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Pilot Training Next: Modeling Skill Transfer in a Military Learning Environment

Heather M. Wojton, Project Leader

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Emily A. Fedele

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About This Publication

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The IDA Technical Review Committee was chaired by Mr. Robert R. Soule.

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Executive Summary

This product is a repackaging of content from three previously approved briefings. We have put together pieces of these briefings for a short presentation at the Human Factors & Ergonomics Society 2019 Annual Meeting. All technical content has undergone technical review and is approved by the sponsor for release.

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Pilot Training Next: Modeling Skill Transfer in a Military Learning Environment

Authors: Drs. Daniel Porter, Emily Fedele, & Heather Wojton

Presenting: Dr. Daniel Porter
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HFES 2019
November 1, 2019

The Pilot Crisis

Fighter pilot shortage grows to one in four, GAO says

Updated April 13, 2018

By Barrie Barber, Staff Writer

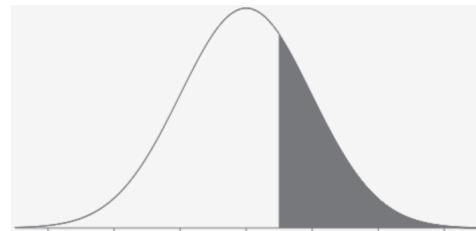
**Shortage can be solved by increasing retention
rate OR increasing growth rate**

Retention improvements have failed

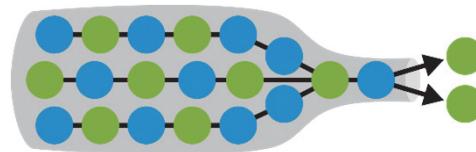
- A variety of retention efforts have been tried
 - All of these efforts have failed to solve the problem
- Lifestyle, family, and location are what matter
 - Pay bonuses aren't enough
- If retention can't be improved, growth must be

Traditional pipeline bandwidth is insufficient for growth

- Student quality must be maintained
 - Must attract and identify more talent

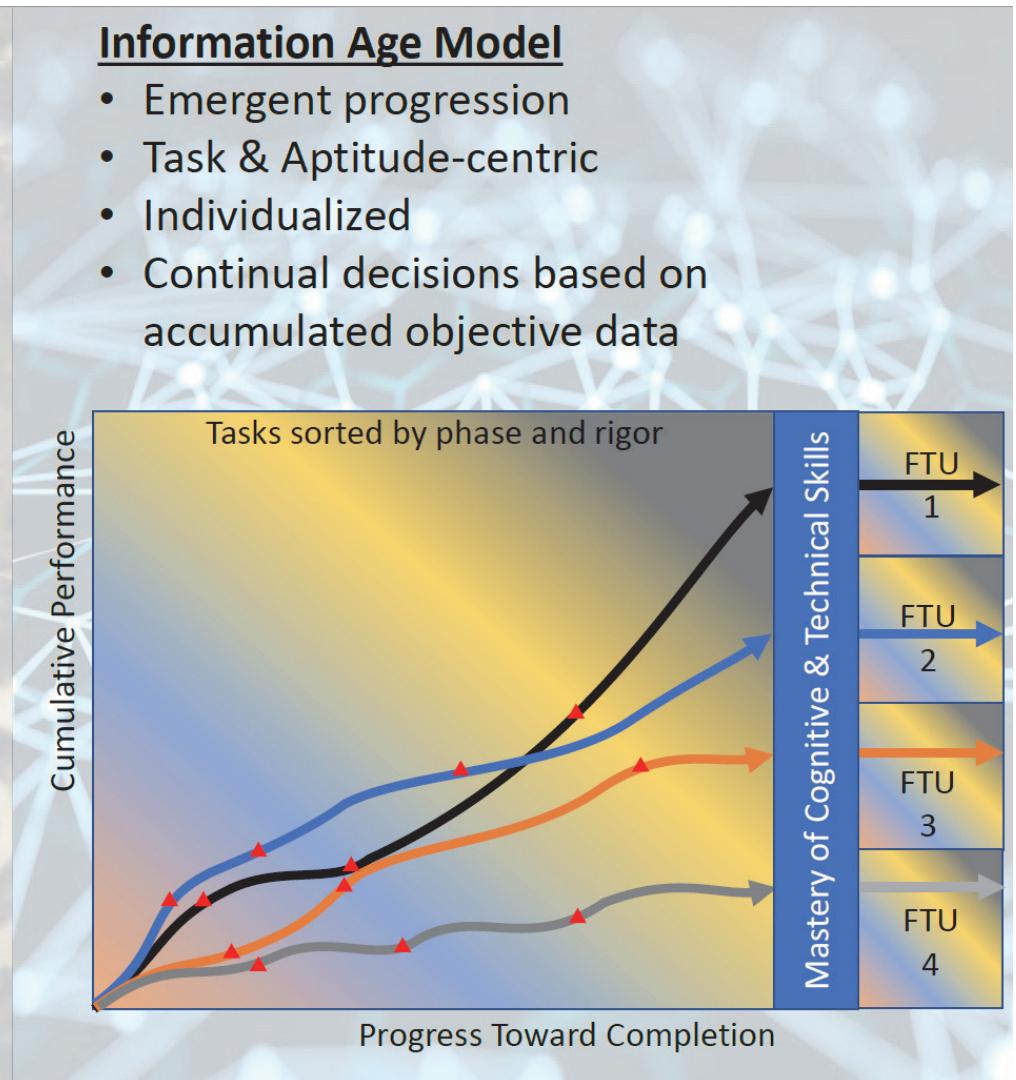
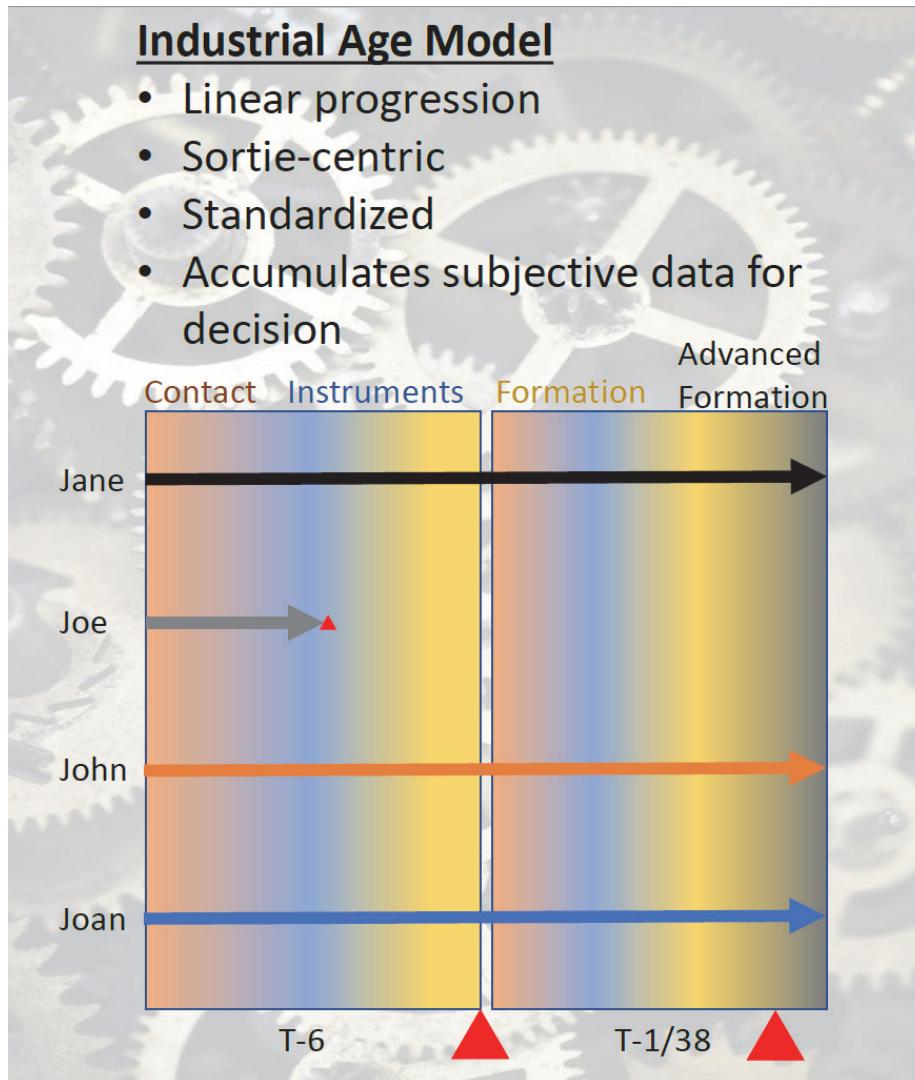


- Not enough instructors, aircraft, or money
 - Have to increase efficiency for this to work



Pilot Training Next is the exploratory attempt to overcome these challenges

Change procedures to incorporate new technology



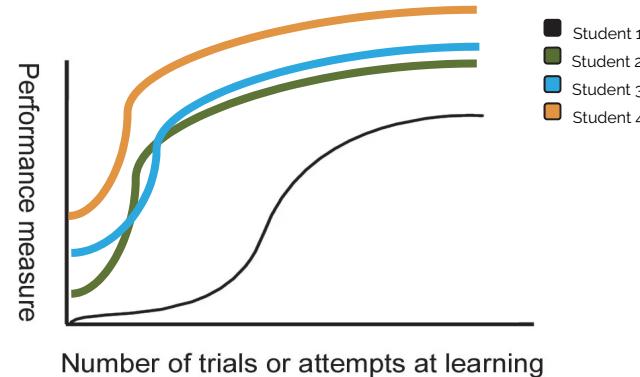
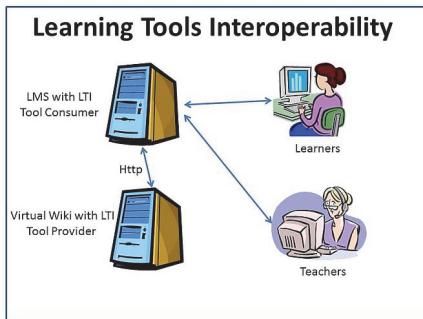
Biggest change is making immersive sims freely available all day through COTS VR technology



Simulators work to a point

- Decades of research and practice show sims work, BUT
 - Combat operational space is more chaotic/less constrained
 - Military hasn't attempted the same level of reliance as civilians
 - Not all skills will transfer equally at all points of practice
- How much is enough? How much is too much?

