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OMB No. 0704-0188*

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1. REPORT DATE (DD-MM-YYYY)		2. REPORT TYPE		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code)

Flight and Maintenance Scheduling Optimization for Military Aircraft

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June 2021

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+ Many more



Source: AF.mil

MITRE

**SOLVING PROBLEMS
FOR A SAFER WORLD™**

Talk Outline

- Problem overview and motivation
- Subject matter background
- Sample (fictional) scheduling output
- Integer programming overview
- Light re-optimization mode

Problem Overview

- The U.S. Air Force must regularly schedule maintenance and tail-to-mission assignments
- Very complex problem:
 - Must fly every flight on the schedule
 - Maintenance is a function of how often aircraft are flown
 - Different flights require different aircraft configurations
 - Many types of maintenance
 - Maintenance capacity constraints
 - Must spread out major maintenance over the year
 - Many details determine whether a schedule is feasible or more desirable

Not Just a Math Problem

- We are planning a **decision support system**
 - Need to anticipate how constraints and considerations differ with the user group
 - Need failure modes; cannot just say “infeasible”
 - Must think about user interactions, visualizations
 - Must think about **selective re-optimization**
 - What if the user wants to re-optimize an approved schedule without needlessly changing prior decisions?

Main contributions qua research:

- Even more complex version of the flight and maintenance scheduling problem
- Thinking about how this model could power a decision support system

- Many researchers have written great papers on Flight and Maintenance Scheduling, e.g.:

- Marlow and Dell 2017
- Peschiera et al 2020
- Cho 2011
- Hahn and Newman 2008
- Kozanidis et al 2012
- Verhoeff et al 2015

- Several considerations in our work that is not in most others:

- Aircraft configuration considerations
- Phase flow staircase w/ “leapfrogging” options
- “Checkerboarding” requirements
- Deployment assignments
- Maintenance station constraints
- Many maintenance job types
- Many secondary and tertiary objective criteria
- Pre-flight check requirements
- Weapons load training assignments

Delimitation: Crawling Before Walking and Running

- Start with monthly scheduling
 - Yearly, quarterly, weekly, daily can come later
- Two types of optimization modes:
 - New schedule creation
 - ***Light re-optimization***—optimally adapting an existing schedule to meet new requirements

Subject Matter Background: Flying Requirements

- All flights must have an assigned tail
 - Turn pattern
 - Mix of mission types
- Each day specifies a
 - Turn pattern
 - Mix of mission types
- Flying “12 turn 10” means
 - 10 aircraft fly twice
 - 2 aircraft fly once
 - 2 aircraft should be ready-to-fly as spares
- Specific flights also require specific aircraft configurations
- Aircraft need a 72-hour pre-flight check to fly
- Some wings prefer to “checkerboard” flights to avoid having to fly one aircraft on back-to-back days



Source: AF.mil



Source: Wikimedia Commons

Subject Matter Background: Aircraft Configurations

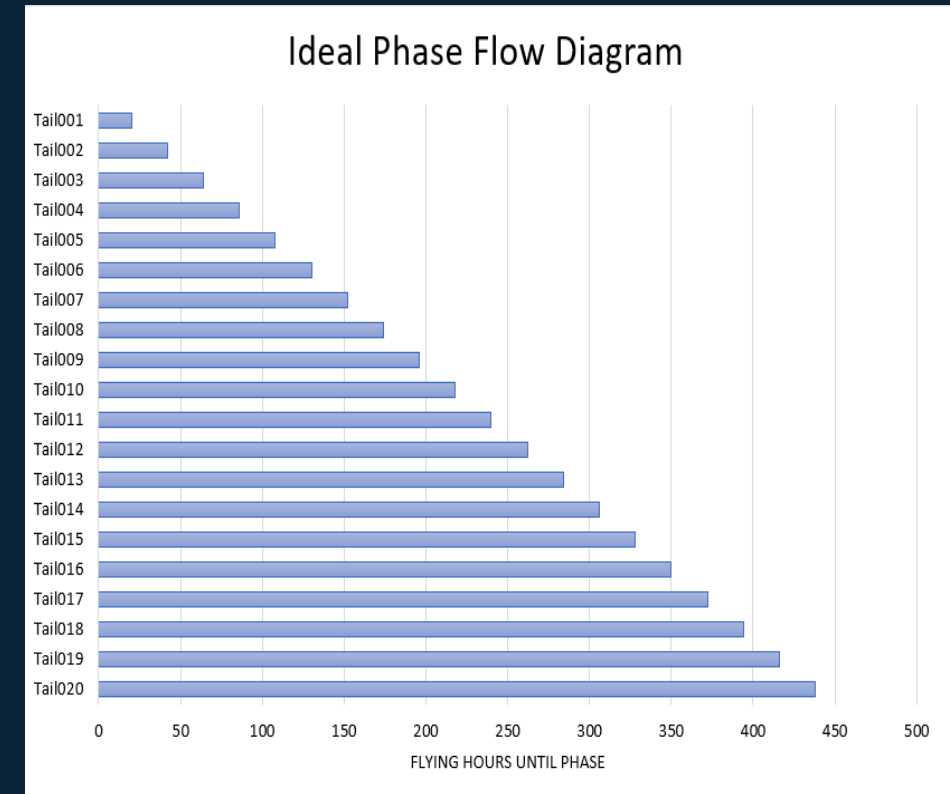
- Aircraft configuration := permutation of weapons, fuel tankers and sensors on an aircraft
- Flights require an allowing configuration
- Maintenance may forbid certain configurations
- Limited configuration resources (e.g., sensors)
 - Restricts the number of aircraft that can be in a certain configuration at any time



