Systems Engineering Analysis Cohort 24 (SEA-24)

"High Altitude ASW for the P-8A"

IPR #2

26 Oct 2016

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CAPSTONE Timeline

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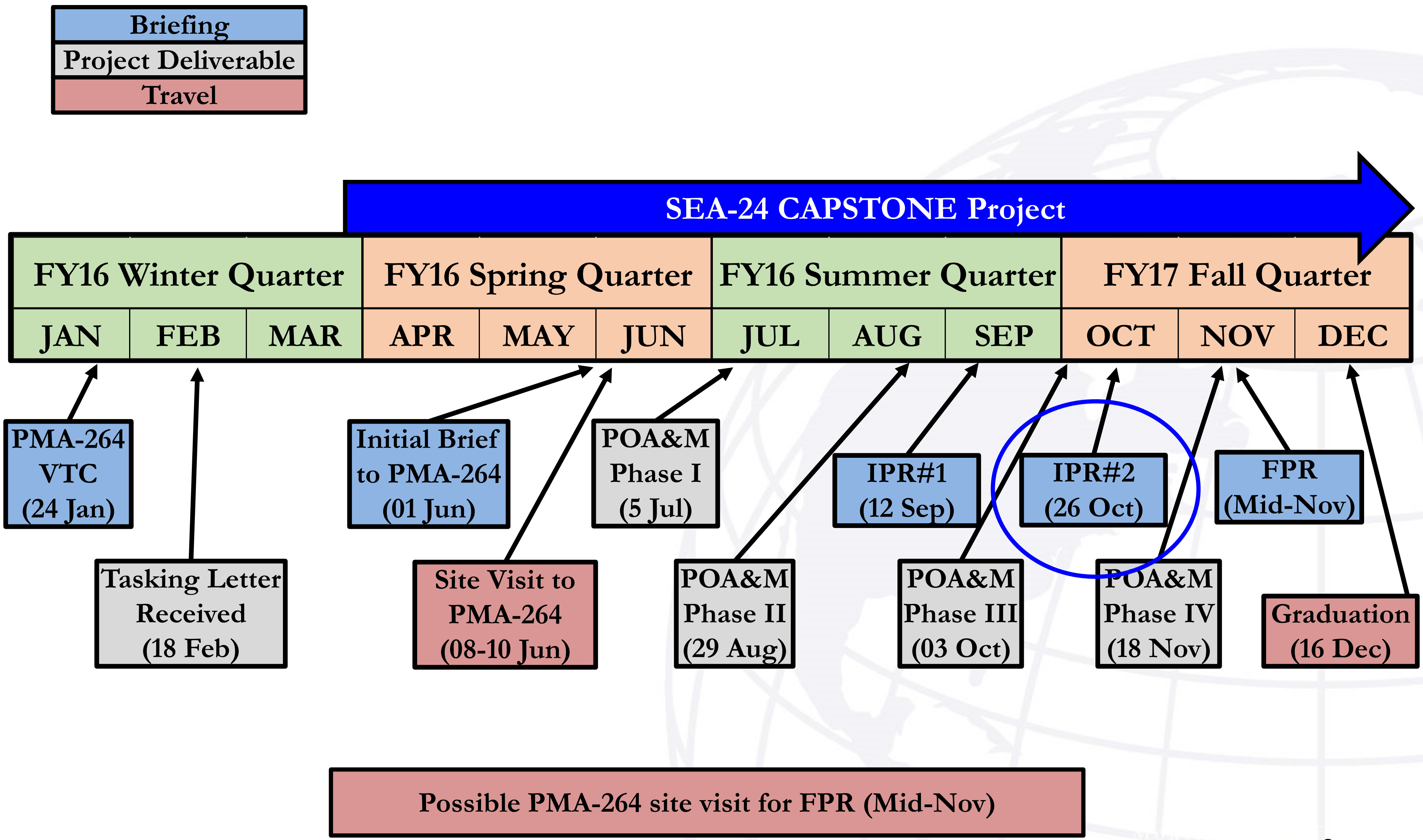

Tasking Scoped Further

(U) <u>Scoped Tasking</u>:

(U) SEA-24 will investigate a systems of systems (SoS) centered around the P-8A Poseidon and the Coyote® Unmanned Targeting Air System (UTAS) with MAD sensor in an attempt to reduce the time to Find, Fix, Track, Target, and Engage (F2T2E) a submarine while carefully considering cost, operator task saturation, P-8A sonobouy storage capacity, and projected technological advancements in the 2025-2030 timeframe to ensure each system architecture is a viable system in support of High Altitude ASW (HAASW) operations.

Tracking Progress

(U) Phase III: Development of Alternative Solutions

- Finalize Key Performance Parameters (KPP)
- Generate System Design Alternatives
- Conduct Analysis of Design Alternatives (AoA)
- Cost Analysis of Alternatives

(U) Completion: 30 October 2016

Scenario Description (SIPR)

What does this mean?

(U) SEA-24 must develop a System of Systems design where system architecture becomes the focus of the analysis.

- (U) How can we employ a UTAS with MAD sensor to sufficiently support the P-8A during High Altitude ASW (HAASW) operations?
- (U) How can we reduce the time required to Find, Fix, Track, Target, and Engage a submarine with a P-8A?
- (U) What becomes the more important UTAS performance trait for each SoS architecture design?
  - UTAS speed vs. UTAS endurance

(U) Is a SoS employing UTAS with MAD better than the current doctrine of using DIFAR/DICASS sonobuoys in the Find, Fix, Track, Target, and Engage sequence in terms of time, mission cost, and added functionality to the P-8A ASW mission?