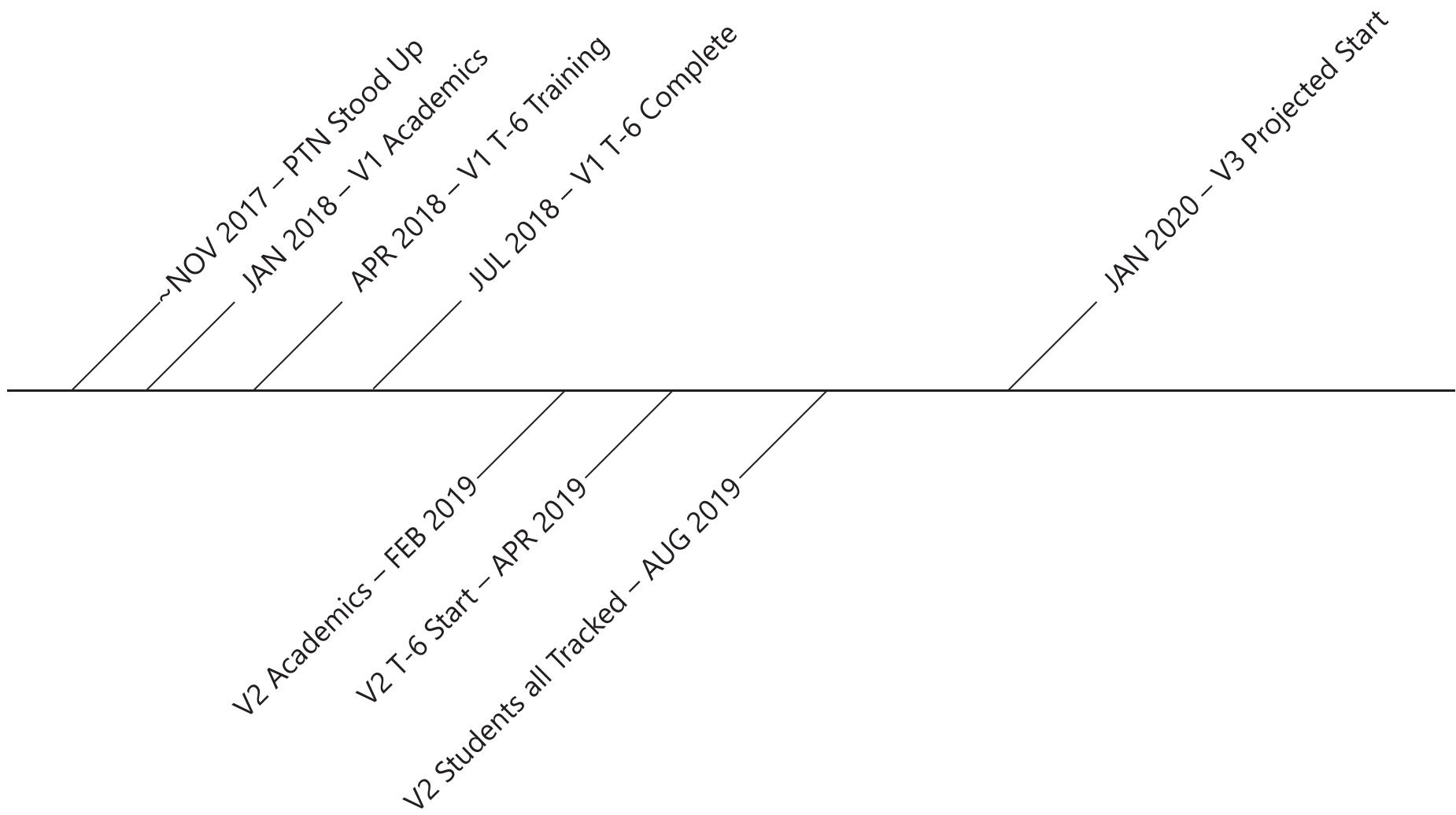
"Learn anywhere; validate in the aircraft."



PTN started with the T-6 to validate skill learning



PTN is on track to run one cohort per year



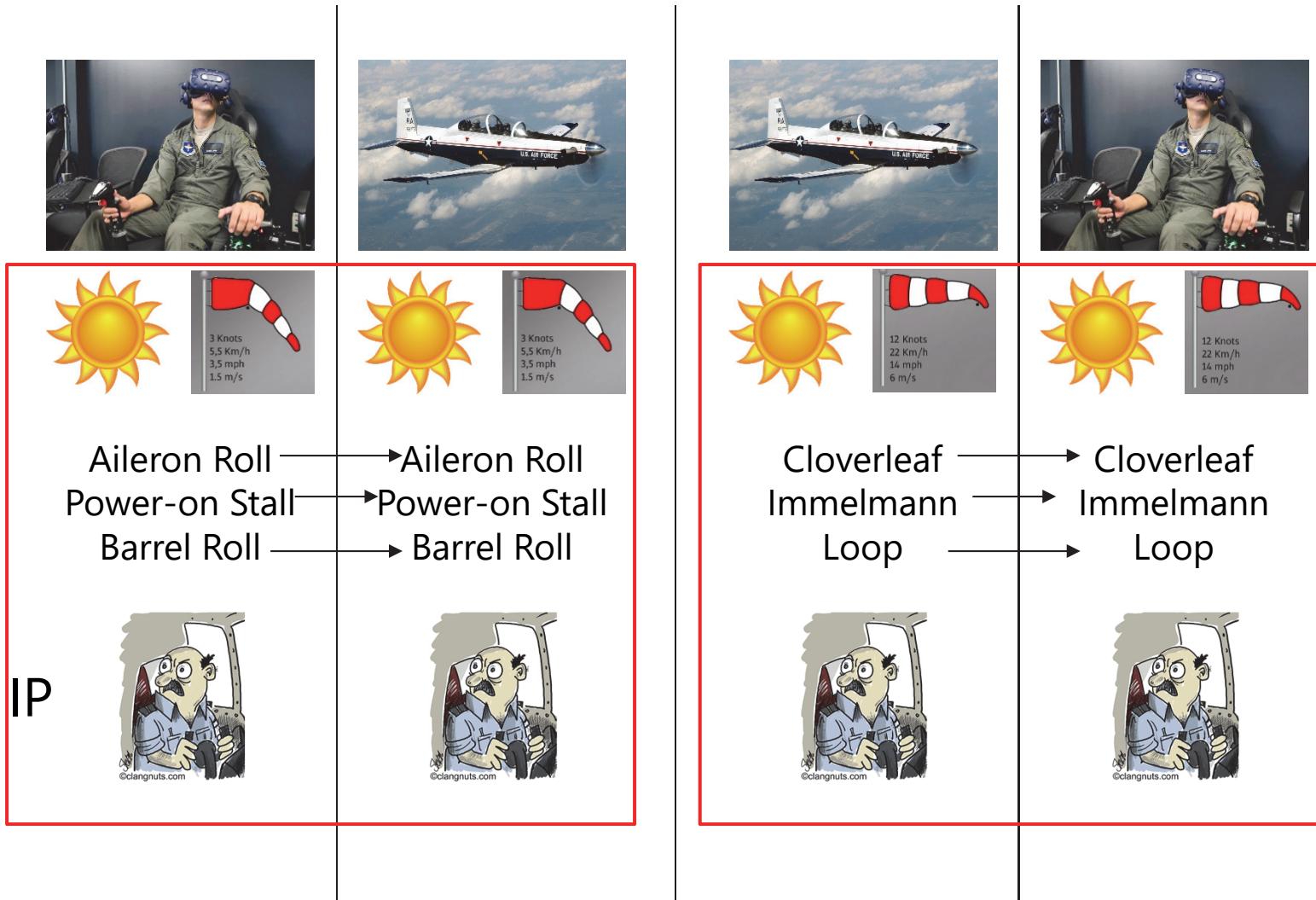
PTN graduated their first cohort in 2018

- Started with 15 traditional students
 - Pinned wings on 13 officers
- PTN accelerated and individualized the training schedule
 - Compressed traditional 28-week T-6 syllabus into 8-10 weeks
 - Students progressed at their own pace
- Good first pass, but not sufficient evidence to change the entire Air Force training infrastructure

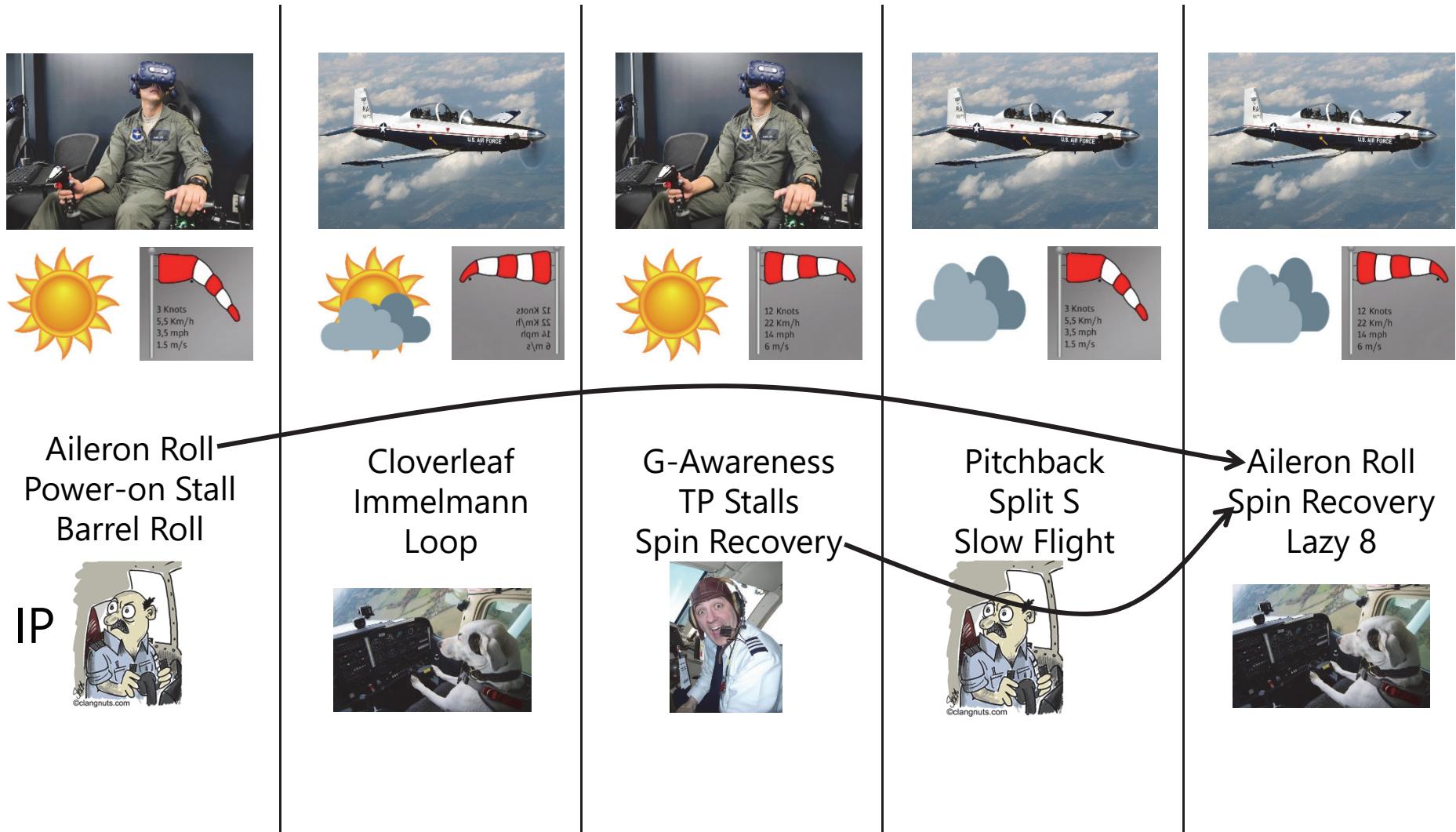
**PTN needs to demonstrate that skills
still transfer from sim to sortie even with
these new processes and technologies**

Why is this hard?

Matching conditions would allow us to easily pair simulator and flight grades for modeling



Operational realism makes skill transfer hard to model

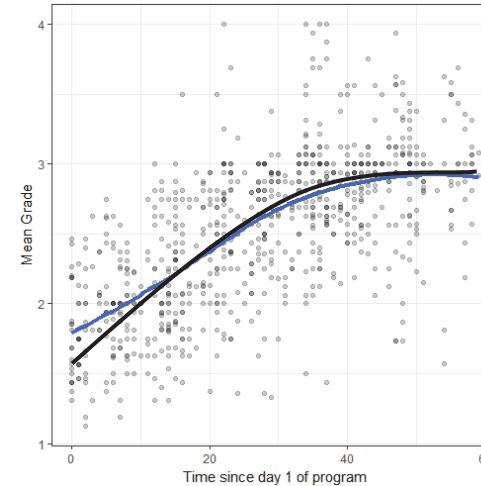
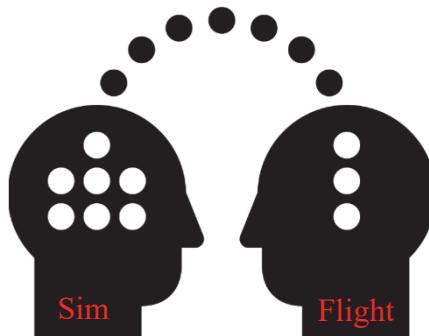


Solution:

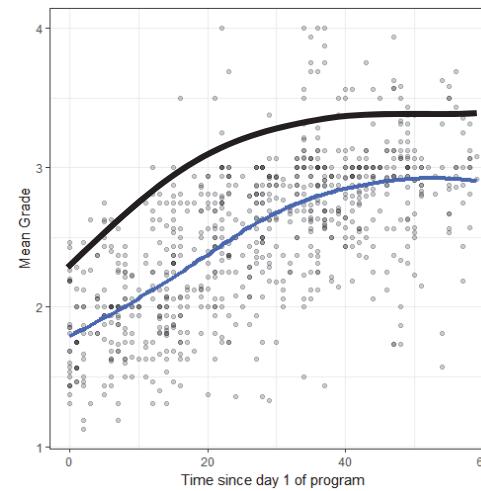
Compare general learning trajectories in the aircraft and simulator to evaluate transfer