Source: Wikimedia Commons

Subject Matter Background: Phase Flow

- Aircraft undergo major phased maintenance every X flying hours
 - Could take many days to complete
- Operational schedulers prefer to maintain a relatively uniform phase flow staircase
- Suggests another set of constraints
 - Don't sacrifice long-term flow for short-term gains



Showing how far each aircraft is from major phased mx

- Having a perfect phase flow is not an end in itself but one of many considerations when managing a fleet

Subject Matter Background: Maintenance Limitations

- Rule-of-thumb planning:
 - At most X aircraft in maintenance per day
 - At most Y maintenance jobs per day
 - At most 1 aircraft per maintenance station
 - Maintenance stations are unavailable on certain days

- Maintenance stations:

Hangar Spaces

Fuel Barn

Wash Rack

Weight &
Balancing
Station

Paint Barn

Corrosion Check
Station

...

Subject Matter Background: Additional Factors

- **Regular use**—aircraft should be flown regularly
- **Scheduling time windows**—maintenance must be performed within certain time windows
 - could be calendar-based or flying-hour-based
- **Phase hour consumption**—don't throw away flying hours before major phase maintenance!
- **Pre-scheduled activity**—aircraft sometimes must go off-base for pre-scheduled activity such as depot maintenance, deployments, etc.
- **Weapons load training**—each wing typically uses at least one aircraft for weapons load training each week



Source: Wikimedia Commons

Sample Output

- Test Case: Two squadrons flying two missions per day
- Many pre-scheduled activity

	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	Total:							
	1-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	11-Apr	12-Apr	13-Apr	14-Apr	15-Apr	16-Apr	17-Apr	18-Apr	19-Apr	20-Apr	21-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr								
tail001	F	wash				corro		F					F	F																	5							
tail002		WLT					F		F							F				F	F		SP				F		F		7							
tail003		F					F*		F				F	F			F										F		SP		7							
tail004		F					SP			SP					F		PDMPREP				depot														2			
tail005	avionics						wash	corro						SP			F				F		F									3						
tail006	depot												PDMACPT														avionics											0
tail007													depot																				0					
tail008											deploy												F	TCI									SP		F		2	
tail009							F*		F					F			SP			SP	F	F							F		SP	6						
tail010	TCTO1+2					TCTOBU								F						WLT								F		F		3						
tail011																				depot													0					
tail012											deploy																							SP		F	1	
tail013																					SP		F					WLT				1						
tail014																						SP		F			F		wash	corro	2							
tail015	SP	SP					F		SP					SP							F										2							
tail016																				TCTO3													0					
tail017						F		F		F			F								TCTO1+2												4					
tail018											deploy																							F			1	
tail019		F				SP		F		F			F		F					wash		corro							F		F	8						
tail020	F						F		F				wash	corro						F		SP									4							
tail021	TCI	F*					F		F		F			F						TCI								F		F	7							
tail022																				loan													0					
tail023	phase								SP		F			WLT									F		F							3						
tail024	F					F														phase																		2
tail025																						F		wash				corro			1							
tail026	F					WLT						SP		F						F		F						wpns		F	5							
tail027																				depot													0					
Total:	4	4	0	0	0	4	4	4	4	4	0	0	4	4	4	0	4	0	0	4	4	4	4	0	0	0	4	4	4	4	4							