Operational Concept

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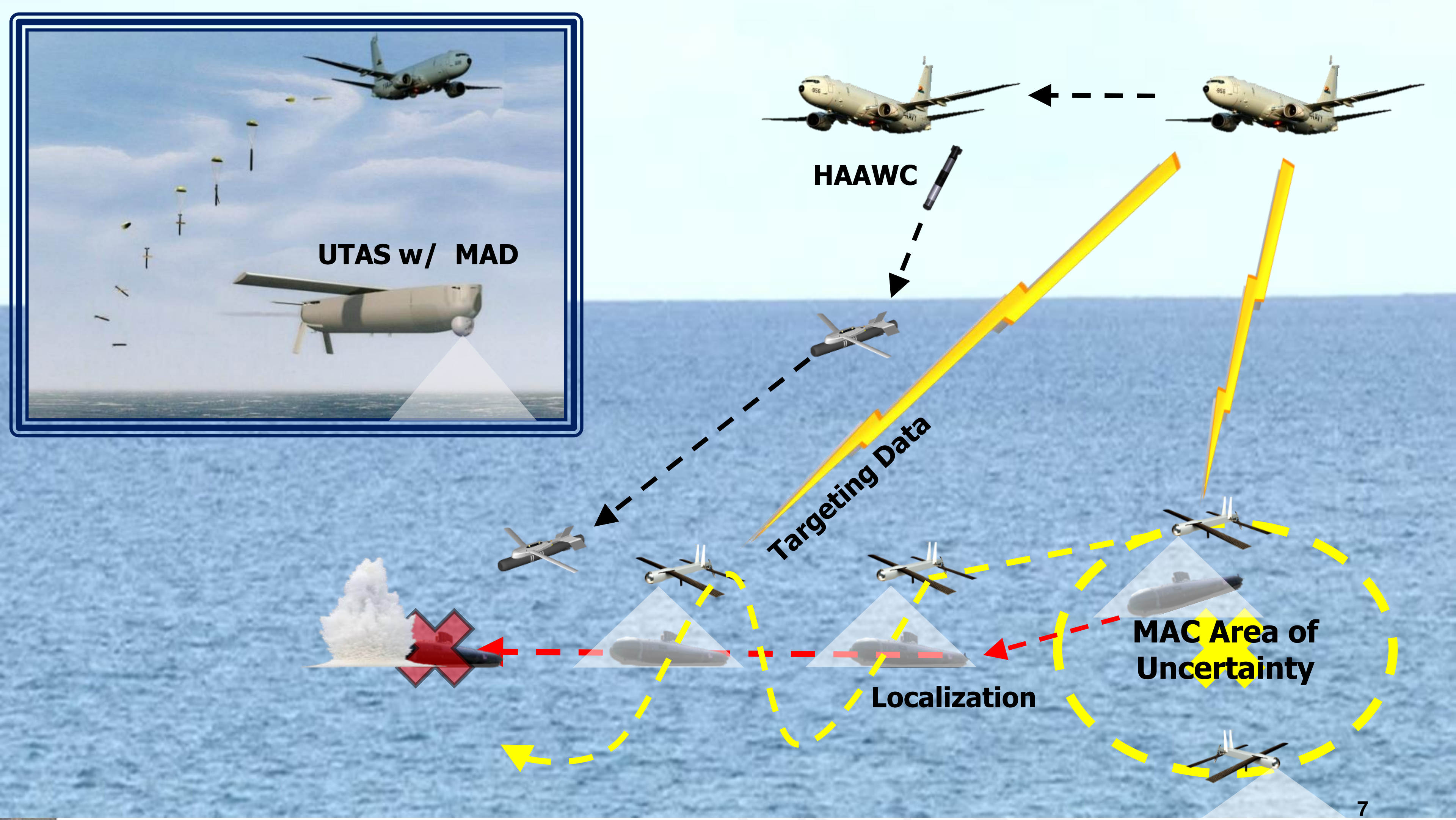
High Altitude ASW w/ P-8A



Critical Operational Issues

COI	Issue	Question
1	Endurance	Are the achievable SWaP endurance rates of a UTAS platform sufficient to support effective P-8A ASW operations?
2	Transportability	Can the UTAS platform be stored and launched from a P-8A platform to support effective ASW operations?
3	Compatibility	Is the UTAS platform compatible with P-8A ASW mission and communication systems?
4	Command and Control (C2)	Can UTAS provide sufficient information to support effective P-8A ASW operations?
5	Speed	Can the UTAS platform operate at sufficient speeds to support effective P-8A ASW operations?
6	Automation	Can the UTAS platform operate autonomously in support of effective P-8A ASW operations?
7	Employment	Can the UTAS platform be readily employed from the P-8A platform to support effective ASW operations?
8	Survivability	Can the UTAS platform survive a challenging electromagnetic (EM) and physical environment?
9	Reliability	Does UTAS platform reliablity align with the required reliability for P-8A ASW operations?
10	Availability	Does UTAS platform availability align with the required availability for P-8A ASW operations?

KPP MOE/MOP

(U) Key Performance Parameters mapped to applicable MOE/MOP will be focus point of modeling/simulation and follow-on analysis

(U) Primary KPP: Time to Complete F2T2E

- MOE 7.1 – Effectiveness of system at ASW operations given varying architectures
    - MOP 7.1.3 – Mean time to complete F2T2E

(U) Secondary KPP: Probability of Detection

- MOE 7.1 – Effectiveness of system at ASW operations given varying architectures
    - MOP 7.1.1 – Total probability of detection given architecture
    - MOP 7.1.2 – Mean time to lay MAC field

(U) Tertiary KPP: Endurance

- MOE 1.1 – UTAS operational endurance
    - MOP 1.1.2 – Probability of detection given UTAS endurance

(U) CAIV: Cost as an Independent Variable

Design of Experiments

(U) Extensive list of potential variables for DoE explored. Four critical variables selected based on stakeholder desires to minimize simulation and maximize analysis output.

(U) Design Variables

- UTAS endurance:
  60, 90, 120, 150 (minutes)
- UTAS speed:
  70, 85, 100, 115 (knots)
- Sub speed:
  3, 6.5, 10 (knots)
- Number of MAC "hits":
  TBD

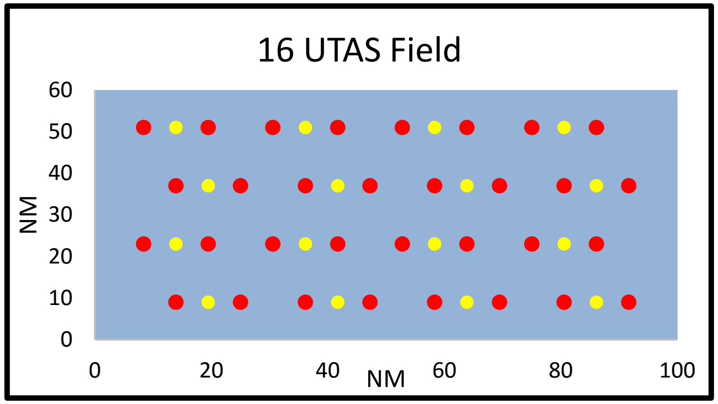
(U) Design Constants

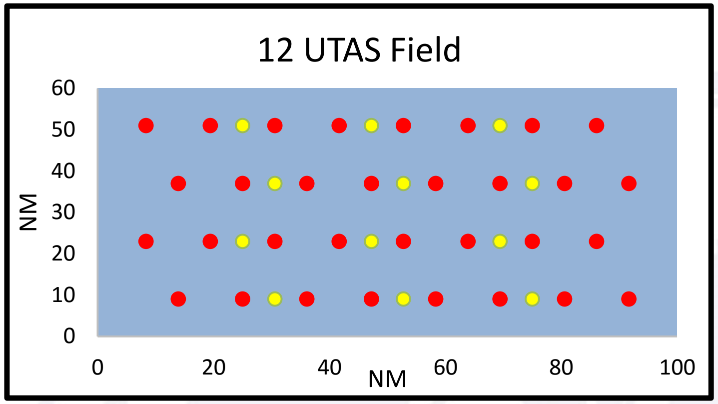
- Op Area dimensions
- # MAC buoys
- P-8A sonobuoy storage
- MAD sweep width
- P-8A on-station time
- UTAS SWaP
- P-8A speed

