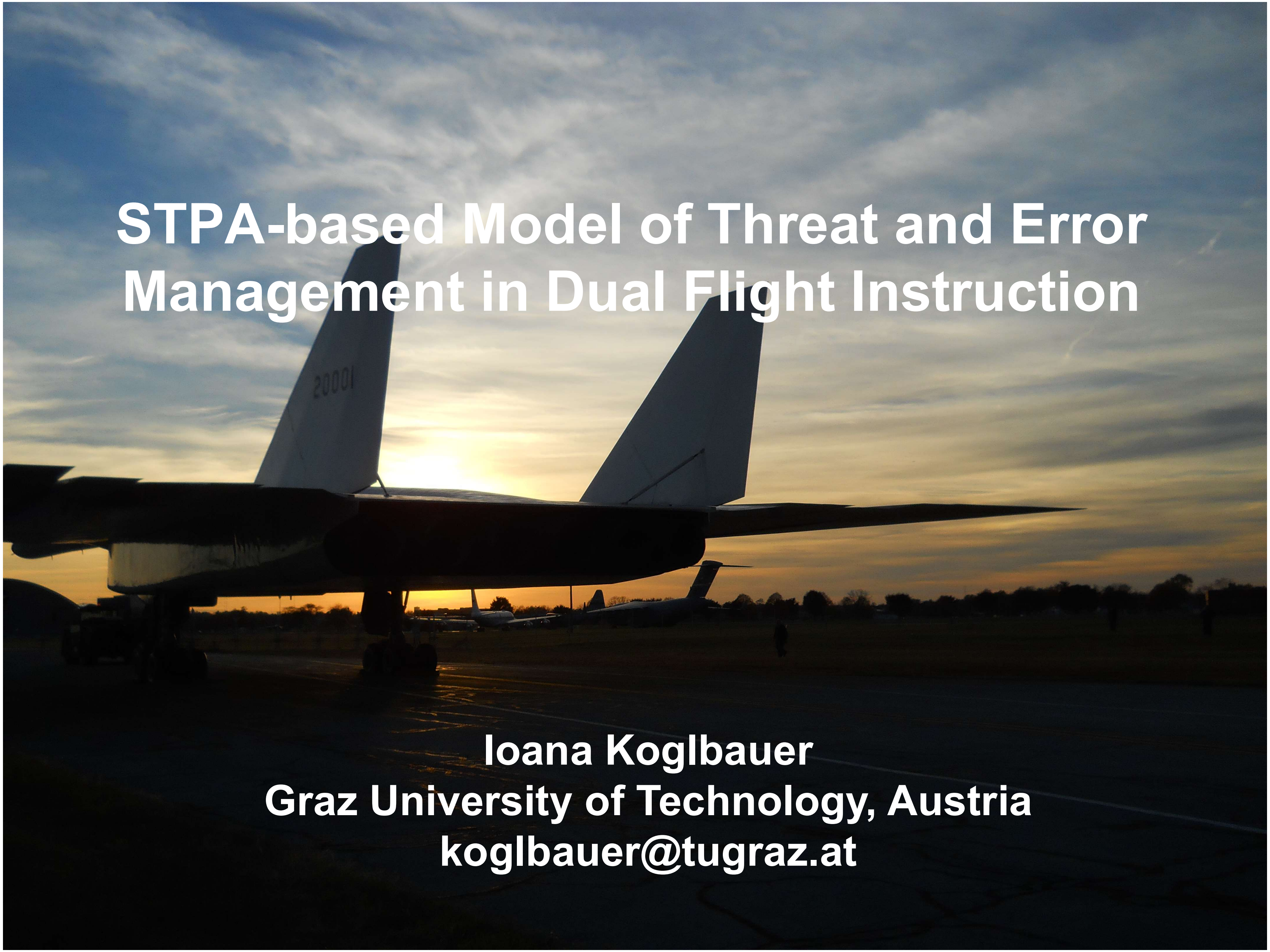

STPA-based Model of Threat and Error Management in Dual Flight Instruction

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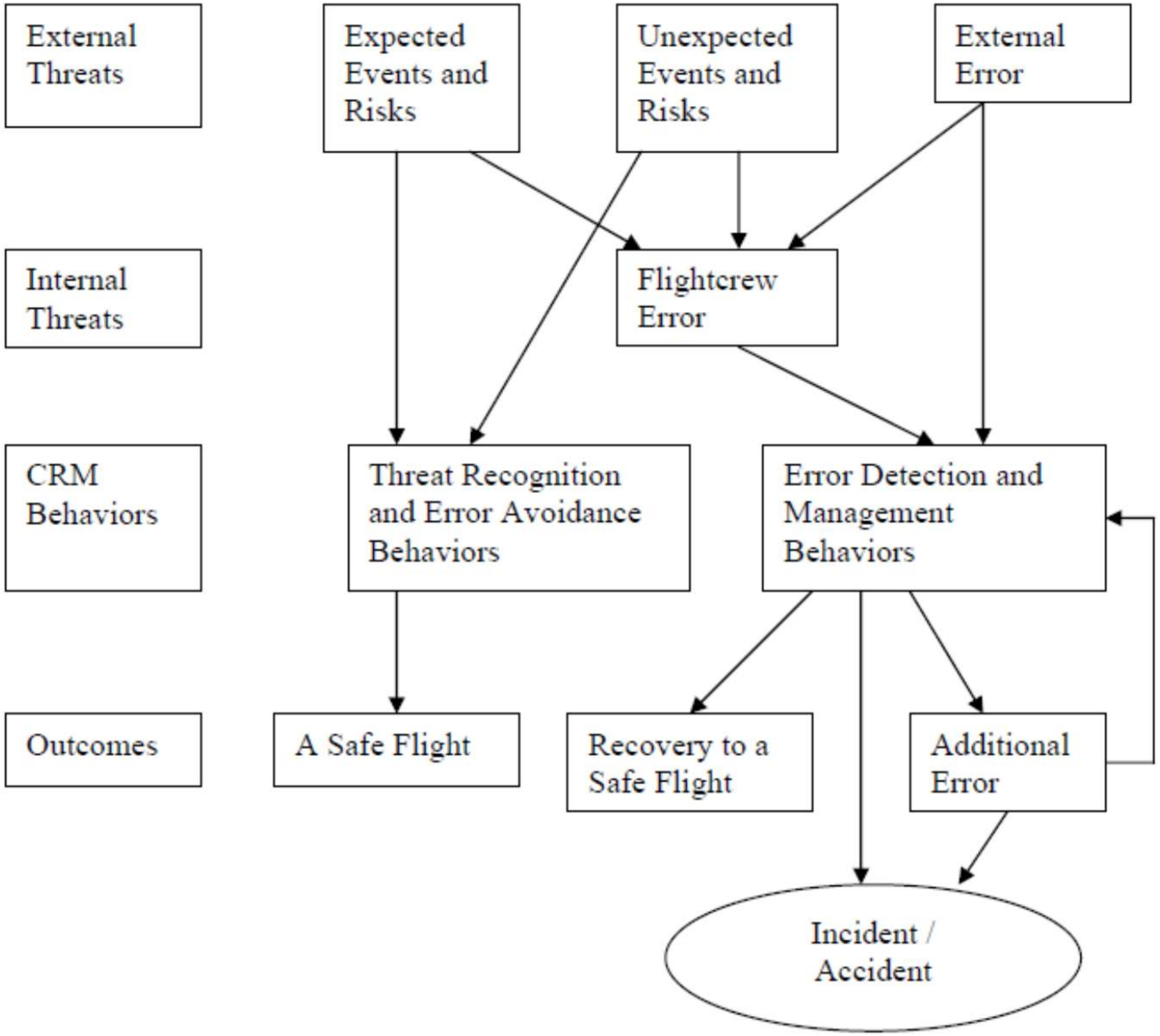
Threat and Error Management (TEM)

Currently the Authorities (EASA, 2011; ACG, 2014) identify TEM as a key ability of:

- Pilots
- Flight instructors
- Flight examiners

The framework of Threat and Error Management

(Helmreich, Klinect & Wilhelm, 1999)



Threat and Error Management (TEM) in Practice

(Klinect, 2005)

N=2612 Observations (10 Airlines)	Average Freq.	Range (10 Airlines)	Number of errors	Frequent error types
Flight Crew Errors	80%	62-95%	7257	Use of automation (25% of flights) Systems/Instruments/Radio (24%) Checklist (23%) Manual aircraft handling (22%) Crew communication with others(22%)
Error Mismanagement	27%	18-47%	1825	Manual handling (79% mismanaged) Ground navigation (61%) Automation (37%) Systems/Instruments/Radio (37%) Checklist (15%)

TEM in Practice

(Klinect, 2005)

N=2612 Observations (10 Airlines)	Average Freq.	Range (10 Airlines)	No. of errors	Frequent errors types (across 10 airlines)
Undesired Aircraft State	34%	24-51%	1347	Incorrect systems configuration (9% of flights) Incorrect automation configuration (6%) Speed deviations (high speed) (6%) Unstable approach (5%) Vertical deviations (3%)
Undesired Aircraft State Mismanagement	13%	5-20%	175	Unstable approach/no go-around (98% mismanaged) Incorrect systems configuration (8% of flights) Incorrect automation configuration (8%) Incorrect flight controls configuration (8%) Lateral deviation (7%)