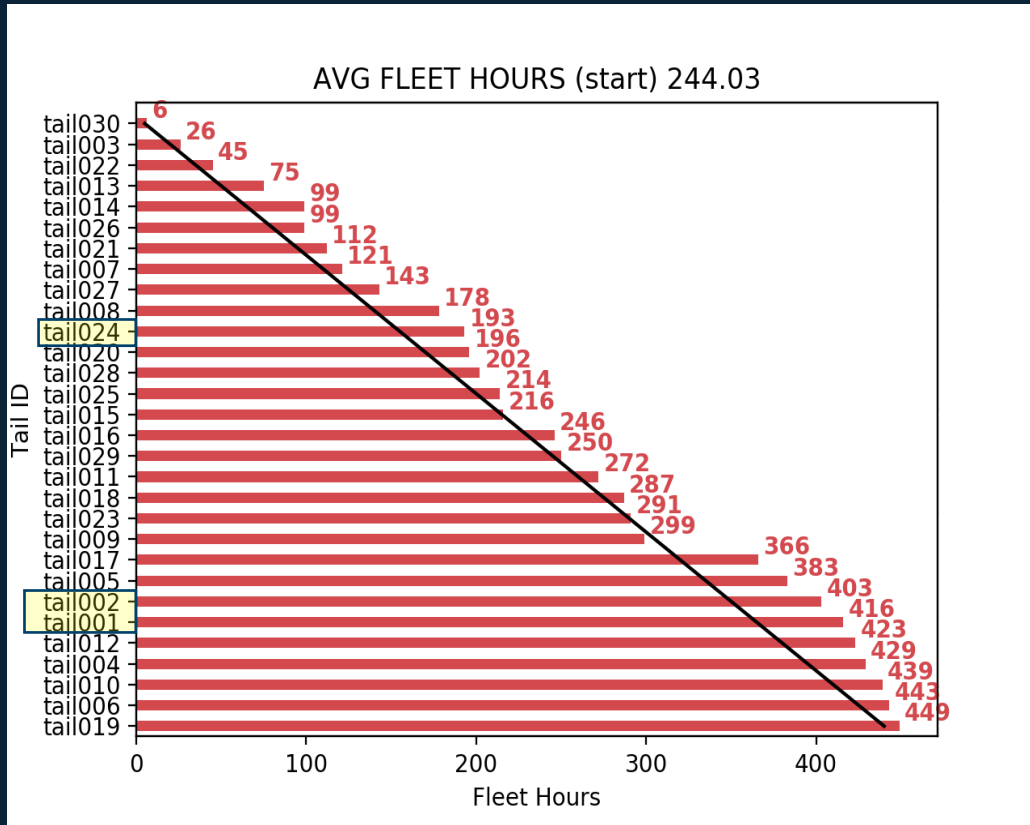
Sample Output

- One squadron flying 20+ missions per day
- Schedule generated in seconds

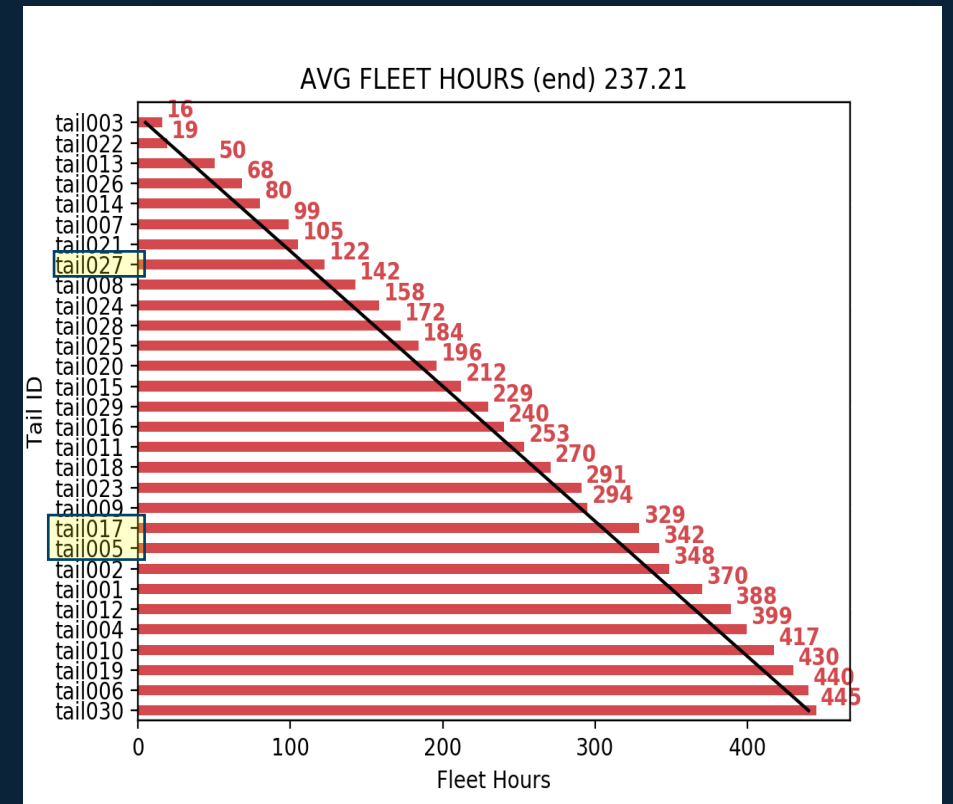
	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	Total:									
	1-Jan	2-Jan	3-Jan	4-Jan	5-Jan	6-Jan	7-Jan	8-Jan	9-Jan	10-Jan	11-Jan	12-Jan	13-Jan	14-Jan	15-Jan	16-Jan	17-Jan	18-Jan	19-Jan	20-Jan	21-Jan	22-Jan	23-Jan	24-Jan	25-Jan	26-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan										
tail001	WLT						avio			F2	F2											SP	F2	F2				F2		F2	14										
tail002			F2	SP																								SP	F2	F2		20									
tail003							F2	F2	SP	F2	F2			wire	chute		F	SP						phase							11										
tail004		engine					F2	F2	F2							SP		F2										F2		SP	14										
tail005			SP	F2			TCTO1				F2	F2				F2	F2	F2										F		F	F	19									
tail006		wash	F2	SP			F2	SP	F2							w&b	F	SP						paint							10										
tail007			F2	F2						F	F2																			F2	13										
tail008			F2	F2			F2	F						WLT														SP		F2	F	14									
tail009							F2	SP								F2		F2											F2		F2	12									
tail010				avio			SP	F	SP												WLT								F2		F2	F2	9								
tail011			rebuild							F2	F2	SP																	F2		F2	12									
tail012			avio				F2	F2	F2							F2	F2	F2														13									
tail013							SP	F2	F2							SP	F2	F2										SP		SP		11									
tail014							F	F2						chute	F															SP	5										
tail015			F2	F2					F2	F2	F2						F		F2									F	F2	F2	22										
tail016									F	SP	SP							F2										F2	SP	F		10									
tail017								wash		F2	SP						F2											F2	SP	SP		14									
tail018			SP	F2				F2	F2	SP																						11									
tail019							F2	SP									F2	F2														8									
tail020																																0									
tail021							wash			F2						gun	SP	F2										F2	SP		SP	8									
tail022			F2	SP				avio	F	F2	F2					SP	F2															12									