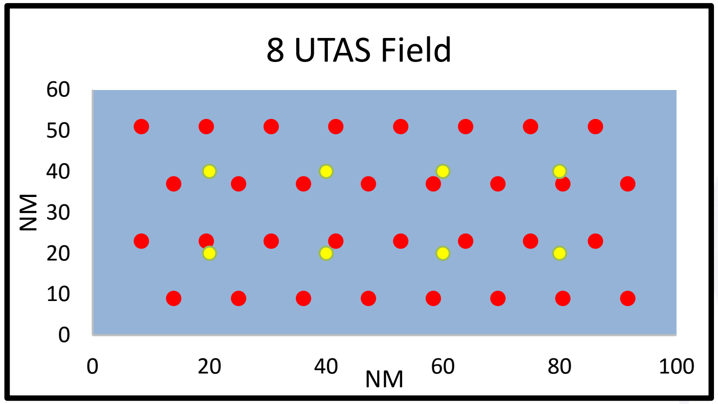
Critical Assumptions

- **(U) Type of sound propagation ignored**
  - Treated as "event" within simulation model
- **(U) Probability of False Alarm (P_f) ignored**
  - **Treated as a MAC event with projected MAD P_d for each event**
- **(U) Battery power/life assumed to peak at 2.5 hours**
  - Projected estimate to the 2025-2030 timeframe
- **(U) AN/SSQ-125 (MAC) "Field" pattern & distances set as constant**
  - Initial MAC Area of Uncertainty (AOU) set as constant (**XX** meters)
- **(U) 32-36 UTAS allocated for total P-8A mission**
  - Based upon 129 total SLC storage

Architecture Alternatives







1. Laying 16 UTAS with MAC
2. Laying 12 UTAS with MAC
3. Laying 8 UTAS with MAC
4. P-8A fly to and Deploy 1
5. P-8A fly to and Deploy 2
6. P-8A fly to and Deploy 3
7. P-8A fly to and Deploy 4
8. P-8A fly to and localize with DIFAR/DICASS

(U) Time-based model analyzing F2T2E sequence across multiple architectures using a Design of Experiments of critical input factors

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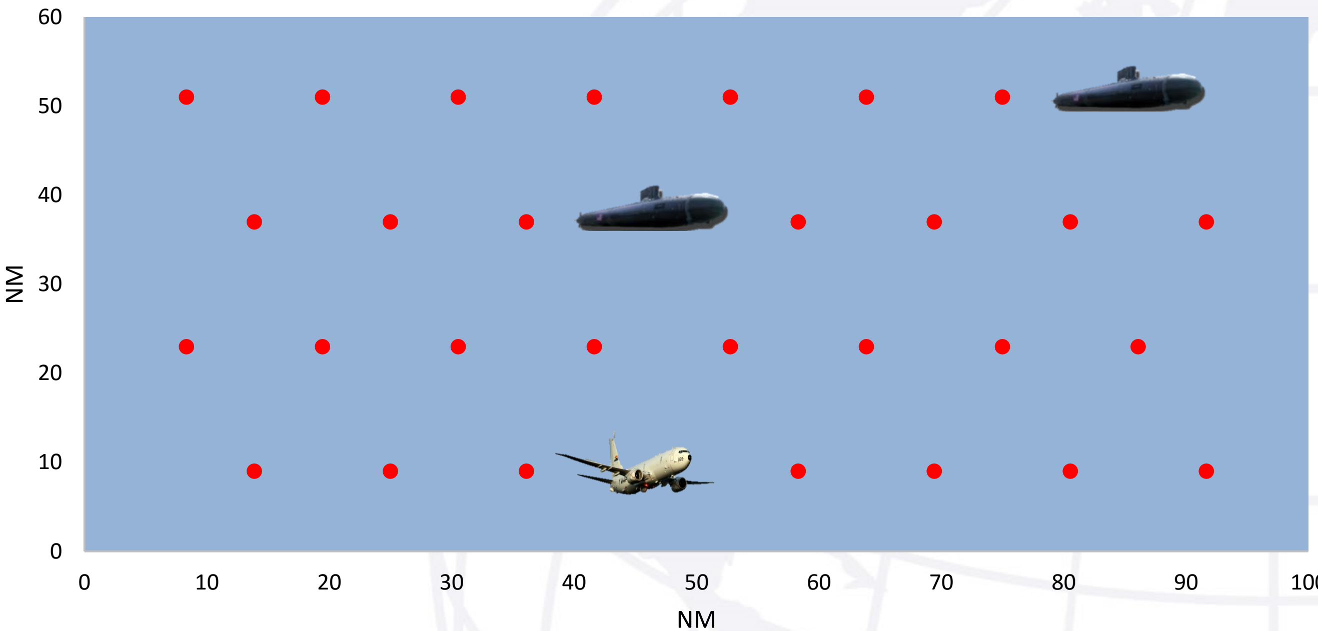
(U) Building the Buoy Field

SSQ-125	X	Y	Time
1	13.88889	9	0
2	25	9	0.031746
3	36.11111	9	0.063492
4	47.22222	9	0.095238
5	58.33333	9	0.126984
6	69.44444	9	0.15873
7	80.55556	9	0.190476
8	91.66667	9	0.222222
9	86.11111	23	0.265257
10	75	23	0.297003
11	63.88889	23	0.328749
12	52.77778	23	0.360495
13	41.66667	23	0.392241
14	30.55556	23	0.423987
15	19.44444	23	0.455733
16	8.333333	23	0.487479
17	13.88889	37	0.530513
18	25	37	0.562259
19	36.11111	37	0.594005
20	47.22222	37	0.625751
21	58.33333	37	0.657497
22	69.44444	37	0.689243
23	80.55556	37	0.720989
24	91.66667	37	0.752735
25	86.11111	51	0.79577
26	75	51	0.827516
27	63.88889	51	0.859262
28	52.77778	51	0.891008
29	41.66667	51	0.922754
30	30.55556	51	0.9545
31	19.44444	51	0.986246
32	8.333333	51	1.017992
Center	50	30	1.151305