STPA-based model of TEM in flight instruction

Goal: provide effective flight training

Accident: injury, loss of life, damage of aircraft or property

Hazards:

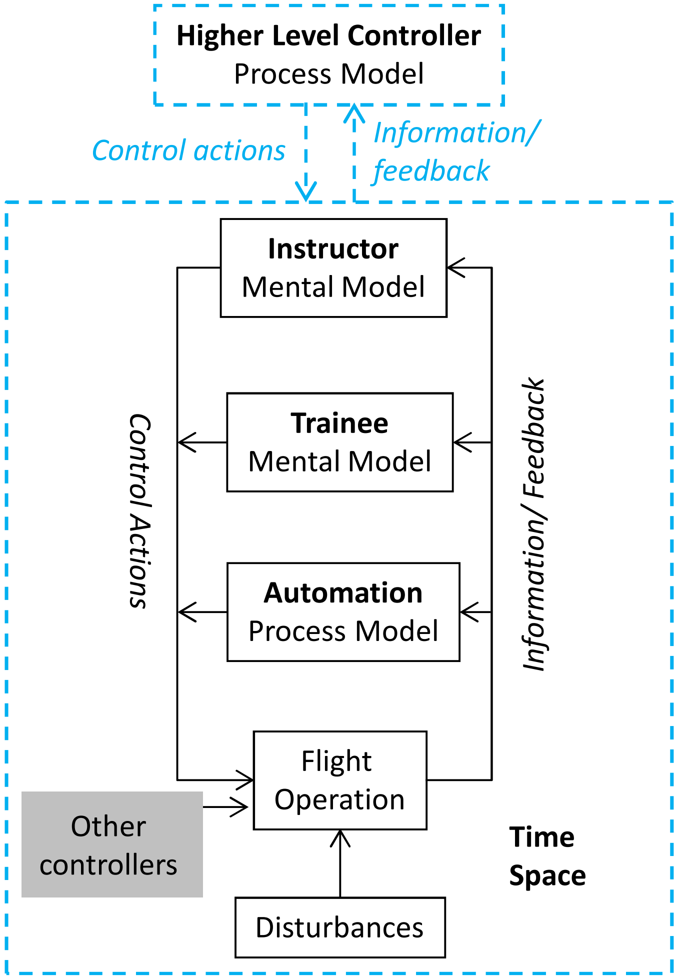
Maneuvering the aircraft outside the safety envelope (undesired aircraft state)
Violating separation from other aircraft, terrain, obstacles

Safety constraints:

The aircraft must be maneuvered within the safety envelope
Separation from other aircraft, terrain, obstacles must be maintained
The FI must assist the trainee in enforcing these safety constraints
The FI must take over the control to enforce these safety constraints if necessary

STPA-based model of TEM in flight instruction

(Koglbauer, 2016)



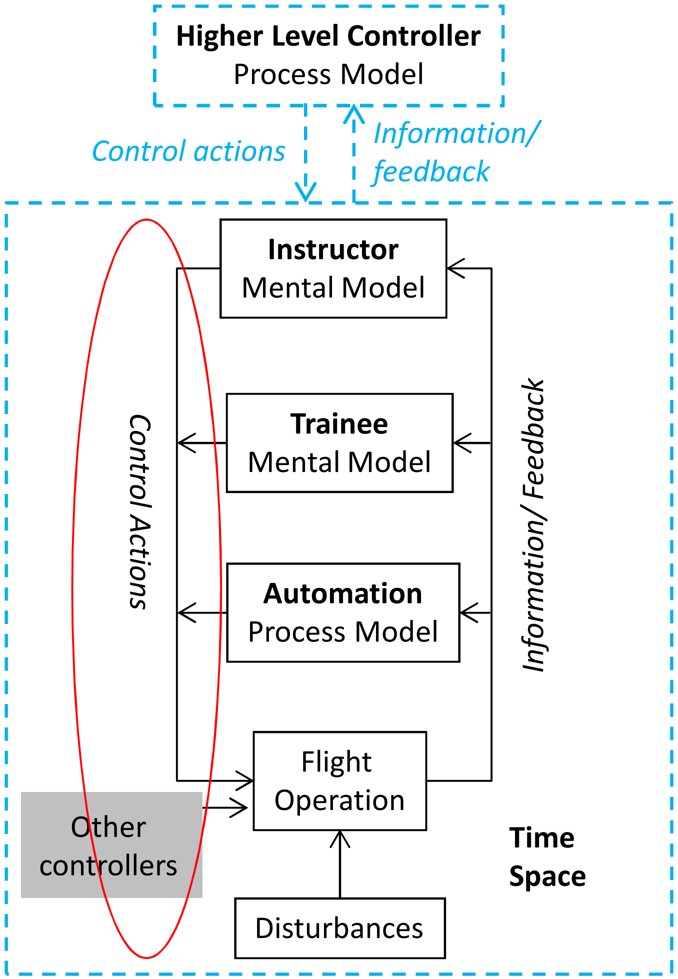
Generic unsafe control actions (UCAs)