tail023																																0									
tail024			SP	F2			F2	F2	F2							F2	paint/2				F2	SP										12									
tail025							WLT								wash	F	F	F2					avio	F2	F2	F		F	F2	F	13										
tail026			F2	F2						F2	F2						F2	F2	F2									F2	F2	F2	F2	26									
tail027			F2	F2			F2	F2	F2	F2	F2					avio	F2	SP	SP					wash		F2	F				27										
tail028		avio	F2	F2			F2	F2	F2	SP	F2					F2	F2	SP										F2	F2	F2		23									
tail029			F2	F2			SP	F2								F2	F2	F2	F2									F2	F2	F2	F2	27									
tail030		wire					F	phase																		F											F2	F2	F2		8
Total:	0	0	20	20	0	0	22	22	22	22	20	0	0	0	22	22	22	20	0	0	0	22	22	22	10	0	0	22	22	22	22										

Optimally Correcting an Out-of-Phase Diagram

Phase Diagram –
Beginning of Month



Phase Diagram –
End of Month



- Our model suggests which tails to fly more, which to fly less to recover phase flow while also considering all other scheduling requirements and constraints

Maintenance Resource View

	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu
	1-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	11-Apr	12-Apr	13-Apr	14-Apr	15-Apr	16-Apr	17-Apr	18-Apr	19-Apr	20-Apr	21-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr
fuel	[Black bar]																													
wash		tail001					tail005						tail020								tail019							tail014		
corrosion						tail001				tail005				tail020									tail019						tail014	
avionics	tail005																											tail006		
phase	tail023																													
hangar 1		tail010																												
hangar 2	tail016	tail021																			tail021			tail008						
hangar 3																														
hangar 4	[Black bar]																													

- Can see which maintenance resources are bottlenecking scheduling, if any
- Can also plan around known periods of unavailability

Sample Output

Switching from TYPE2 to TYPE1 requires a major re-config
 Model optimized which aircraft to re-config to support schedule