UTAS		
Speed	70	NM/hr
Endurance	2	hr

P-8A		
On Station	5	hr
Speed	350	NM/hr

Enemy Sub	
X	91.23797
Y	31.09635
Time	0.109312



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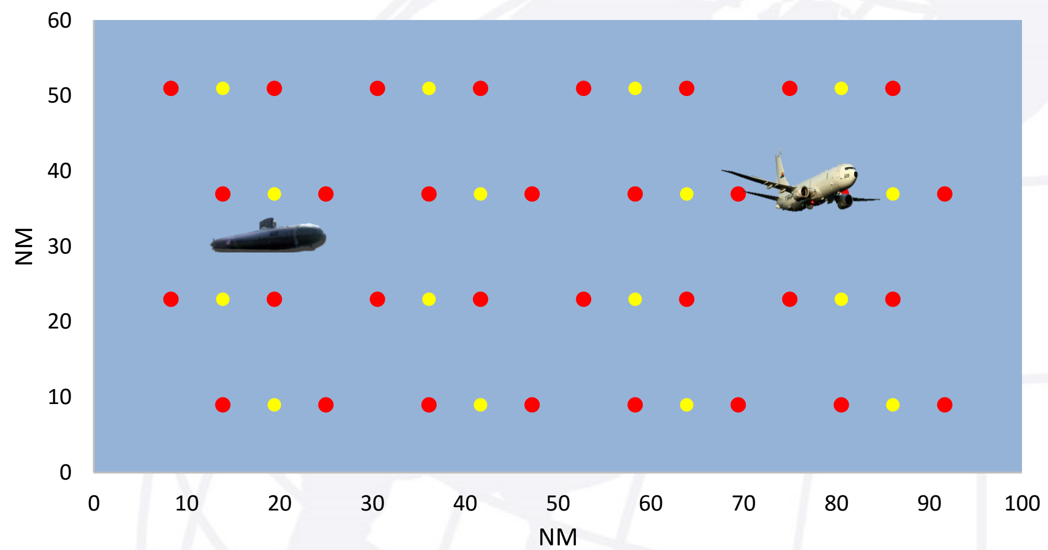
(U) Laying the Buoy Field with UTAS

UTAS	X	Y	Fly to Sub
1	19.44444444	9	0.274178
2	41.66666667	9	0.586602
3	63.88888889	9	0.902548
4	86.11111111	9	1.219281
5	80.55555556	23	1.14514
6	58.33333333	23	0.830471
7	36.11111111	23	0.519214
8	13.88888889	23	0.225931
9	19.44444444	37	0.422365
10	41.66666667	37	0.66882
11	63.88888889	37	0.958024
12	86.11111111	37	1.260898
13	80.55555556	51	1.254816
14	58.33333333	51	0.976166
15	36.11111111	51	0.729932
16	13.88888889	51	0.560592



Distribution of Fly To Times

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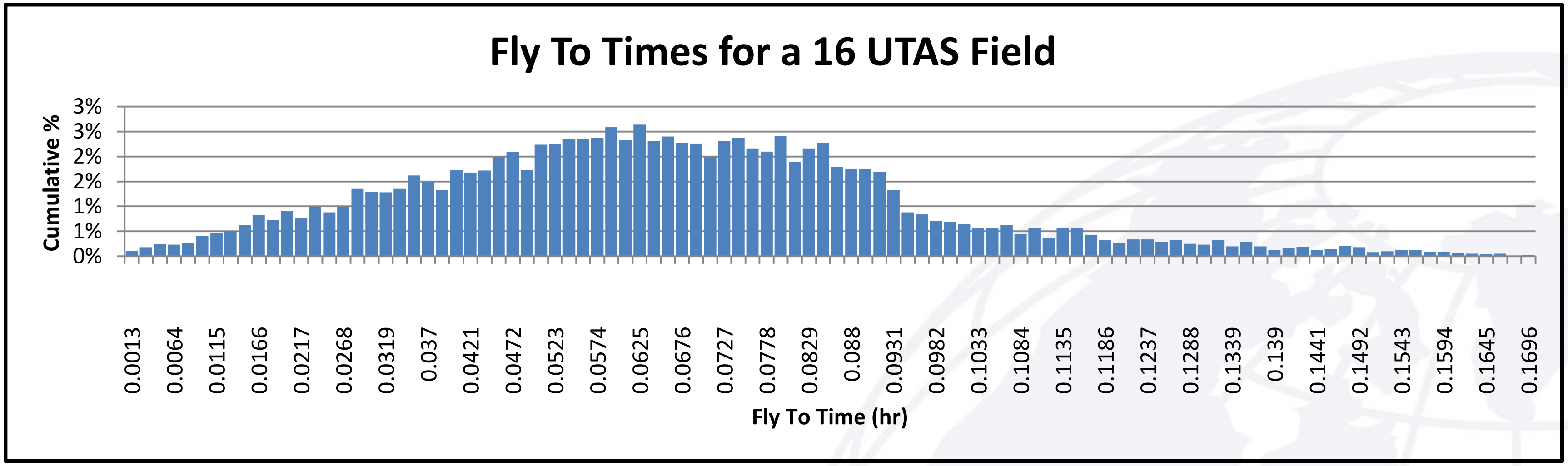
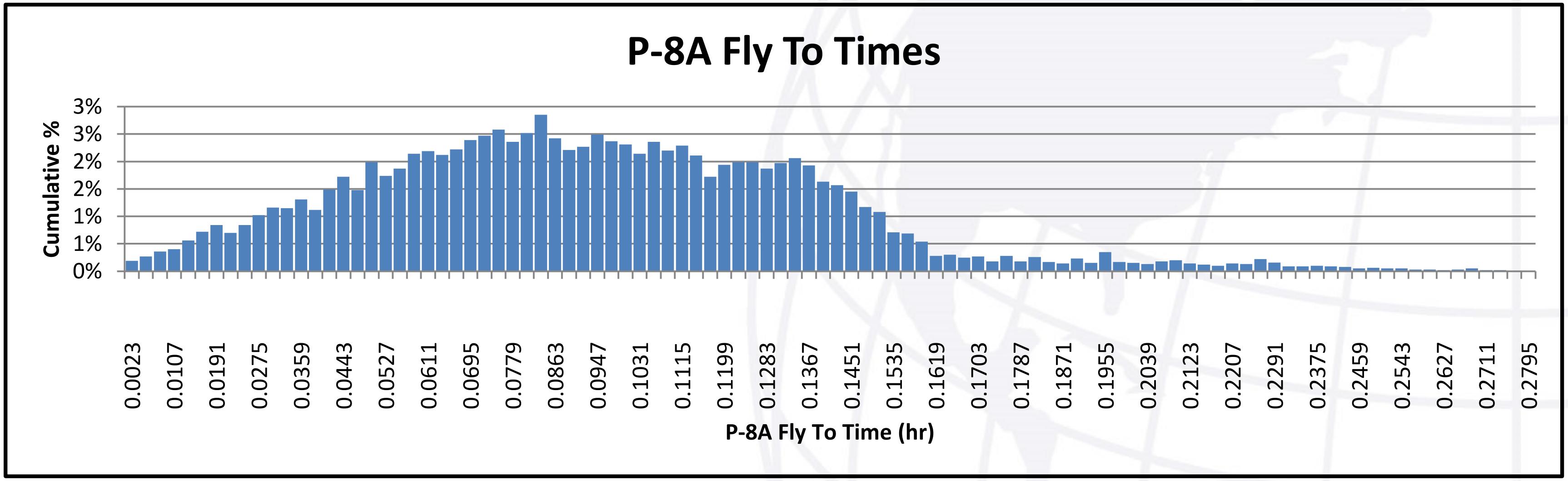