Aligned learning trajectories suggest transfer

Skill transference

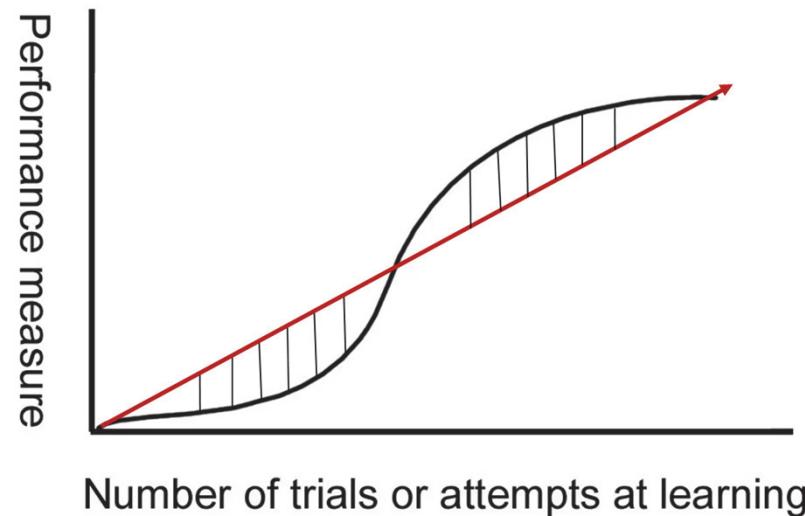


Less skill transference



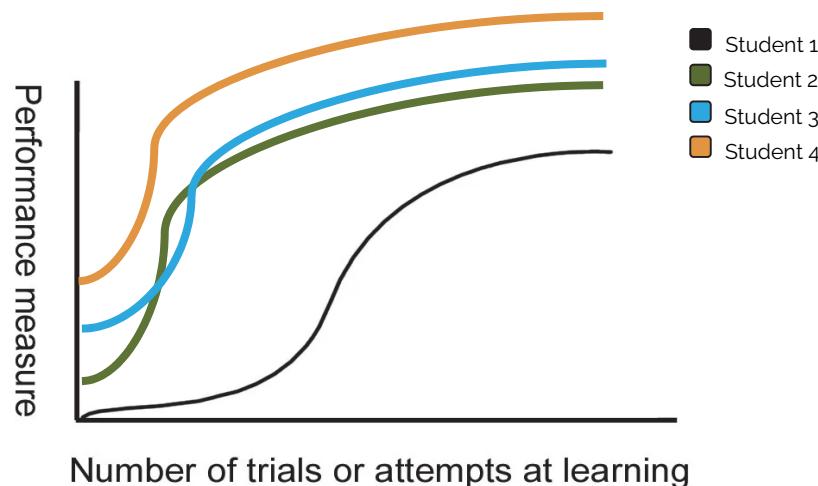
Standard models won't work for PTN data

- Standard modeling techniques assume:
 - Linear progression
 - Normally distributed residuals
 - Same starting point
 - Same progression for all
 - Data points are independent
- PTN data violate
these assumptions



Learning trajectories require special models

- Credible models of human learning must:
 - Allow people to start at different points
 - Allow people to learn at different rates
 - Account for dependencies in data
- Mixed Modeling framework is needed for human data



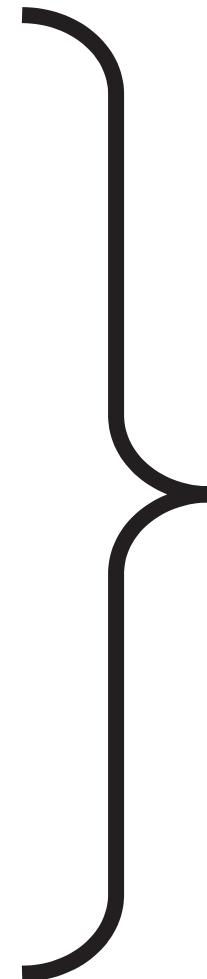
Building a Credible Model

Raw data are noisy



Why does performance vary between people?

- Practice
- Talent/Personal Factors
- Circumstances
- Judge/Grader
- Unknown unknowns

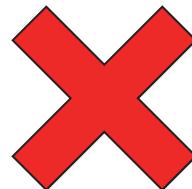


Model Goal:
Which of these
matter and
how much?

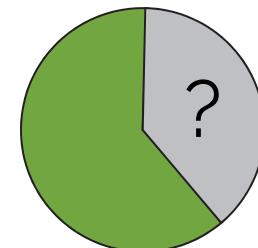
How do we measure amount of practice?

- Amount of formal training?
 - Flight hours?
 - # of maneuvers attempted?
 - # of syllabus events to date?

- Self-led practice?
 - Sim freeplay?
 - Visualization?
 - Book studying?



Days into
Training



Students graded on general and specific criteria

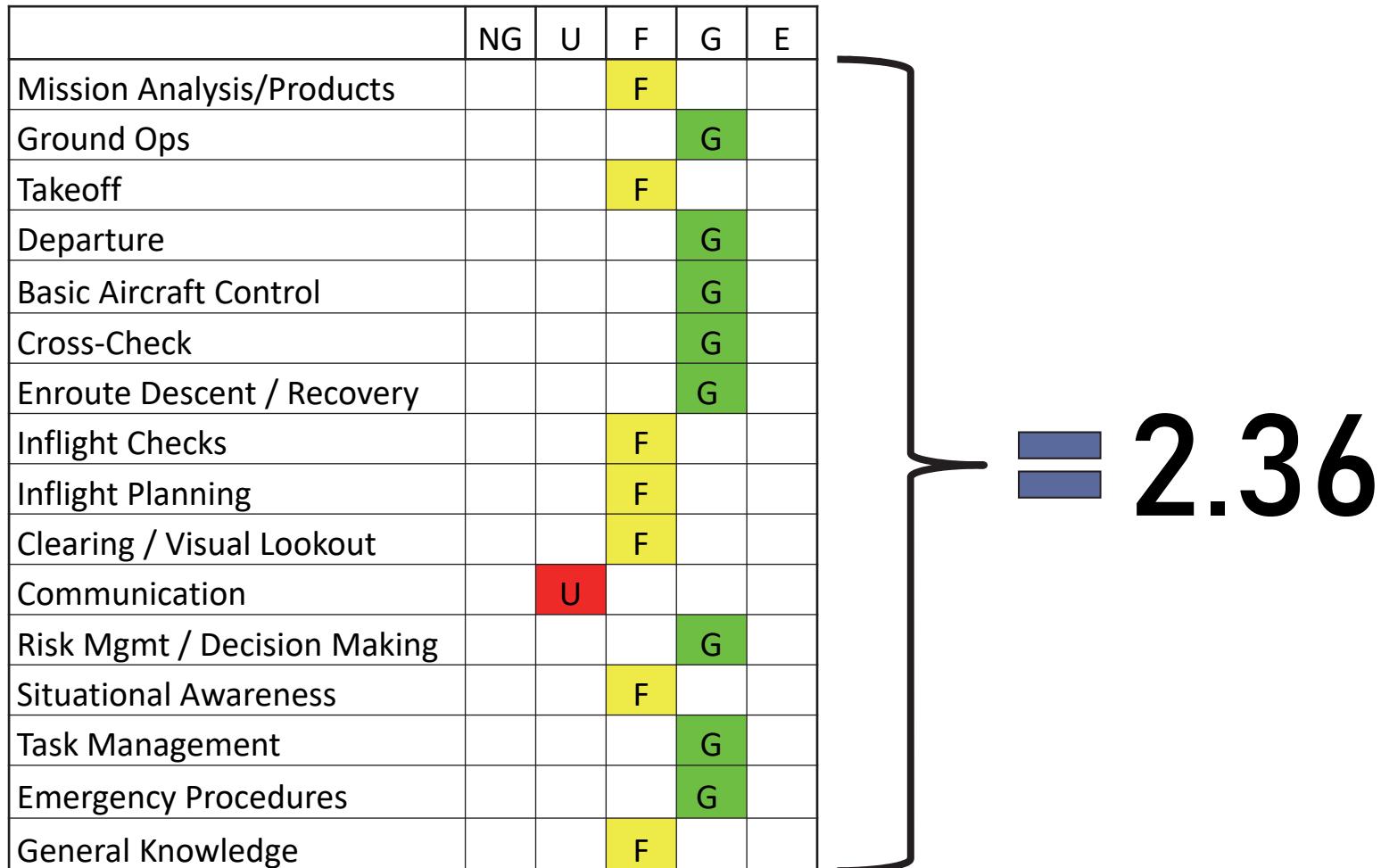
General

Mission Analysis/Products
Ground Ops
Takeoff
Departure
Basic Aircraft Control
Cross-Check
Enroute Descent / Recovery
Inflight Checks
Inflight Planning
Clearing / Visual Lookout
Communication
Risk Mgmt / Decision Making
Situational Awareness
Task Management
Emergency Procedures
General Knowledge

Specific

Wing Takeoff
Interval Takeoff
Instrument Trail
G-Warmup / Awareness
Lead Platform
Pitchout (Both)
Fingertip (Wing)
Route (Wing)
Fighting Wing (Wing)
Straight Ahead Rejoin
Turning Rejoin
Overshoot
Echelon (Wing)
Breakout (Wing)
Lost Wingman (Both)
Extended Trail (Wing)
Position Change
Formation Approach (Both)
Formation Landing (Both)
Battle Damage Check
Flt Integrity / Wingman Consideration

Defined performance as average in general category



Building learning trajectories for flights vs. sims

- Learning Trajectory Model
 - Data = all V1 T-6 syllabus events, both flights & sims

Mean General Grade =

Intercept

$\beta_{(\text{Simulator} \mid \text{Flight})}$ +

β_{Practice} +

$\beta_{\text{Practice}^2}$ +

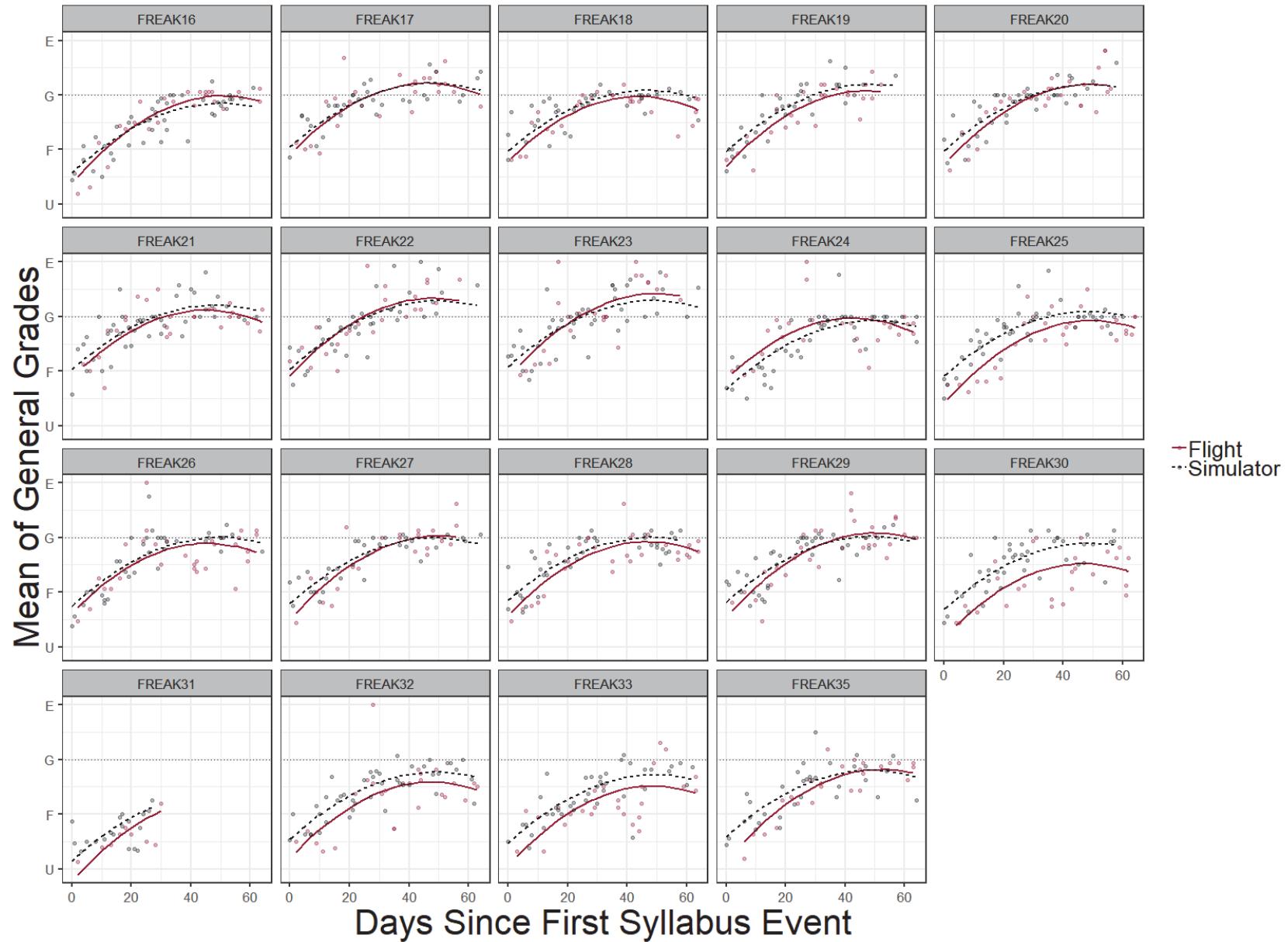
$\beta_{(\text{Practice}^2 * (\text{Simulator} \mid \text{Flight}))}$ +