		wed	thu	fri	TYPEO	sun	mon	tue	wed	thu	fri	TYPEO	sun	mon	tue	wed	thu	fri	TYPEO	sun	mon	tue	wed	thu	Total:																																	
	phase hrs	1-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	11-Apr	12-Apr	13-Apr	14-Apr	15-Apr	16-Apr	17-Apr	18-Apr	19-Apr	20-Apr	21-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr																											
tail001	98.2	TYPE2	wash				corro		SP	TYPEO																					4																											
tail002	450	TYPEO										TYPEO			reconfig							TYPE1		TYPE1				SP	TYPE1		TYPEO	6																										
tail003	173.1	wlt																																																			1					
tail004	39.6						TYPEO									PDMPREP															pdm	1																										
tail005	193.2	avionics					TYPE2		wash					corro		TYPEO																TYPE1	6																									
tail006	128.7	pdm																													avionics	0																										
tail007	38.2	pdm																															0																									
tail008	167.6	deploy																																																				0				
tail009	346		TYPEO					TYPEO			TYPEO			SP		TYPE2																	TYPEO	7																								
tail010	111.3		TCTO					TYPE2																										SP	3																							
tail011	63.8	pdm																																																				0				
tail012	326.3	deploy																																																					0			
tail013	90.8	deploy																																			3																					
tail014	227.3	deploy																																			1																					
tail015	133.8		TYPEO						SP		TYPE2					TYPEO																			TYPEO	4																						
tail016	441.7		TCTO3						SP		TYPEO																								TYPE1	4																						
tail017	403.4		TYPE2					SP		TYPE2																										TCTO	3																					
tail018	114.1	deploy																																																					0			
tail019	405.7													TYPEO		TYPEO																				TYPE1	5																					
tail020	355.6	SP	SP				TYPEO	*	TYPE2																											TYPE1	4																					
tail021	93.6	TYPEO	TYPEO					TYPEO			TYPEO																									SP	6																					
tail022	43	loan																																																			0					
tail023	0	phase																																		6																						
tail024	48.8	TYPE2					TYPE2		TYPEO		TYPE2			phase																															4													
tail025	135.7	deploy																																																								1
tail026	406.8							TYPE2		TYPE2						TYPEO																					TYPEO	7																				
tail027	278.8	pdm																																																								0
Total:		4	4	0	0	0	4	4	4	4	4	0	0	4	4	4	0	4	0	0	4	4	4	4	0	0	0	4	4	4	4	4	4	4	4	4																						

Major re-config job

Scheduling Optimization Model Inputs

Flying Schedule Requirements:

- Turn pattern for each day
- Mission types for each day
- No fly days
- No mx days
- Config needs

Aircraft data:

- Location
- Age
- Phase countdowns
- Current configuration

Mx Job list:

- Aircraft
- Earliest day
- Latest day
- Due day
- Duration
- Mx station?

Scheduling Rules:

- Constraints
- Mx stations
- Mx station blackouts
- Re-config times
- Rules of thumb

Blackout List:

- PDM
- Scheduled deployments
- Known NMC aircraft waiting for parts

Phase flow requirements:

- Target staircase
- Queue positions
- Change allowances

Additional Data:

- Deployment options
- Mapping of configurations to mission types

Scheduling
Optimization
Model

Integer Program Sprawls Over Several Pages

- Just providing a plain English overview today

$$\sum_{a \in A} \sum_{d \in D} \left[\sum_{r \in R} \sum_{j \in \mathcal{J}} x_{j,a,d} \right] \quad (29)$$

$$(1 - \Delta_{\%}) \left(b_0 + \Delta_{hrs} \sum_{p \in QP_s(a)} p \alpha_{a,p} \right) \leq hrsLft_a - \sum_{m \in M} \sum_{d \in D} hrs_m q_{a,m,d} \quad (30)$$

Subject to:

$$\sum_{d \in TW(j)} x_{j,a(j),d} + skip_j^{job} = 1 \quad \forall j \in \mathcal{J} \quad (2)$$

$$\sum_{d \in D} \sum_{j \in \mathcal{J}(r)} x_{j,a(j),d} \leq R_{max,r} \quad \forall r \in R; \forall d \in D \quad (3)$$

$$x_{j,a(j),d} - x_{pair(j),a(j),pair(d)} = 0 \quad \forall d \in TW(j); \forall j \in \mathcal{J}_{pred} \quad (4)$$

$$\lambda nmc_{a,d} \geq \sum_{w \in W_{LLT}(w(d))} \lambda \omega_{a,w} + \sum_{d \in D} \sum_{j \in \mathcal{J}(a,d)} \xi_j x_{j,a,d} \quad \forall a \in A, \forall d \in D \quad (5)$$

$$\sum_{a \in A} nmc_{a,d} \leq NMC_{max} \quad \forall d \in D \quad (6)$$

$$1 - nmc_{a,d} \geq \sum_{tp \in TP} y_{a,tp,d} \quad \forall a \in A; \forall d \in D \quad (7)$$

$$\sum_{a \in A(s)} y_{a,tp,d} = numTPs_{s,tp,d} - skip_{a,tp,d}^{tp} \quad \forall tp \in TP; \forall s \in S; \forall d \in D \quad (8)$$

$$\sum_{a \in A(s)} q_{a,m,d} = numMType_{s,m,d} - skip_{s,m,d}^{miss} \quad \forall m \in M; \forall s \in S; \forall d \in D \quad (9)$$

$$\sum_{m \in M} q_{a,m,d} \leq \sum_{tp \in TP} |tp| y_{a,tp,d} \quad \forall a \in A; \forall d \in D \quad (10)$$

$$\sum_{tp \in TP} y_{a,tp,d} \leq \sum_{d \in D} \sum_{(d, check_{day})} chk_{a,d} \quad \forall a \in A; \forall d \in D \quad (11)$$