Flaming Datum Search

(U) Origin:

- The Flaming Datum problem is one of relocating an enemy target that is fleeing after momentarily revealing its position (i.e. submarine engagement)
- Time-varying area resulting from latency of ASW asset on-station time

(U) Why is it relevant to our problem?:

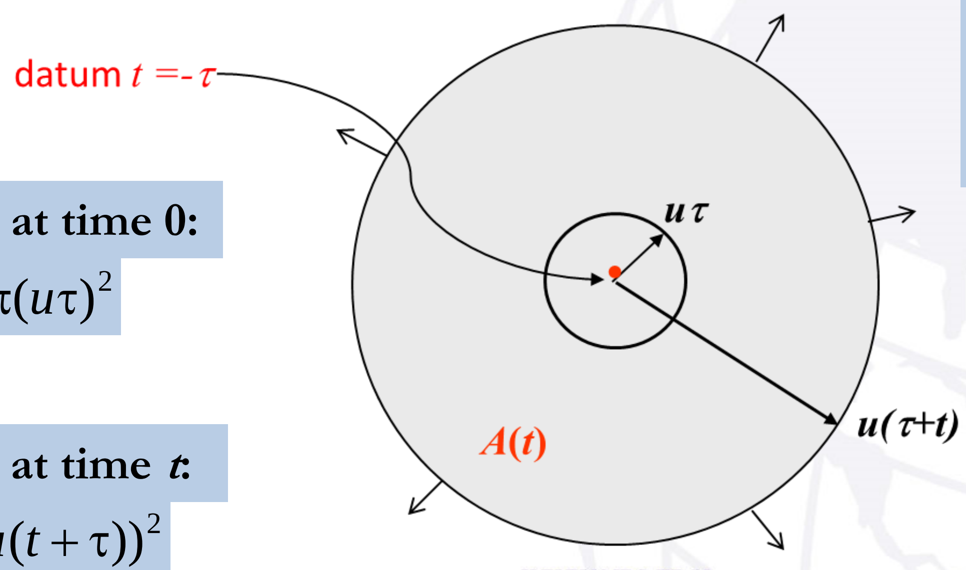
- We have very accurate information about the specific location of the submarine at a specific point in time (MAC 'hit' Datum)

(U) Challenge:

- How can we get ASW asset to the MAC Datum as quickly as possible?

(U) How does it work?:

- Consider target detected at random time at a random location
- Target begins evading at constant speed in random direction which can change at any time
- Searcher arrives at a calculated time late and commences random search at chosen speed
- At $t = 0$, target is located somewhere in a MAC AOU circle, centered at datum, of radius determined from calculated time latency



- Target evasion speed, u
- Search speed, v
- Time late, τ

Search area at time 0:

$$A(0) = \pi(u\tau)^2$$

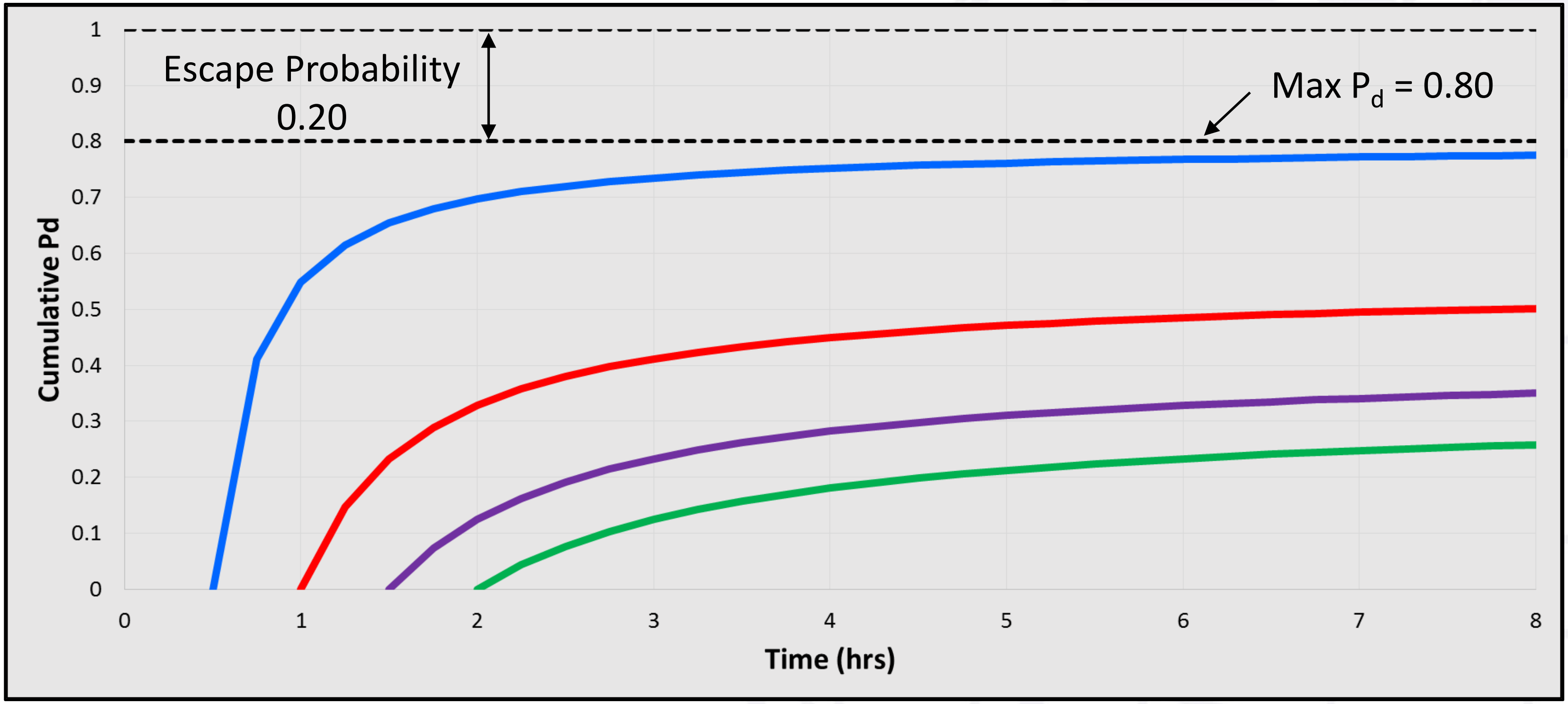
Search area at time t:

$$A(t) = \pi(u(t+\tau))^2$$

Flaming Datum Search

$$F_T(t) = 1 - \exp\left(-\frac{wv}{\pi u^2}\left(\frac{1}{\tau} - \frac{1}{\tau + t}\right)\right)$$