$\beta_{(\text{Practice}^2 * (\text{Simulator} \mid \text{Flight}))}$ +

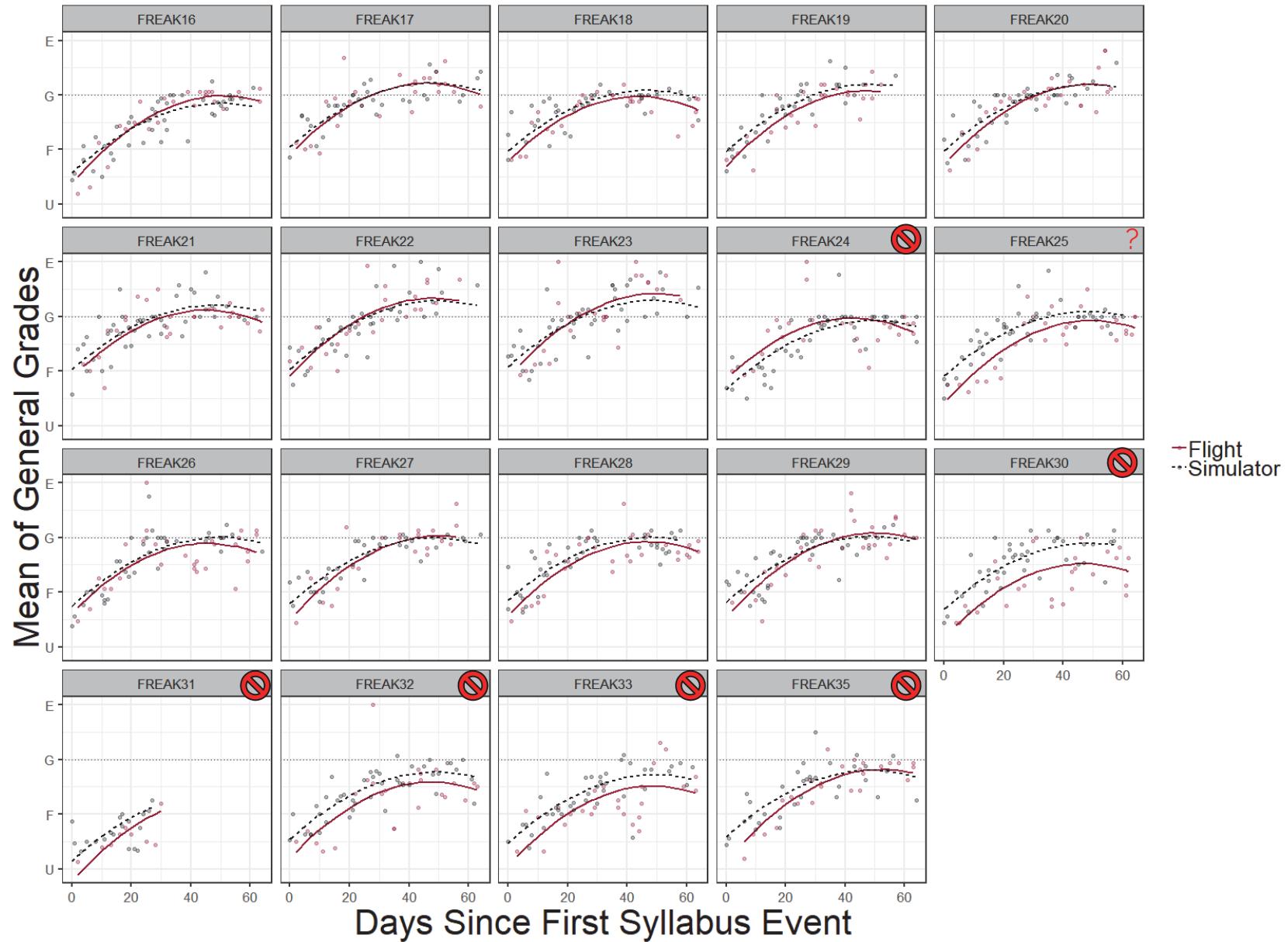
Unique Intercept for each Student in (Simulator | Flight)

Unique β_{Practice} for each Student in (Simulator | Flight)

Learning trajectories align in the T-6

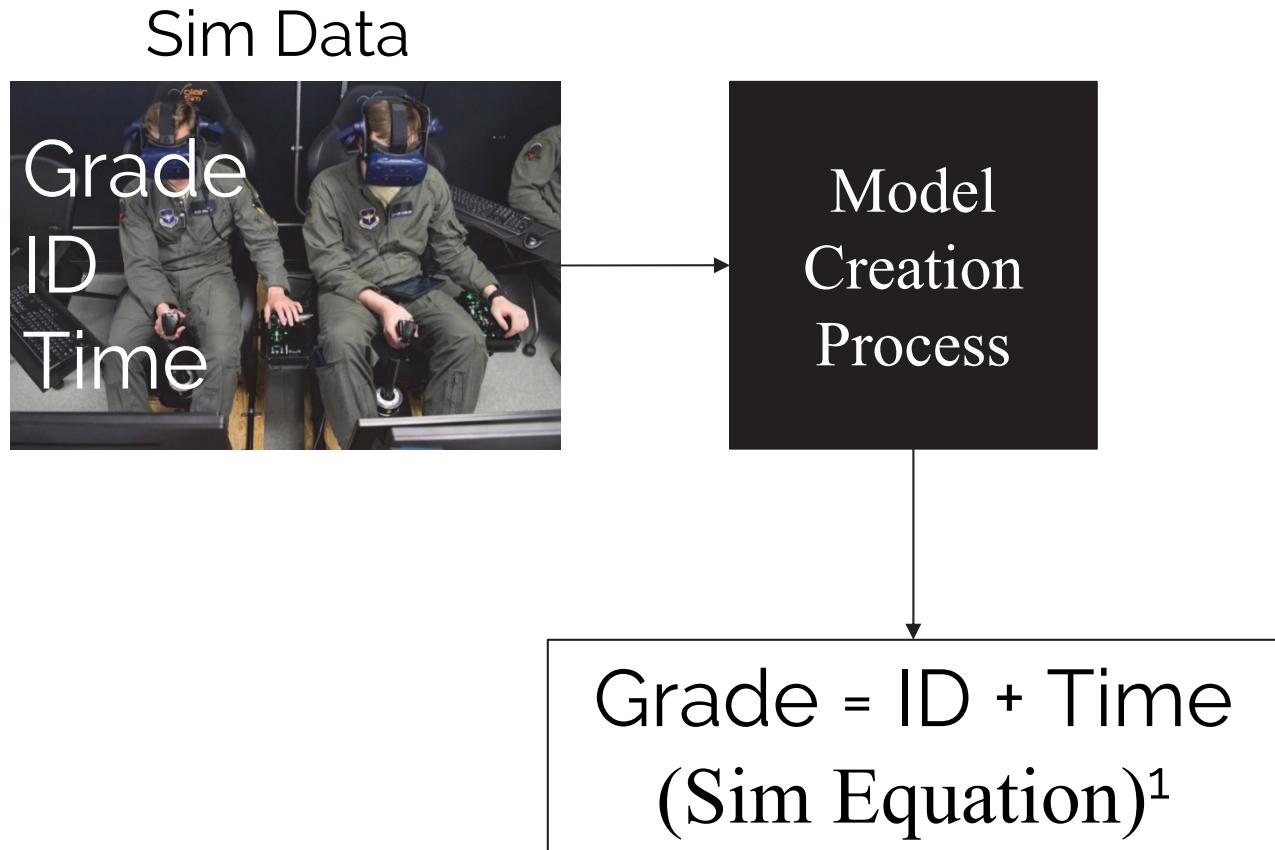


Some FREAKs' sim/flight trajectories looks different



**Learning trajectories are suggestive, but
not direct evidence of skill transfer**

Step 1: Build a model using the simulator data only



¹ Equation is simplified

Building a simulator-only learning trajectory model

- Learning Trajectory Model
 - Data = all V1 T-6 graded simulator events

Mean General Grade =

Intercept

β_{Practice} +

$\beta_{\text{Practice}^2}$ +

Unique Intercept for each Student in (Simulator | Flight)

Unique β_{Practice} for each Student in (Simulator | Flight)

Step 2: Feed flight data to the simulator-only model

Flight Data



ID

Time

$$\text{Grade} = \text{ID} + \text{Time}$$

(Sim Equation)

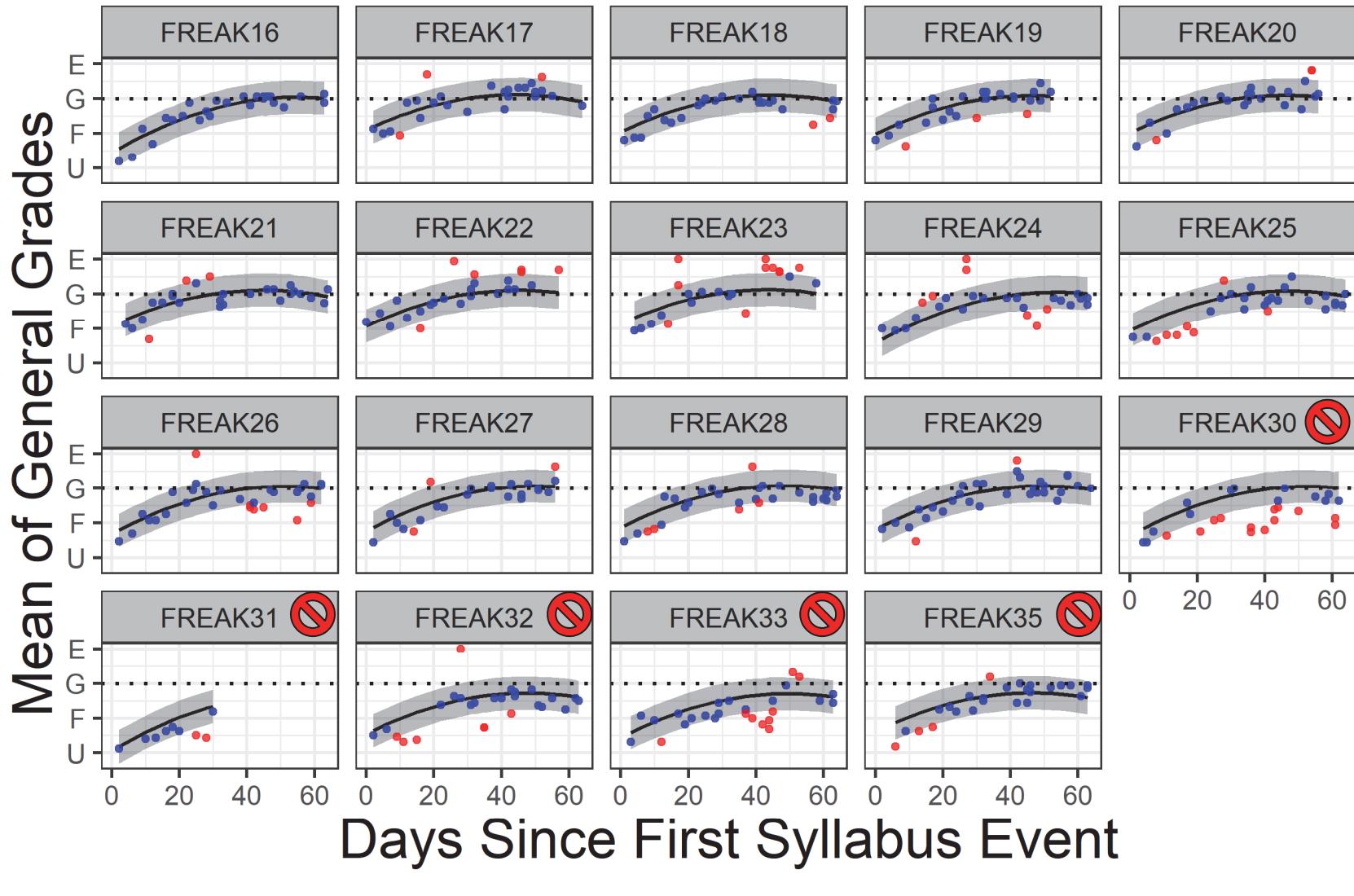
Predicted Grade

ID	Time	Real Grade	Predicted Grade
FREAK16	24	3.36	3.16

If the sim model predicts flight grades well, we have much stronger evidence of skill transfer