$$\sum_{m \in M} \sum_{d \in W^-(w, regFly)} q_{a,m,d} + \sum_{\sigma \in W^-(w, regFly)} \delta_{a,\sigma} + \sum_{w \in W^-(w, regFly)} BOFly(a, w) \geq (1 - skip_{a,w}^{reg}) \quad \forall a \in A; \forall w \in W \quad (12)$$

$$\sum_{m \in M(a)} \sum_{d \leq due(req)} hrs_m q_{a(req),m,d} \geq phaHrs_{a(req),req}^{min} \quad \forall req \in Ph \quad (13)$$

$$\sum_{m \in M(a)} \sum_{d \leq due(req)} hrs_m q_{a(req),m,d} \leq phaHrs_{a(req),req}^{max} \quad \forall req \in Ph \quad (14)$$

$$b_0 = hrsLft_{a_{nzt}}^{start} - \sum_{d \in D} \sum_{m \in M(d_{nzt})} hrs_m q_{a_{nzt},m,d} - hrsBO(a_{nzt}) - \sum_{\sigma \in D} hrs_{\sigma} \delta_{a_{nzt},\sigma} \quad (15)$$

$$A(s) \setminus \{phase, a_{nzt}\} \quad (16)$$

$$W(j); \forall j \in \mathcal{J} \quad (31)$$

$$A(s) \setminus \{phase, a_{nzt}\} \quad \forall a \in A; \forall d \in D \quad (32)$$

$$\forall a \in A \quad (33)$$

$$\forall a \in A \quad (34)$$

$$\forall a \in A; \forall \sigma \in \mathcal{D} \quad (35)$$

$$\forall p \in Pos(s); s \in S \quad (36)$$

$$\forall a \in A; \forall d \in D \quad (37)$$

$$\forall a \in A; \forall d \in D \quad (38)$$

$$\forall a \in A; \forall d \in D \quad (39)$$

$$\forall a \in A; \forall d \in D \quad (40)$$

$$\forall p \in Pos(s(a)) \quad (41)$$

$$\forall a \in A; \forall d \in D \quad (42)$$

$$\forall w \in W \quad (24)$$

$$\forall j \in \mathcal{J} \quad (43)$$

$$\forall a \in A \quad (25)$$

$$\forall a \in A \quad (27)$$

$$\forall a \in A \quad (47)$$

$$\forall a \in A \quad (48)$$

$$\forall a \in A; \forall d \in D \quad (49)$$

$$\forall \sigma \in \mathcal{D} \quad (26)$$

$$\forall \sigma \in \mathcal{D} \quad (23)$$

$$\forall a \in A; \forall d \in D \quad (21)$$

$$\forall a \in A; \forall d \in D \quad (22)$$

$$\forall a \in A; \forall d \in D \quad (20)$$

$$\forall a \in A; \forall d \in D \quad (17)$$

$$\forall a \in A; \forall d \in D \quad (18)$$

Integer Programming Summary: Decision Variables

- Primary Decision Variables:
 - When to schedule a maintenance job
 - Which aircraft fly which missions each day
 - Which tails to assign to deployments
 - Which tails to assign to weapons load training

- Secondary Decisions:
 - When to re-configure aircraft
 - When to perform pre-flight checks

- Myriad of slack variables

Primary Decision Variables:

- $x_{j,a,d} \in \{0,1\}$, indicates whether job j is scheduled to start on aircraft a on day d
- $y_{a,tp,d} \in \{0,1\}$, indicates whether aircraft a is flying turn pattern tp on day d
- $\omega_{a,w} \in \{0,1\}$, indicates whether aircraft a is assigned weapons load training for WLT_{len} consecutive weeks, beginning on week w
- $\delta_{a,\sigma} \in \{0,1\}$, indicates whether aircraft a is assigned deployment σ

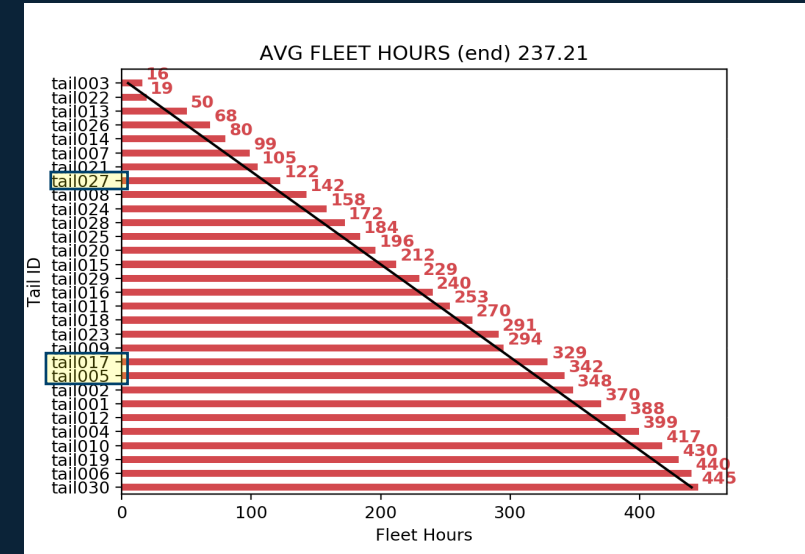
- State Indicator Variables:
 - Aircraft configuration states
 - Whether aircraft is in maintenance
 - Whether aircraft is mission capable
 - More ...