(Koglbauer, 2016)

Control Action	**CA causes hazard**	**Lack of CA causes hazard**	**CA too early/ too late/ wrong sequence**	**CA too long or too short causes hazard**
Instructor UCAs	**Conflicting or uncoordinated control inputs;**	**Does not provide a CA or does not take over the control**	**Provides control inputs too late; Takes over the control too late;**	**Provides too short or too long CA**
Trainee UCAs	Provides inadequate CAs	Does not perform a required CA; Does not follow the instructor's command	Provides CA too early, too fast, too late or in the wrong sequence;	Provides too short or too long control inputs;
Other controllers	CA causes hazard	Lack of CA causes hazard	CA too early/ too late/ wrong sequence	CA too long or too short

Categories of multiple CAs

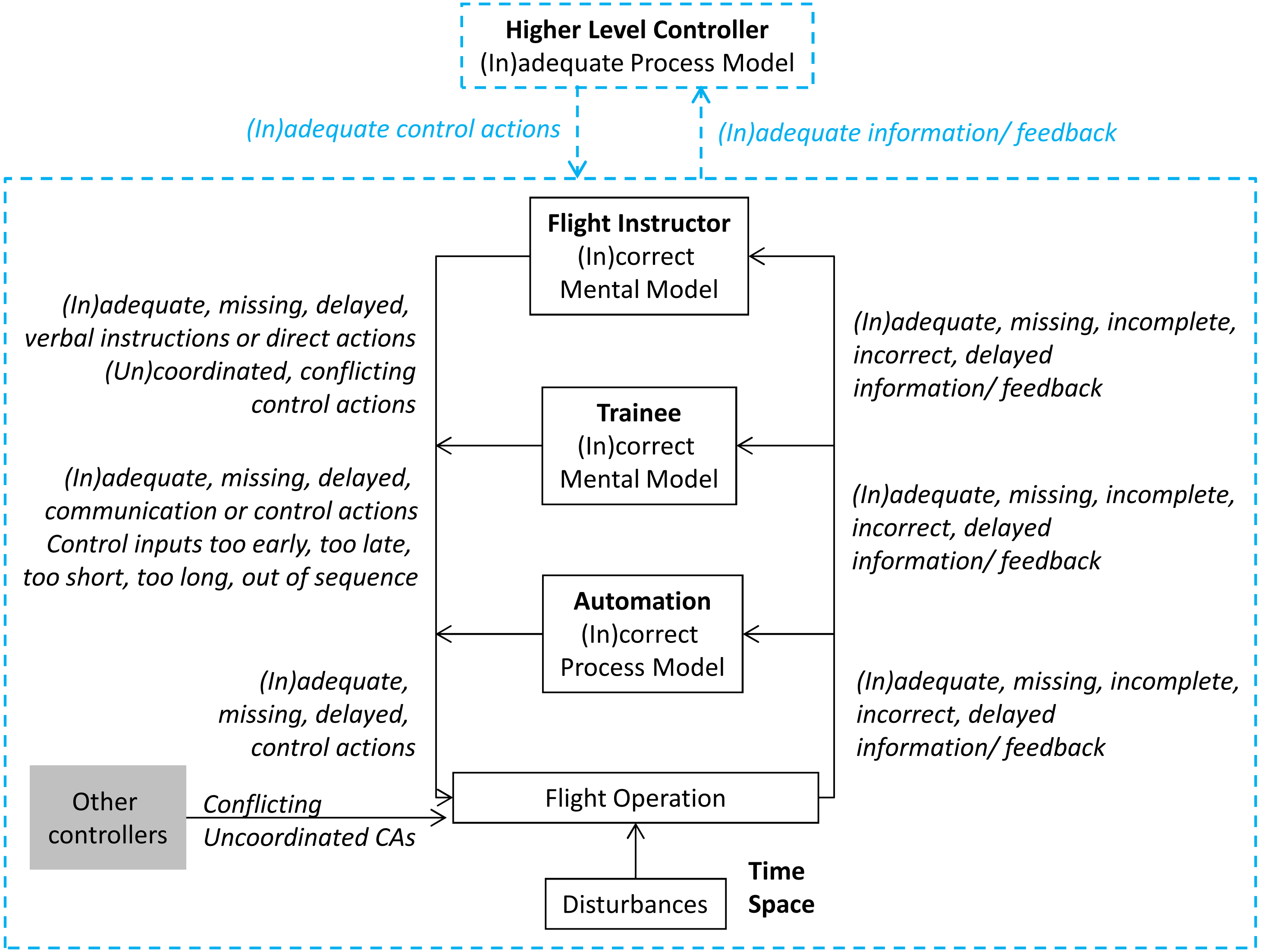
(Leveson, 2011)