Also provides insights into potential points of intervention

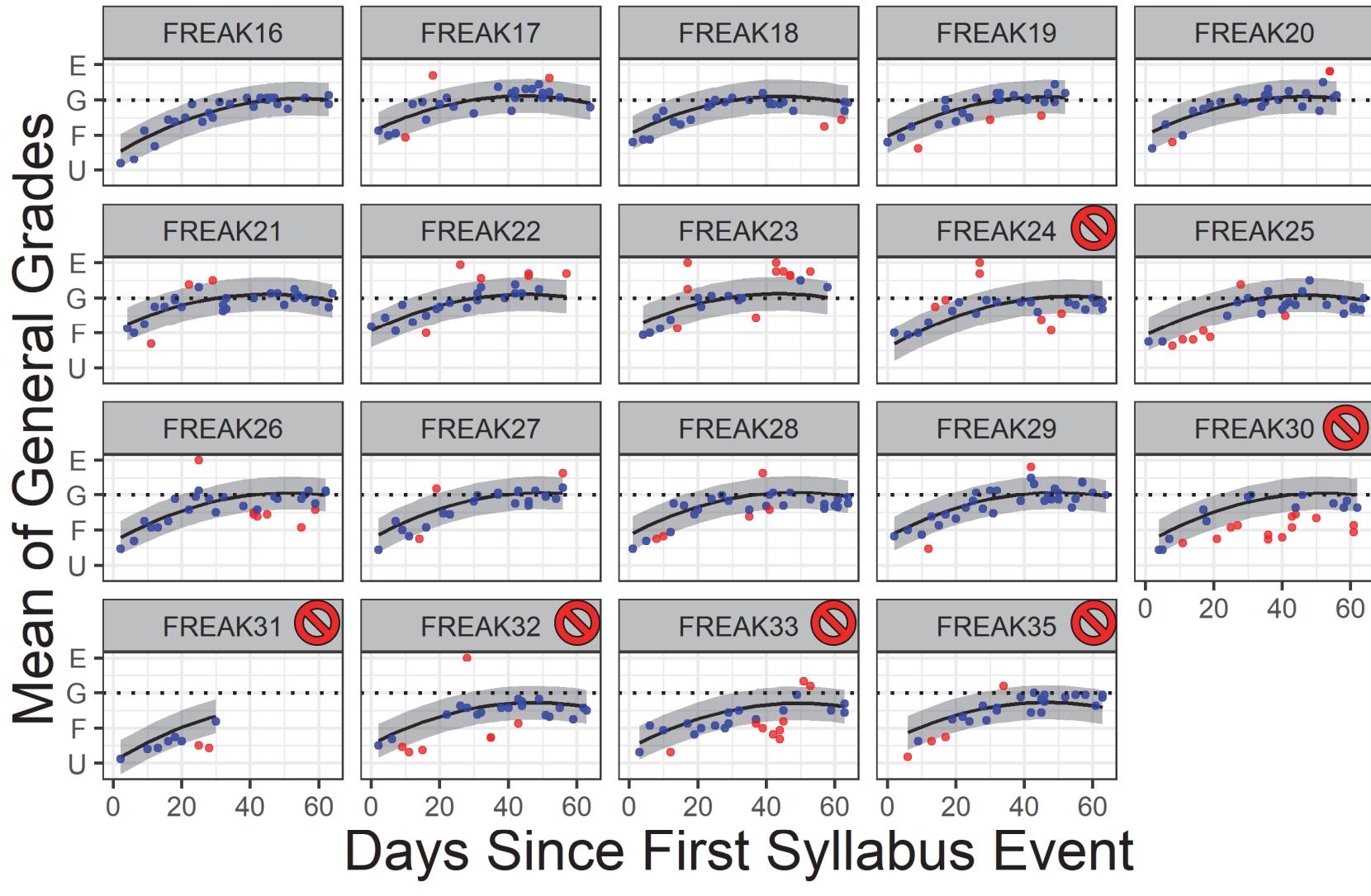
Sim model fits flight data well for students who pass



- Outside 90% PI
- Within 90% PI

Did not reach
MAF/CAF

Model error is twice* as high for failing students



Did not reach
MAF/CAF

$${}^*t(136.4) = -3.15, p = .002$$

PTN has provided evidence that changing processes to incorporate new technology has enabled learning transfer from the simulator to the aircraft

**Analysts can use modeled learning
trajectories to evaluate skill transfer in
unstructured learning environments**

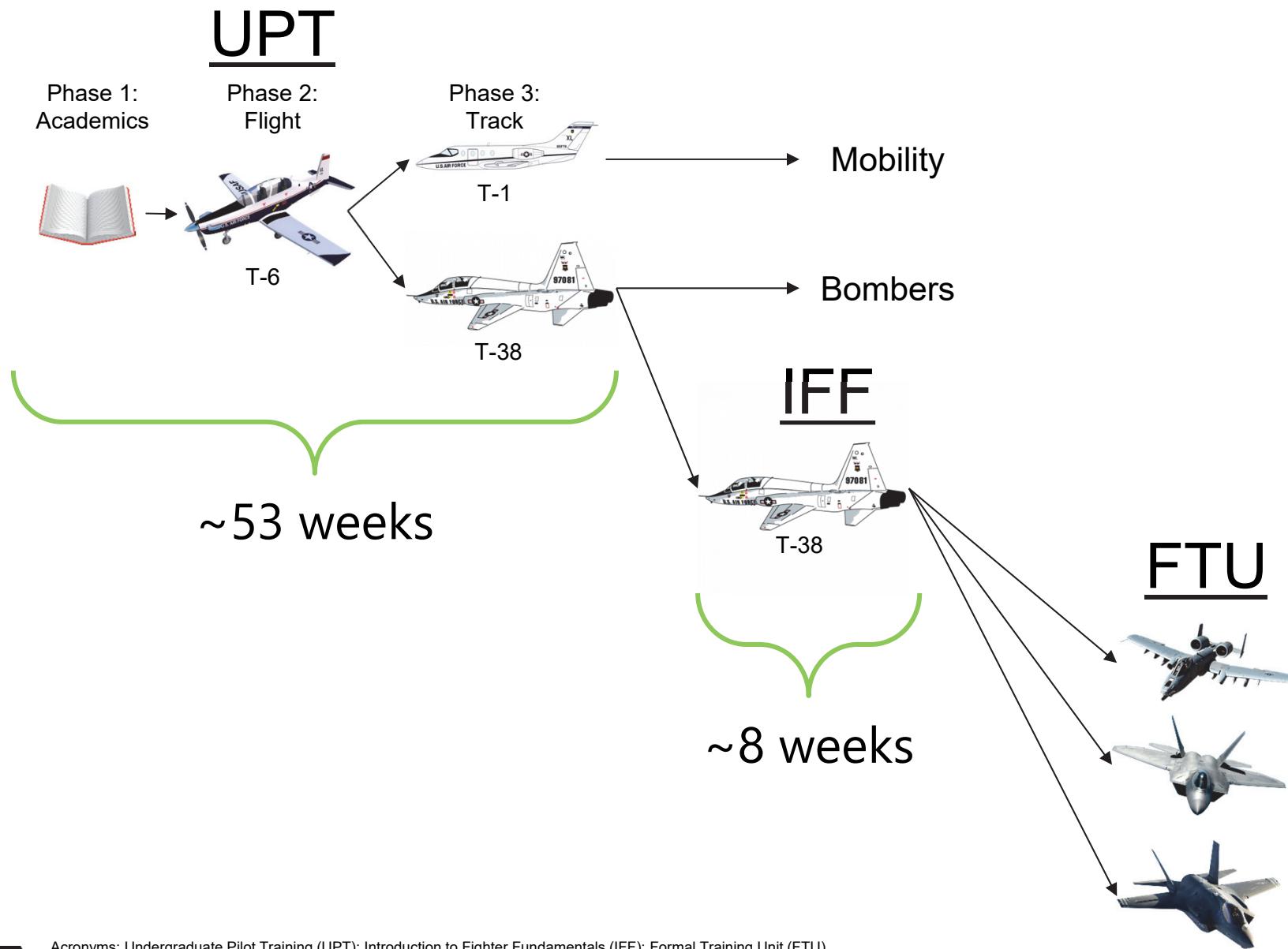
Lessons for other programs

- As we leverage sims more and more, it is increasingly important to evaluate how well they enable skill transfer
 - Bad sims hide their acquisition cost in training
- To measure skill transfer, we need an outcome we can track over time equivalently between sim and reality
 - In PTN, this was grades
- Missing data or meta-data can kill this evaluation
 - High-quality data collection is more important than ever