- Target evasion speed, u
- Search speed, v
- Time late, τ
- Sweep width, w



How Long to Search?

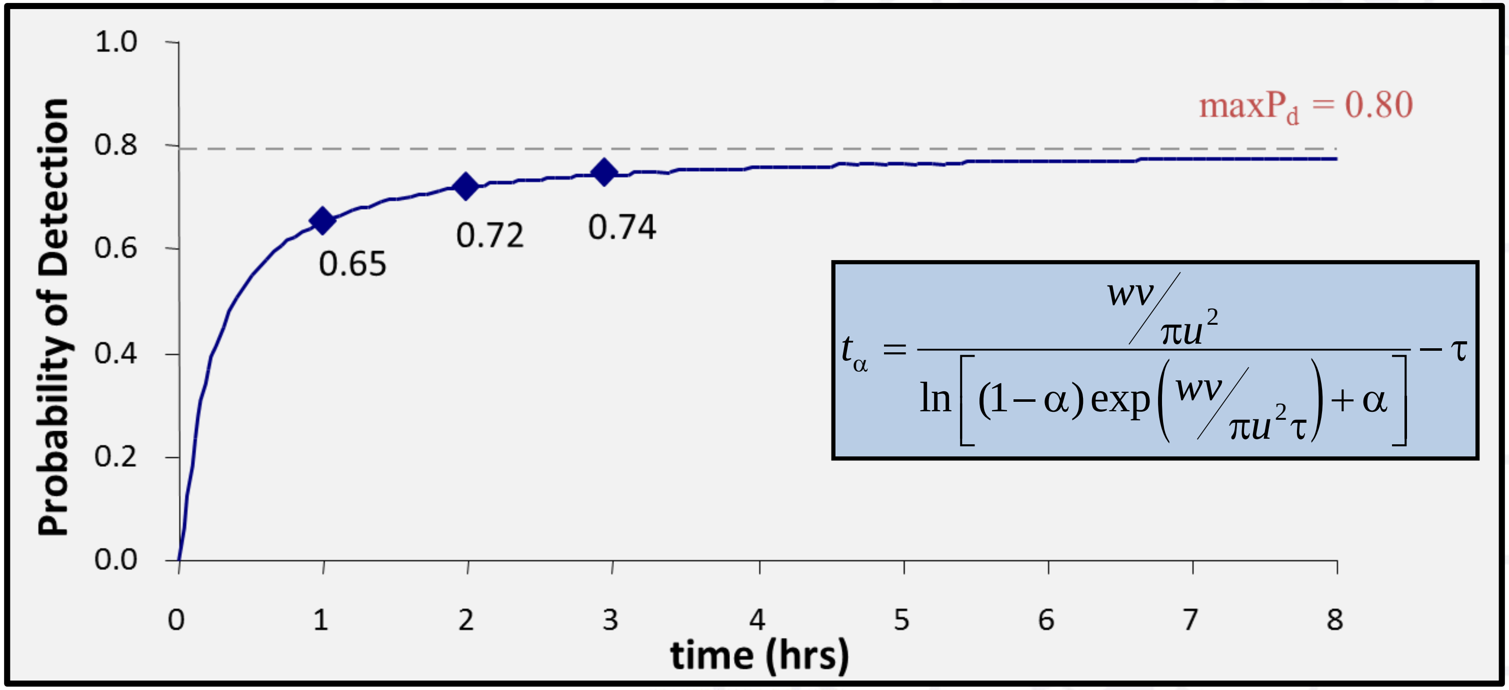
(U) "Knee of the curve" or "diminishing returns"?

82% of $\max P_d$ is attained after 1 hour of search

90% of $\max P_d$ after 2 hours

93% of $\max P_d$ after 3 hours

- An infinite amount of time is needed to get the remaining %



$$t_\alpha = \frac{wv/\pi u^2}{\ln\left[(1-\alpha)\exp\left(wv/\pi u^2 \tau\right) + \alpha\right]} - \tau$$

MAD Sweep Width/Depth (SIPR)

2x Swarm & 1 Sub 6.5kts

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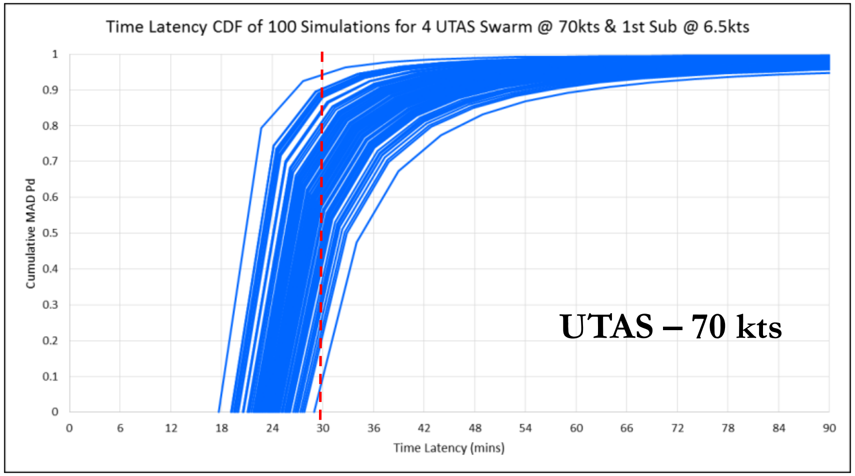