- **Only one safe control action is provided** (e.g., FI gives a command, the trainee does not act or the trainee manages the attitude but the automation does not add thrust)
- **Multiple safe control actions are provided** (e.g., stick inputs)
- **Both safe and unsafe control actions are provided** (e.g., go-around attitude and inadequate thrust)
- **Only unsafe control actions are provided** (e.g., the trainee is flying below the glide path and the FI commands a go-around too late)

STPA-based TEM model for flight instruction

(Koglbauer, 2016)



How control actions can be uncoordinated
(Leveson, 2011)

- Misconception of the situation
- Miscommunication between FI, trainee, other controllers
- FI’s overconfidence in automation, trainee
- Unclear responsibility
- Delayed control under pressure/ desire to let the trainee fly
- Satisfaction by other controllers‘ actions (e.g., CA initiated, does not check for feedback)
- Confusion by other controllers‘ unexpected control actions
- Etc.

Scenario 1: The FI takes over the control too late

(Koglbauer, 2016)

Ex. go-around

This scenario could occur in following situations:

• The FI **relies too much on inadequate feedback received from the trainee** and detects too late that trainee's CAs do not have the expected effect,

• The FI has an **inadequate feedback from automation**, believes that the automation will handle some parameters and detects too late that it does not, or

• The FI has an **inadequate mental model for anticipating the trainee's errors**,

• The FI has an inadequate mental model **of the parameters which require her/ his intervention** during a mismanaged unstable approach;

• The FI is **confused by unexpected control actions of the trainee or of the automation**

•The FI is distracted, fatigued

Example: Measures for avoiding scenario 1

(Koglbauer, 2016)

•The FI **monitors** the flight situation, instruments, automation and the trainee and avoids distraction;

• The FI **double-checks the information and feedback provided by the trainee and automation;**

• The FI is **trained to anticipate trainees' errors**;

• The **FI specifies or receives from her/ his organization procedures that specify parameters for taking over the control**

• The FI considers factors that could delay her/ his CAs (e.g. fatigue, high workload) and **reacts earlier** than usual (e.g., go-around at 600 or 700 ft instead of 500ft)

The FI receives recurrent training on these tasks

The management re-evaluates the procedures over time

Scenario 2: The trainee provides too short CA and brings the aircraft in a hazardous state

For example the trainee stops too soon to reduce thrust, resulting in an unstable approach.

This scenario could occur in following situations:

The trainee does not **monitor** the instrument indications for **feedback** because she or he uses an inadequate scanning pattern, or is distracted, or

The trainee has an inadequate mental model:

- of how to adequately **apply the control inputs**
- **for anticipating** the effects of her/ his control inputs, or
- of the **required parameters** for the approach, or
- of **automation** and believes that the automation will handle some parameters when it does not (Koglbauer, 2016)

Example: how can scenario 2 be avoided?

(Koglbauer, 2016)

The FI provides information, checks and gives feedback about the trainees':

- scanning pattern
- anticipation of effects of her/ his control inputs
- knowledge of the flight parameters used in approach
- mental model of the automation used in the particular type of aircraft

The instructor repeats the above actions until the trainee consistently demonstrates an appropriate behavior

The FI manages the learning environment: long and short briefings, debriefings, simulators (e.g., cockpit simulator, flight simulator, simulation of scenarios of unstable approaches and practices the necessary corrections with the trainee), flight training area, altitude etc.

Conclusions

- The STPA-based model of TEM for flight instruction is **more comprehensive** and gives a new perspective to the whole instruction process
- Addressing safety issues with STPA has a positive effect on the training quality
- The FI candidates like the STPA-based model

„this the first time I see a model which is really useful"

Future work with the STPA-based TEM model:

- Refine the scenarios
- Develop training programs in a research project with the management
- Identify complex scenarios for pilot, instructor, and examiner, CRM training

Literature

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