Thank You

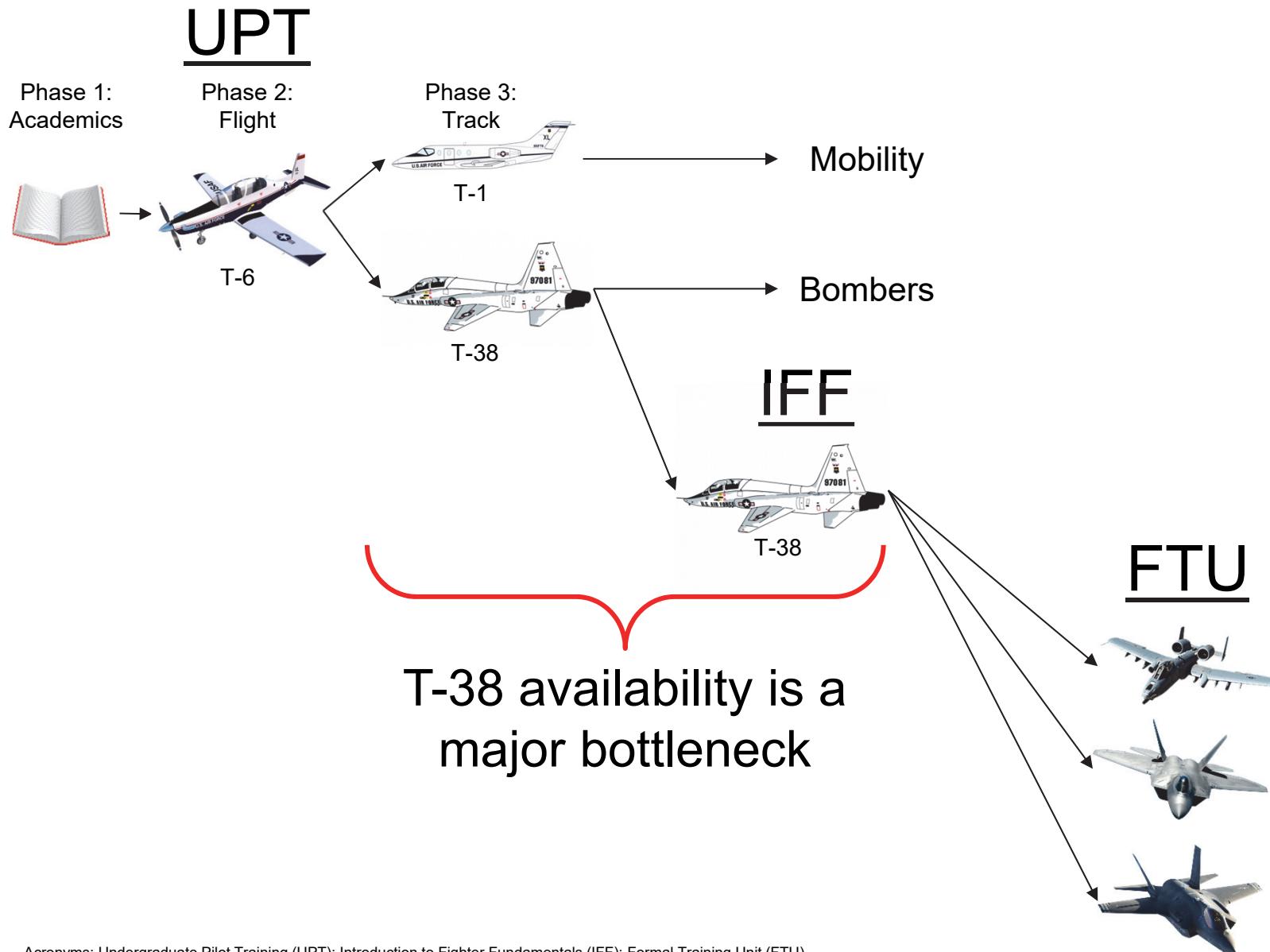
Backups

Air Force pipeline gets increasingly specialized



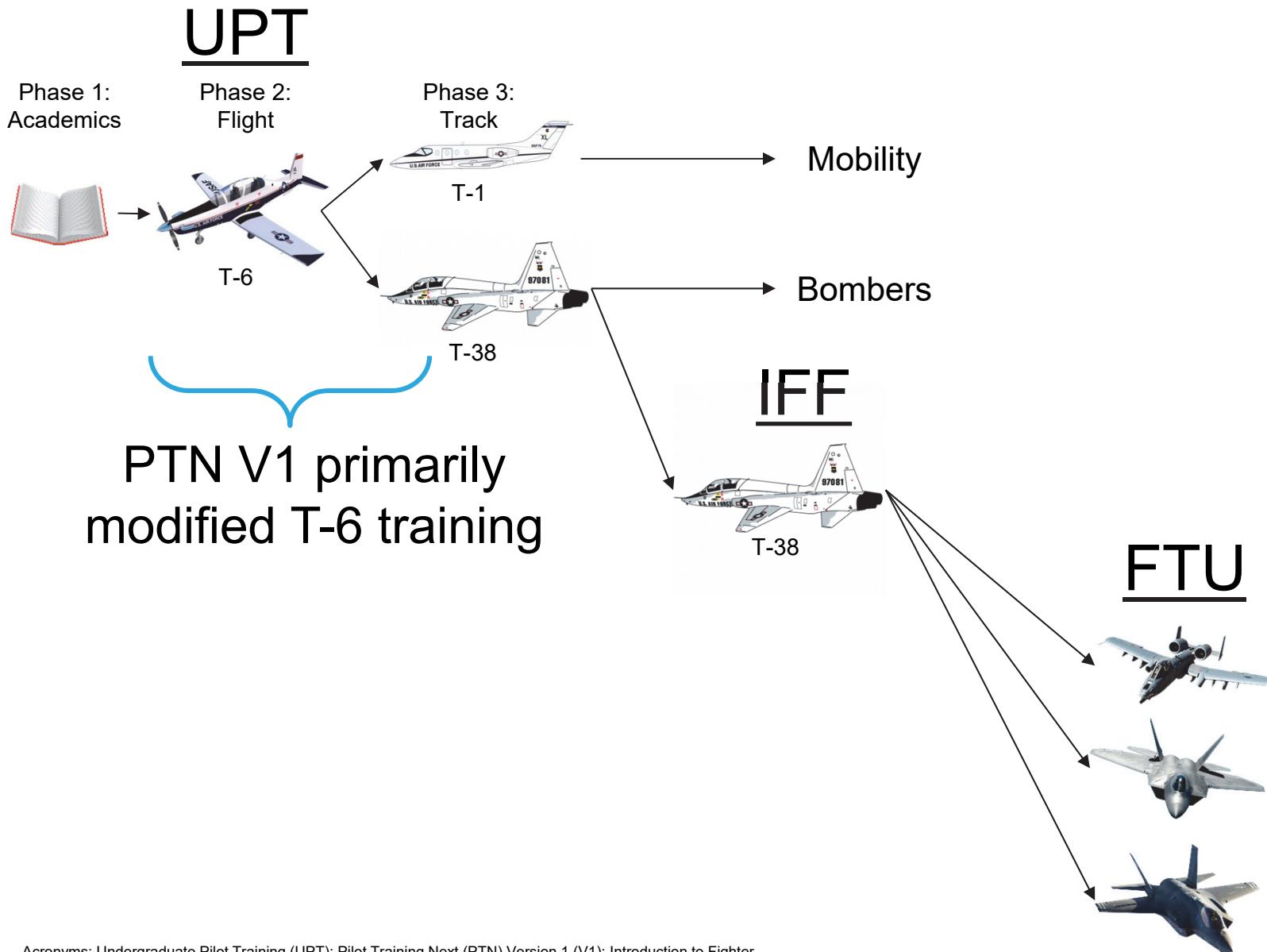
Acronyms: Undergraduate Pilot Training (UPT); Introduction to Fighter Fundamentals (IFF); Formal Training Unit (FTU)

Air Force pipeline gets increasingly specialized



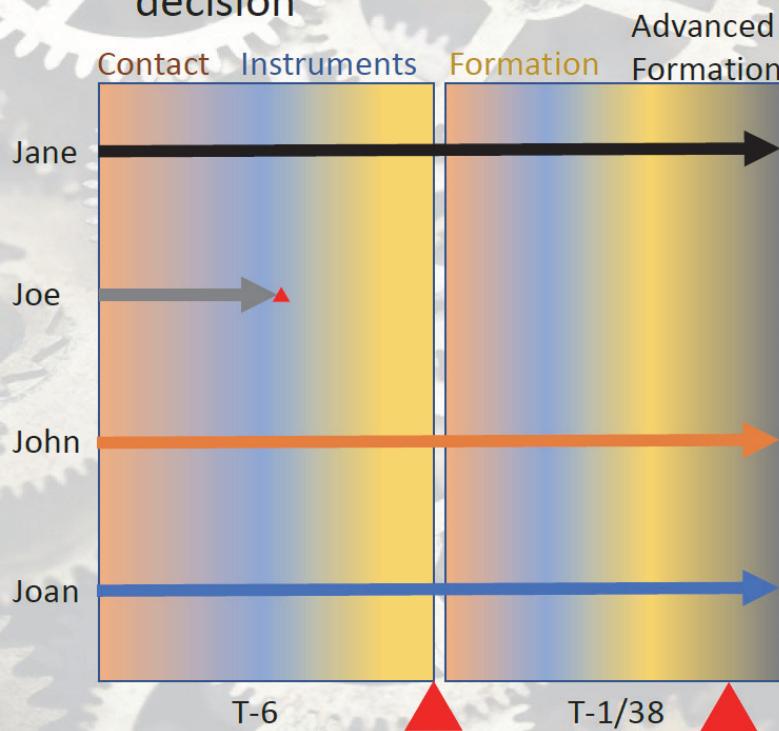
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PTN started with a manageable portion of the pipeline



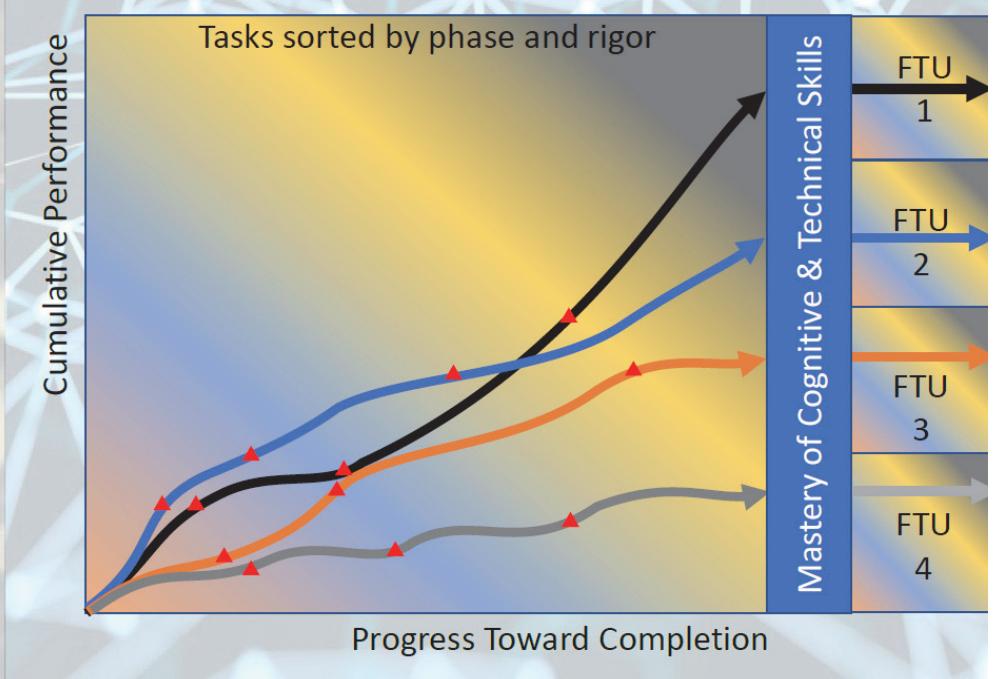
Industrial Age Model

- Linear progression
- Sortie-centric
- Standardized
- Accumulates subjective data for decision



Information Age Model

- Emergent progression
- Task & Aptitude-centric
- Individualized
- Continual decisions based on accumulated objective data