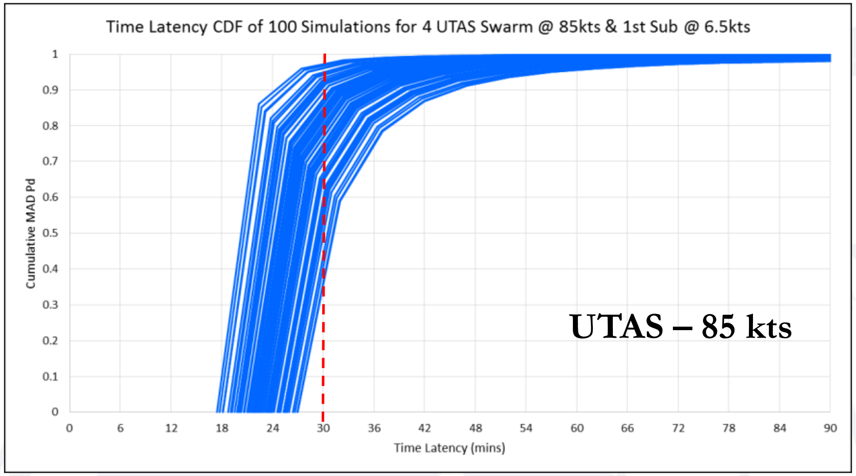

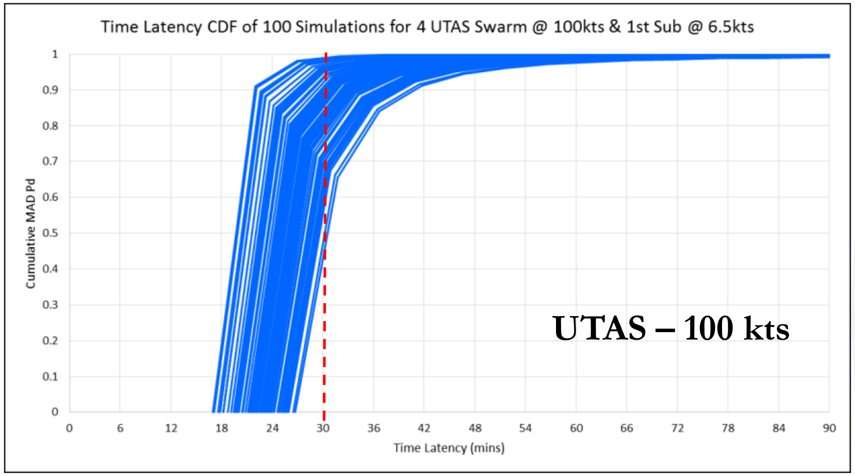

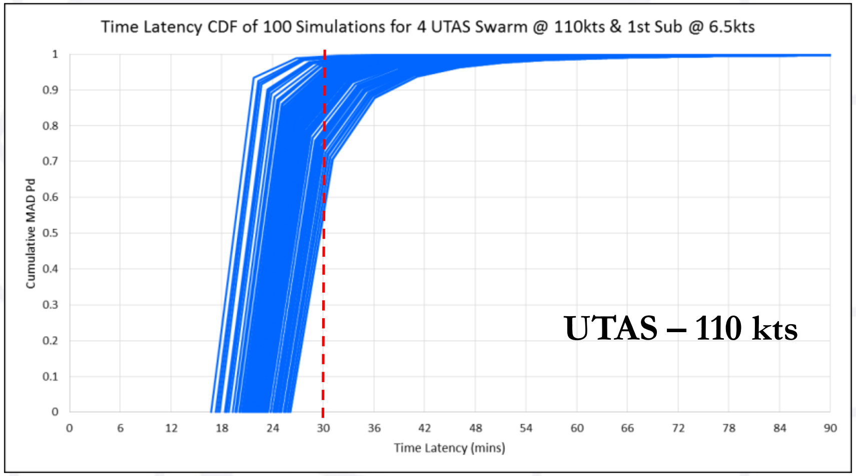

16x Field & 1 Sub 6.5 kts

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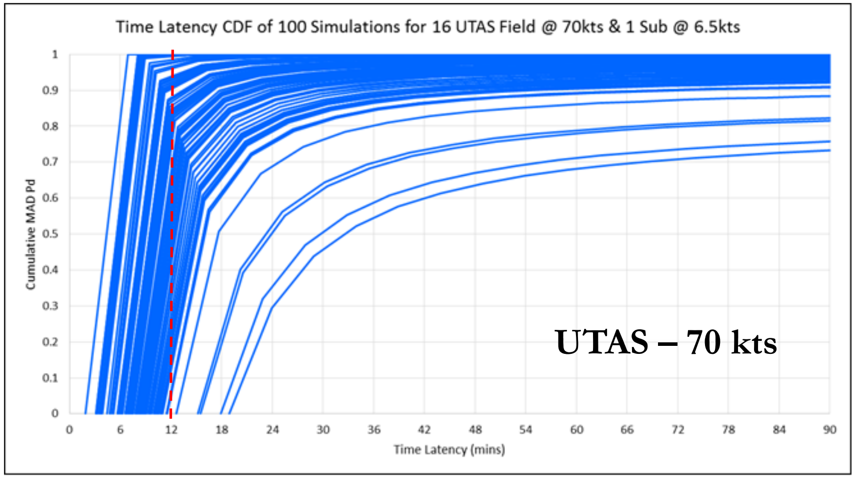
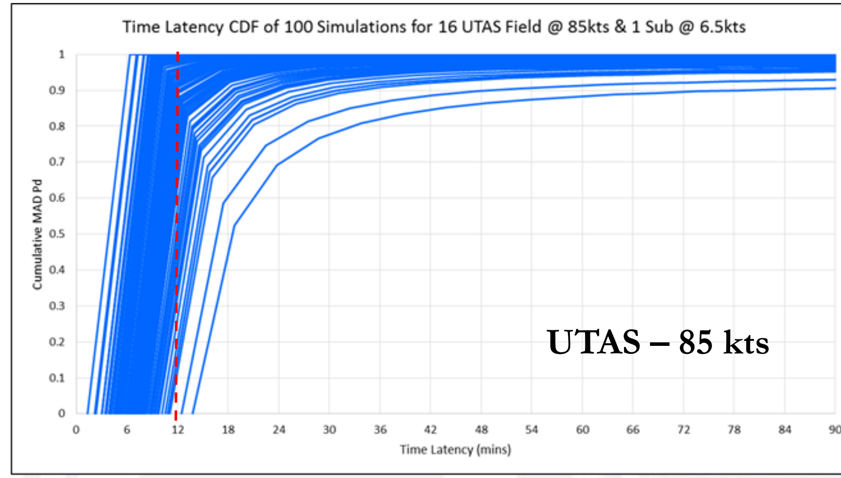
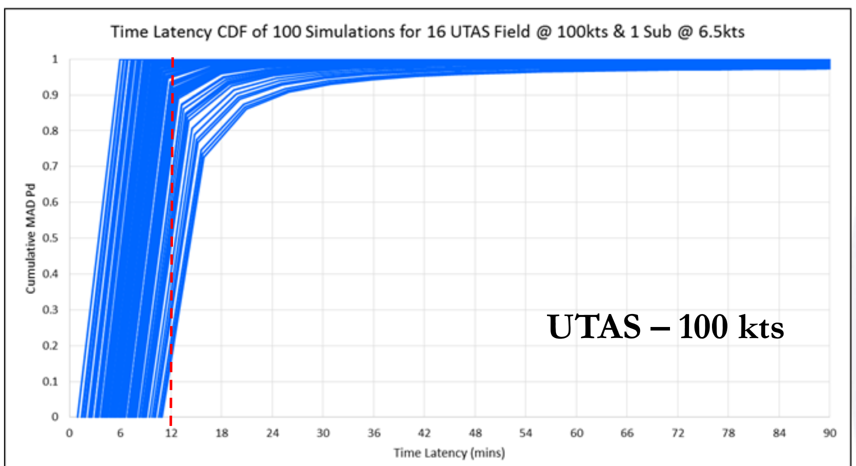
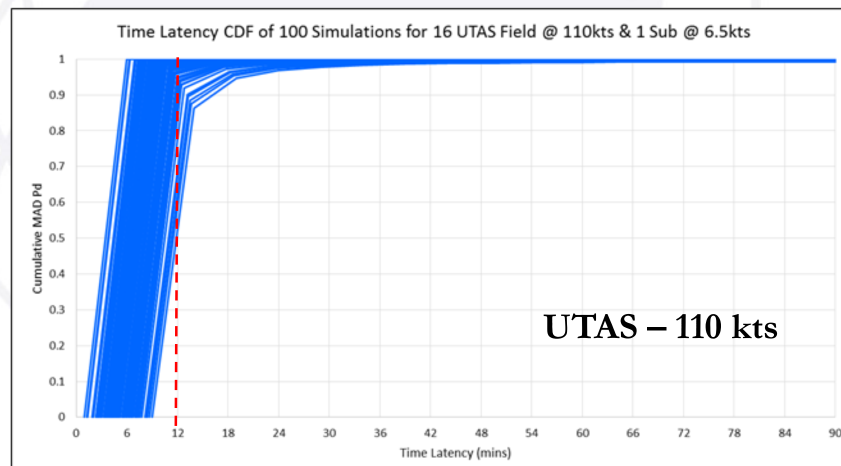
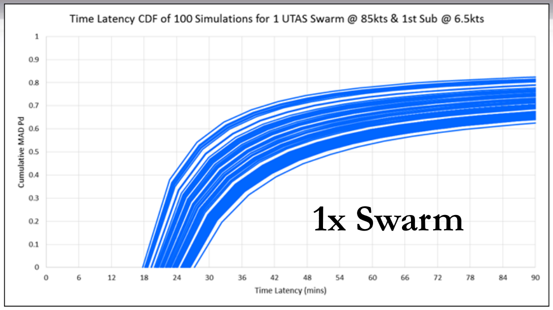