Integer Programming Summary: Constraints

- **Tail-to-mission assignment constraints**
 - Turn pattern
 - Mix of missions
 - Configuration eligibility
 - Recent pre-flight check
- **Maintenance limitations**
 - Station-specific constraints and availabilities
 - General rules of thumb
- **Flying hour consumption constraints**
- **Re-configuration time constraints**
- **Regular use constraints**
- **Scheduling constraints**
 - Time windows
 - Precedence constraints
 - Non-simultaneity
- **Phase flow staircase constraints**
- **Deployment assignment constraints**
- **Limited configuration resources**
- **Weapons load training constraints**
- **Pre-existing activities to plan around**

How We Implement Phase Flow Constraints

1. Create auxiliary variables for:
 - Aircraft's ending position in the phase queue
 - Next aircraft's hours until phase
2. Create a constraint defining one aircraft's hours until phase
3. Create constraints bounding every other aircraft's target hours until phase relative to the first aircraft
4. Constrain the assignment of aircraft to phase queue positions to be a perfect matching



$$b_0 = hrsLft_{a_{nzt}}^{start} - \sum_{d \in D} \sum_{m \in \mathcal{M}(a_{nzt})} hrs_m q_{a_{nzt}, m, d} - hrsBO(a_{nzt}) - \sum_{\sigma \in D} hrs_{\sigma} \delta_{a_{nzt}, \sigma} \quad (15)$$

$$(1 - \Delta\%) \left(b_0 + \Delta_{hrs} \sum_{p \in QP_s(a)} p \alpha_{a, p} \right) \leq hrsLft_a - \sum_{d \in D} \sum_{m \in \mathcal{M}(a)} hrs_m q_{a, m, d} - hrsBO(a) - \sum_{\sigma \in D} hrs_{\sigma} \delta_{a, \sigma} \quad \forall a \in A(s) \setminus \{phase, a_{nzt}\} \quad (16)$$

$$(1 + \Delta\%) \left(b_0 + \Delta_{hrs} \sum_{p \in QP_s(a)} p \alpha_{a, p} \right) \geq hrsLft_a - \sum_{d \in D} \sum_{m \in \mathcal{M}(a)} hrs_m q_{a, m, d} - hrsBO(a) - \sum_{\sigma \in D} hrs_{\sigma} \delta_{a, \sigma} \quad \forall a \in A(s) \setminus \{phase, a_{nzt}\} \quad (17)$$

$$\sum_{p \in QP_s(a)} \alpha_{a, p} = 1 \quad \forall a \in A \quad (18)$$

$$\sum_{a \in A(s)} \alpha_{a, p} = 1 \quad \forall p \in \mathcal{Pos}(s); s \in S \quad (19)$$

Integer Programming Summary: Objective

- **Primary:** Satisfy all major scheduling requirements
- **Secondary:** Avoid major inconveniences as much as possible
 - E.g., reduce days-in-hangar, reduce re-configurations, reduce pre-flight checks, long periods of aircraft idleness, etc.
- **Tertiary:** Have as many nice-to-haves as possible
 - E.g., buffer days after long off-base activity or long maintenance jobs

Many-Criterion Optimization Hierarchy

Most important

- Assign an available tail to every daily flying requirement
- Schedule all maintenance due this month
- Preserve turn patterns (i.e., 12 turn 10 means 12 turn 10)
- Assign available tails to other needed requirements (e.g., WLT, deployments)
- Don't disrupt the phase flow staircase

- Don't throw away flying hours before major phased maintenance
- Avoid unnecessary major aircraft re-configurations
- Fly each tail somewhat regularly

- Preserve all spare aircraft requirements
- Preserve checkerboarding preferences

- Consolidate mx so it takes fewer in-hangar days
- Don't schedule mx, flights, WLT immediately after off-base activities
- Don't schedule mx, flights, WLT immediately after major phase maintenance
- Avoid unnecessary pre-flight checks
- Don't stretch small jobs (5 days or fewer) across weekends and holidays

Least important

- Schedule jobs earlier within the allowed time window for added flexibility

Light Re-optimization Mode

- Light re-optimization := our term for optimally adapting an existing schedule to meet new requirements
 - E.g., to react to a major unscheduled aircraft break, to plan short-notice flights or exercises, to adapt to changes in resource availability, to adapt to delays, etc.
- Avoids schedule from needlessly changing by adding a cost to deviating from the previous solution