PTN V1 students learn through a variety of methods

Academics

Instruction



Self-Study



Formal Events

Graded Sorties



Graded Sims



Free Play

Unsupervised



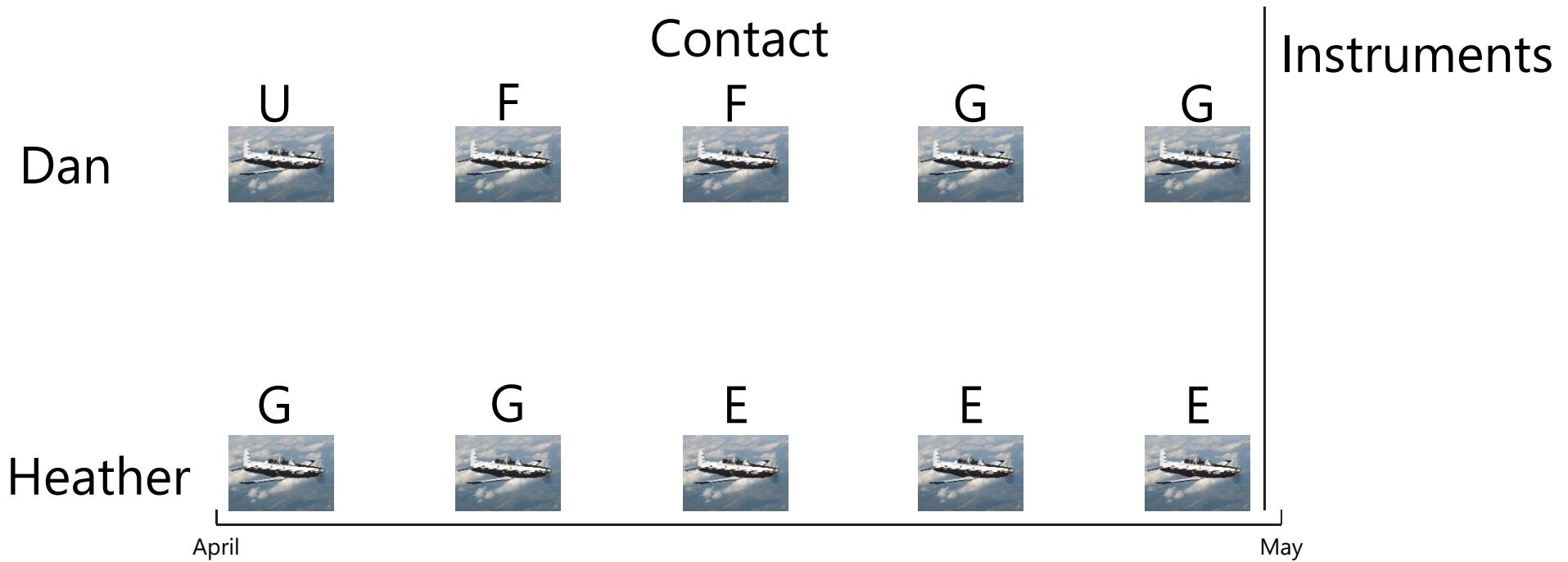
"AI" Instructor



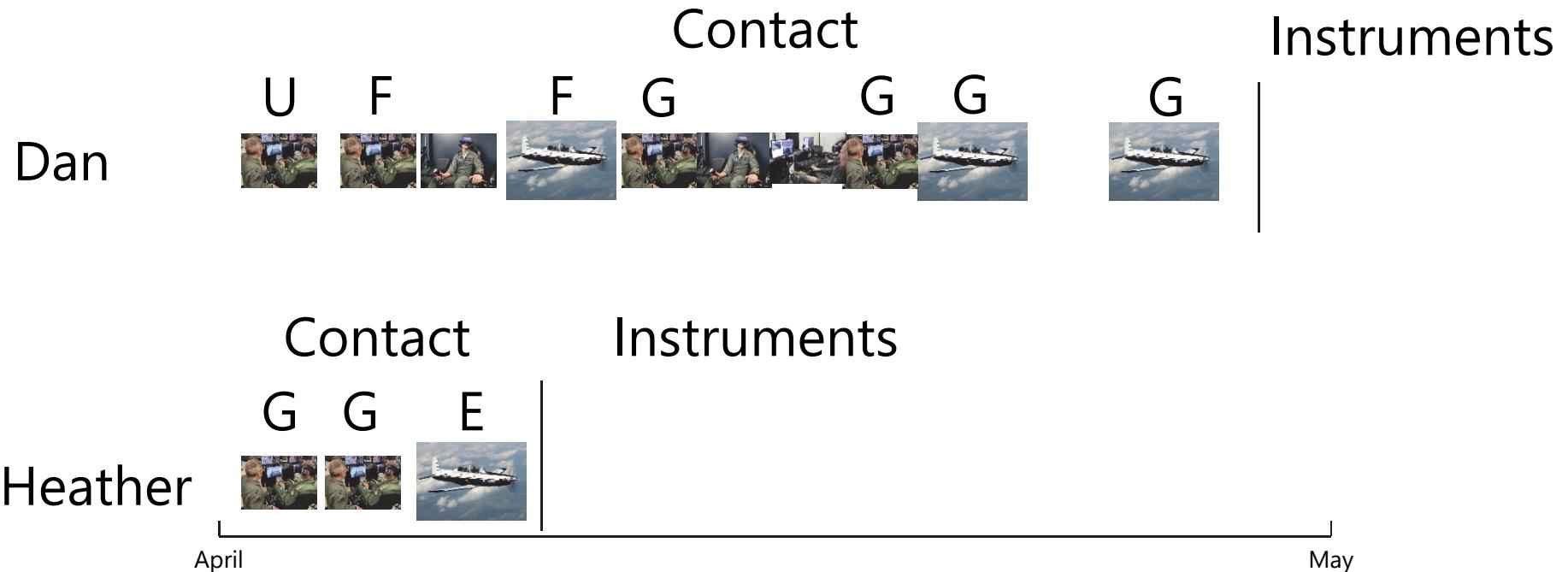
Human IP



The traditional models locks progression together



PTN advances students when they demonstrate proficiency



Building learning trajectories for flights vs. sims

- Learning Trajectory Model
 - Data = all V1 syllabus events, both flights & sims

Mean General Grade =

Intercept

$\beta_{(\text{Simulator} \mid \text{Flight})}$ +

β_{Practice} +

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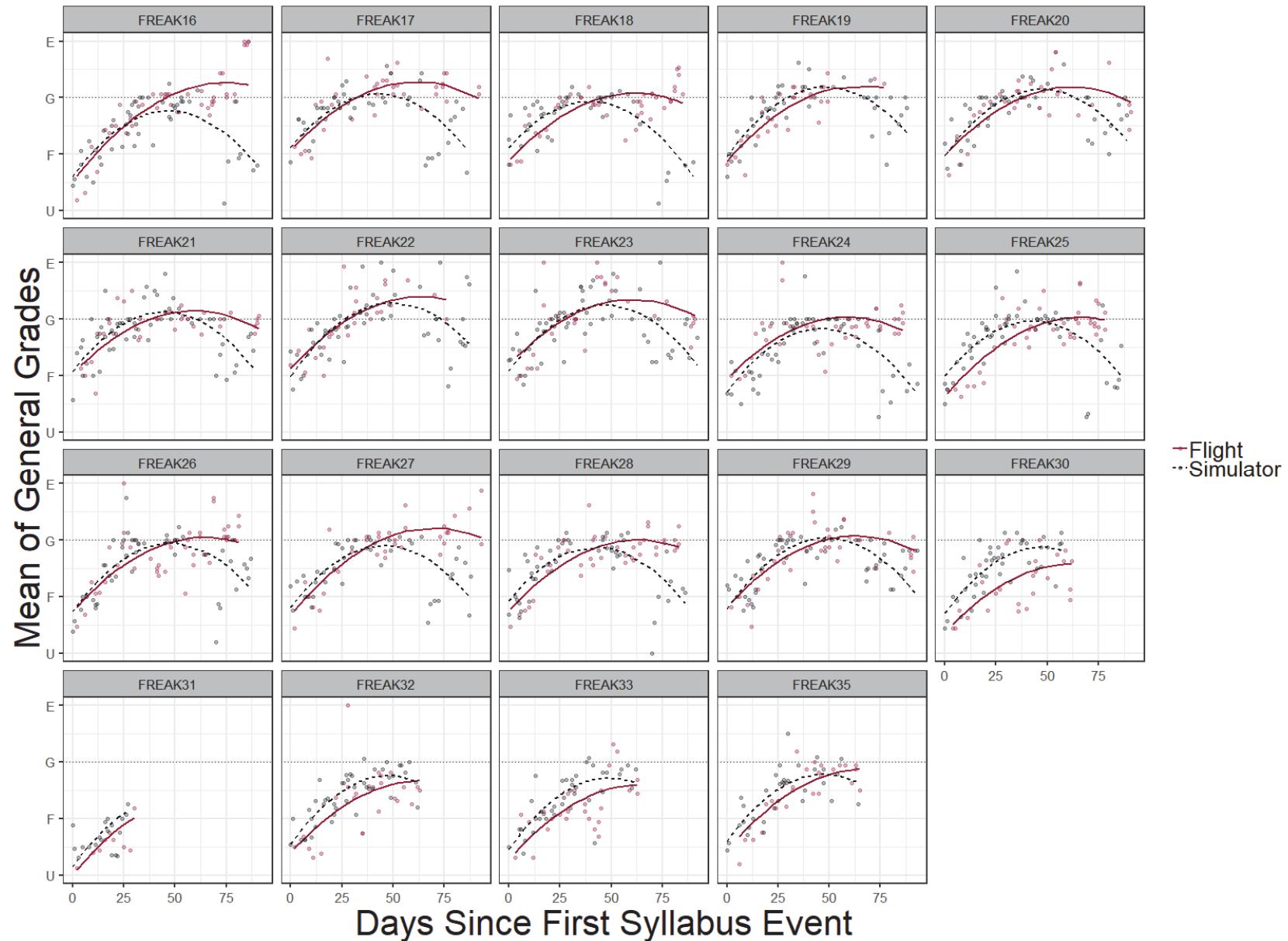
$\beta_{(\text{Practice}^*(\text{Simulator} \mid \text{Flight}))}$ +

$\beta_{(\text{Practice}^2 * (\text{Simulator} \mid \text{Flight}))}$ +

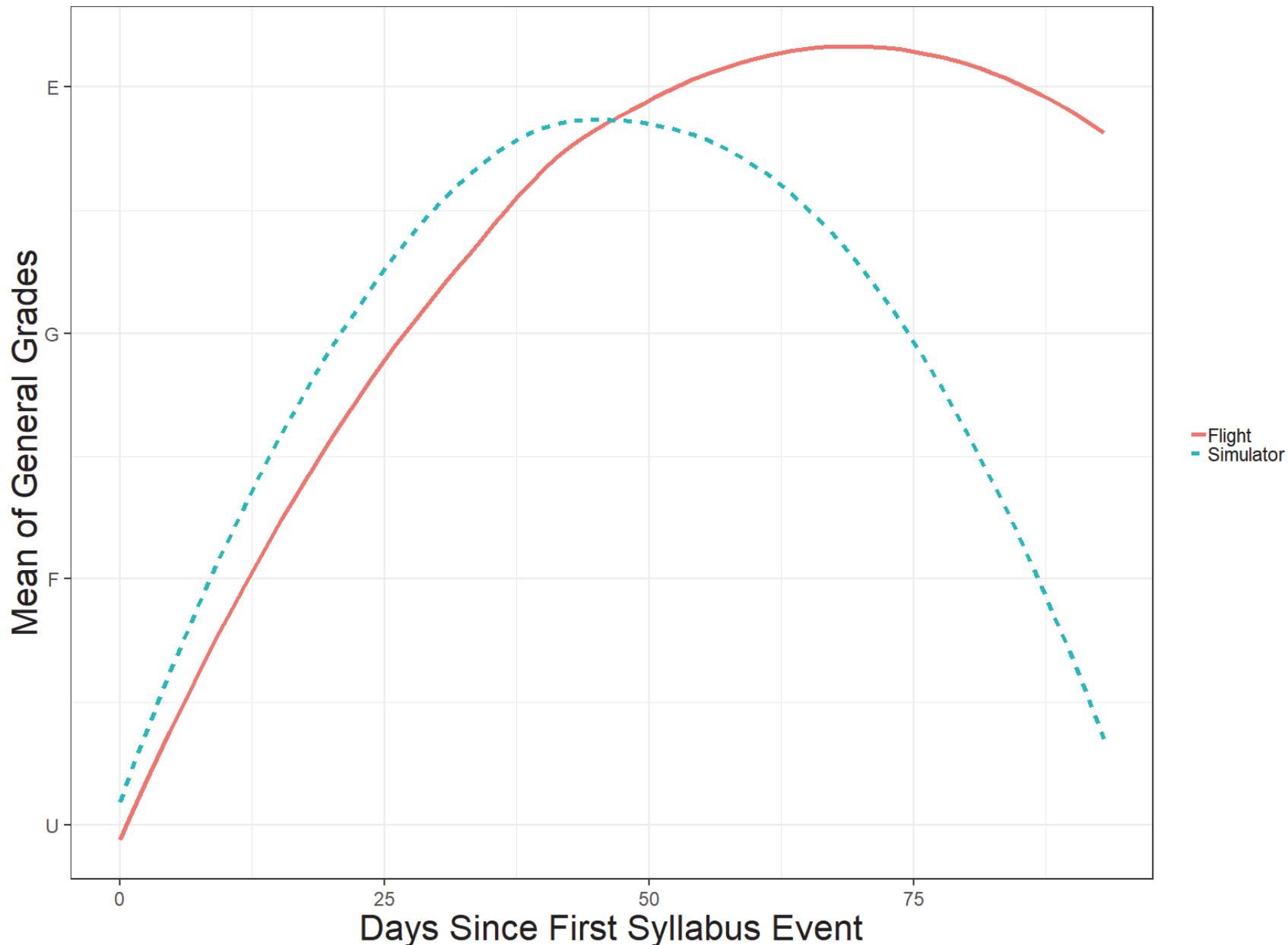
Unique Intercept for each Student in (Simulator | Flight)

Unique β_{Practice} for each Student in (Simulator | Flight)

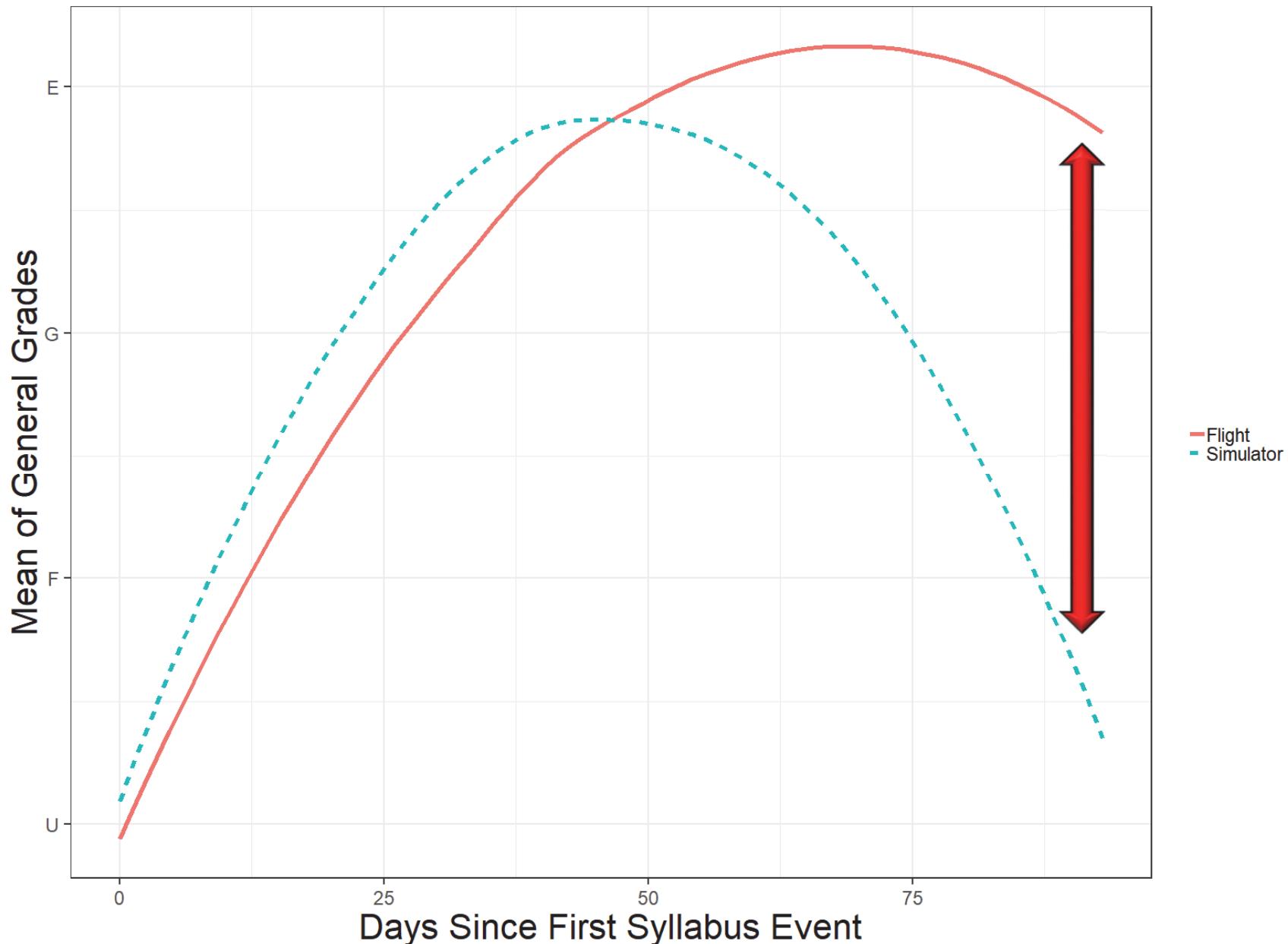
Learning trajectories look different for flights and sims



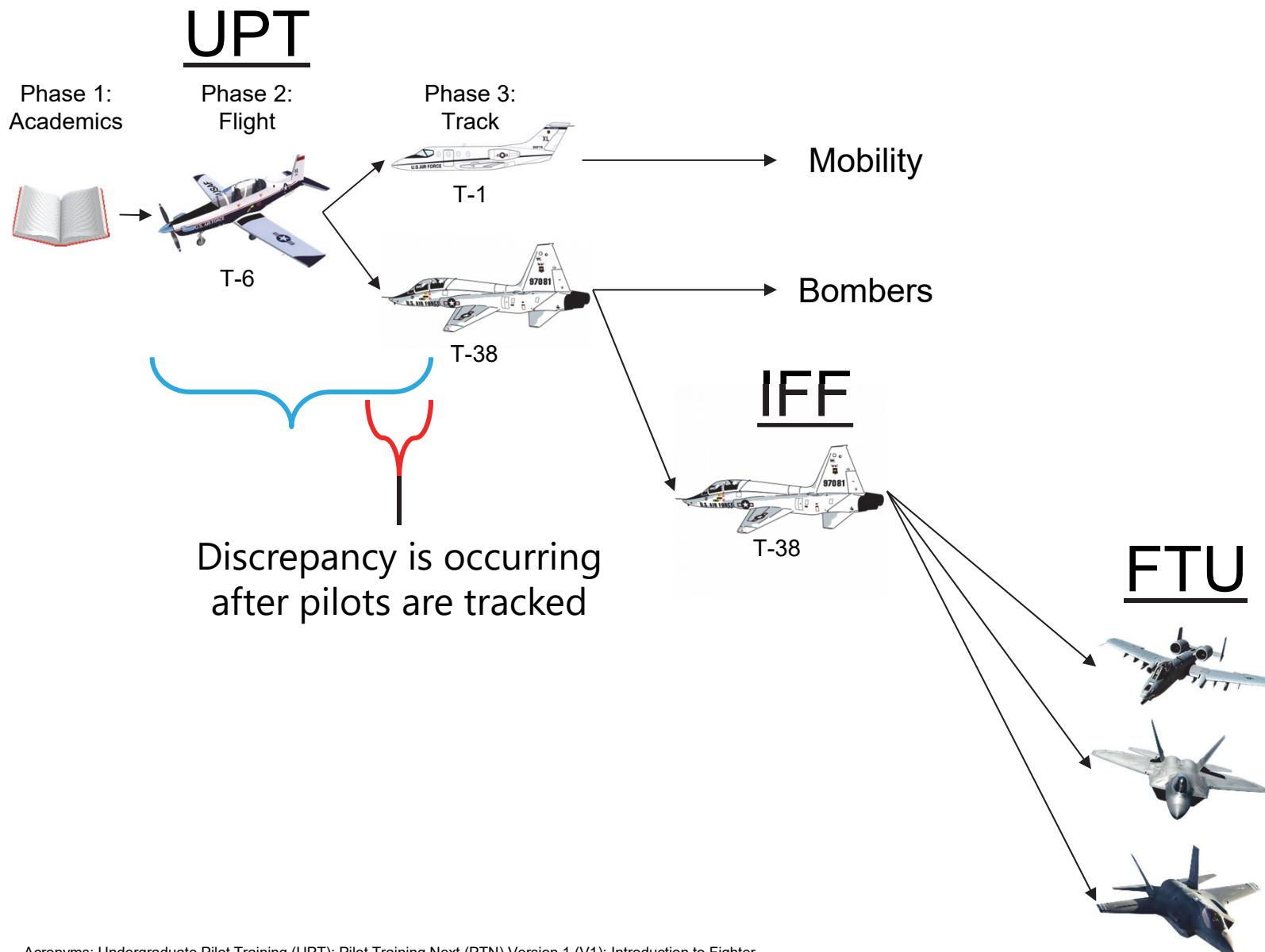
Trajectories parallel for a period



Discrepancy occurring at the end



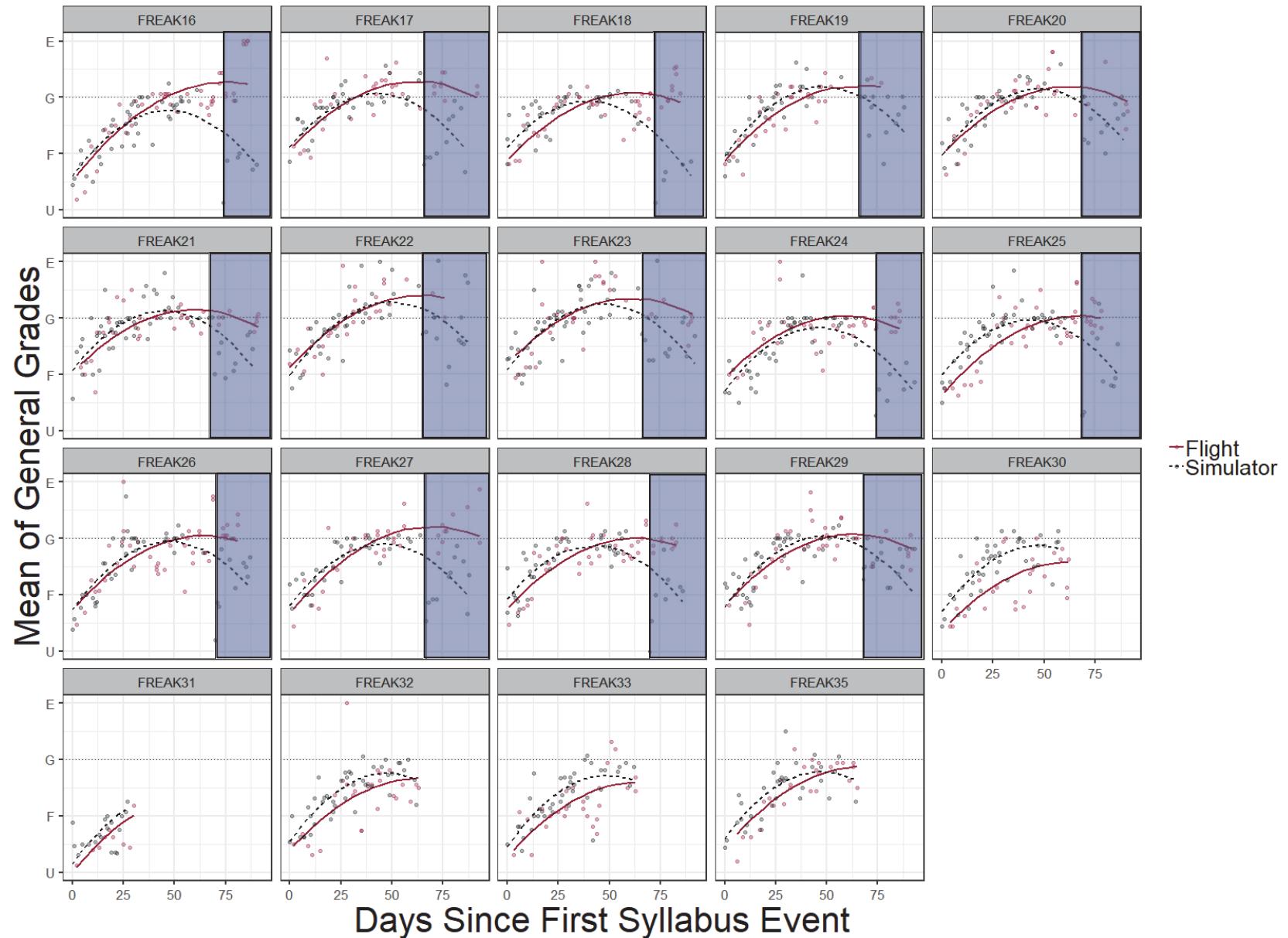
PTN started sims for new aircraft before V1 ended



MAF/CAF may not be achieving transfer

But what about the T-6 syllabus alone?

Starting MAF/CAF Intro hurts sims but not flights



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15. SUBJECT TERMS Air Force; Pilot Training Next (PTN); Simulators; Pilot Training; Linear Mixed Models					
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