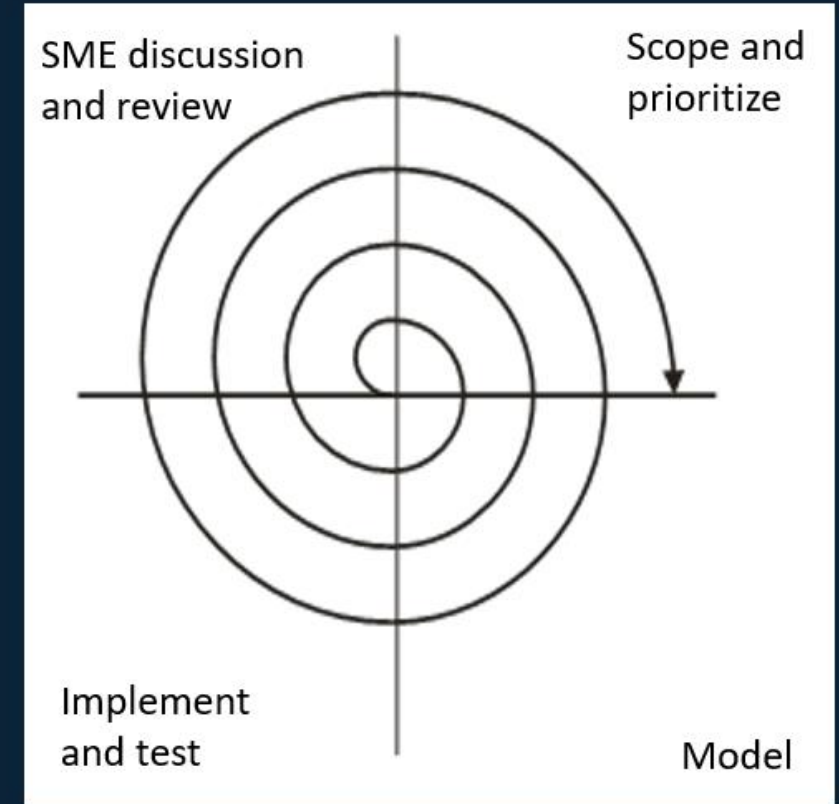
Light Re-optimization Example

- Light re-optimization mode accommodated the unscheduled aircraft break with a handful of changes

		wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	fri	sat	sun	mon	tue	wed	thu	Total:
	phase hrs	1-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	11-Apr	12-Apr	13-Apr	14-Apr	15-Apr	16-Apr	17-Apr	18-Apr	19-Apr	20-Apr	21-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	27-Apr	28-Apr	29-Apr	30-Apr	
tail001	98.2	SP	wash				corro		F	F				F		SP												SP		F	4	
tail002	450		F					SP		F							F				SP	F		F					wlt		5	
tail003	173.1	wlt																												1		
tail004	39.6													SP		F			PDMPREP												pdm	1
tail005	193.2	avionics						wash			corro		F								SP		F									2
tail006	128.7	pdm														PDMACPT										avionics				0		
tail007	38.2	pdm														pdm														0		
tail008	167.6	deploy																								TCI				3		
tail009	346	F						F		F											F		F						F		F	7
tail010	111.3	TCTO						TCTOBU																3								
tail011	63.8	pdm														pdm														0		
tail012	326.3	deploy														deploy														0		
tail013	90.8	deploy																								F				4		
tail014	227.3	deploy														F										wash				corro	1	
tail015	133.8	F	SP	reconfig				F			SP					F								F								4
tail016	441.7	TCTO3																		ac down				1								
tail017	403.4		F				SP		F		SP				F																	3
tail018	114.1	deploy														deploy														0		
tail019	405.7							F						F		F		SP				F	wash			corro		F		F	6	
tail020	355.6		F					F		F				wash		corro					F		SP								4	
tail021	93.6	F	F	TCI			F		SP	reconfig				SP	F		F				TCI			wpns					F		6	
tail022	43	loan														loan														0		
tail023	0	phase								F		F			F		F				F		F				F		F		9	
tail024	48.8	F					F		F		F			phase														4				
tail025	135.7	deploy														deploy														1		
tail026	406.8						F			F				F			F					F		SP				F		F	wpns	7
tail027	278.8	pdm														pdm														0		
Total:		4	4	0	0	0	4	4	4	4	4	0	0	4	4	4	0	4	0	0	4	4	4	4	0	0	0	4	4	4	4	

What We Are Doing Now

- Long range planning mode – for scheduling major activities 12+ months out
- Interactive front-end development
 - User can edit and override any aspect of schedule
 - User can add/modify constraints and change objective trade-off weights using a wizard
- Continuous improvement



Agile model development

The End

MITRE is an excellent place for operations researchers who want to solve challenging and important problems in the public sector and defense



Source: AF.mil

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