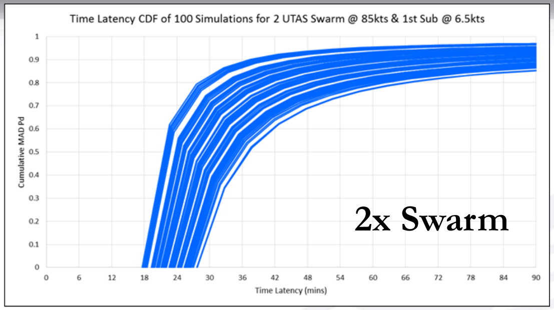


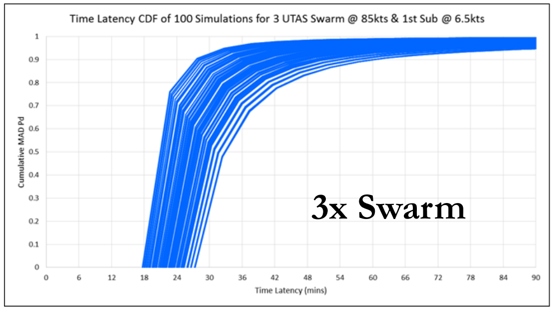


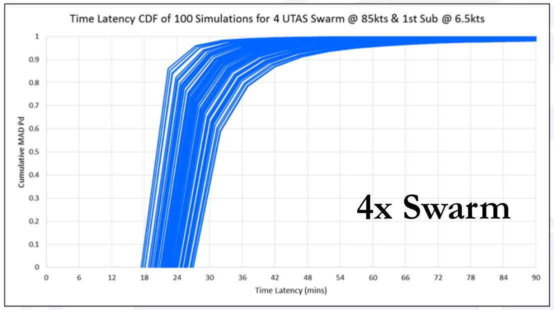


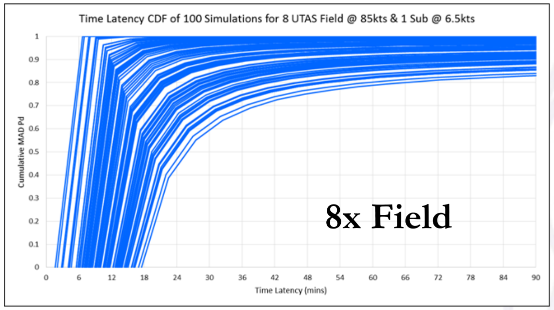
Architecture Comparison

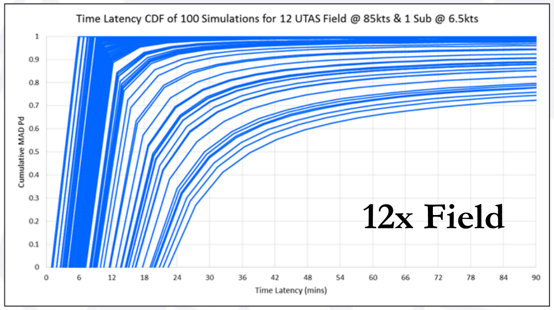


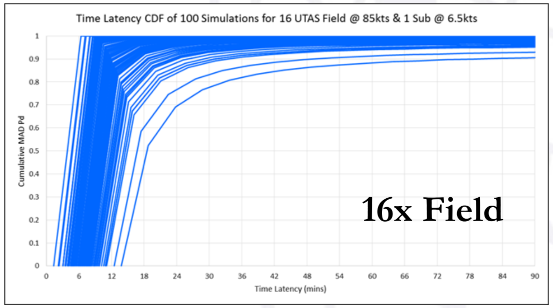












UTAS - 85kts
Sub – 6.5kts

Comparison for 1x Swarm

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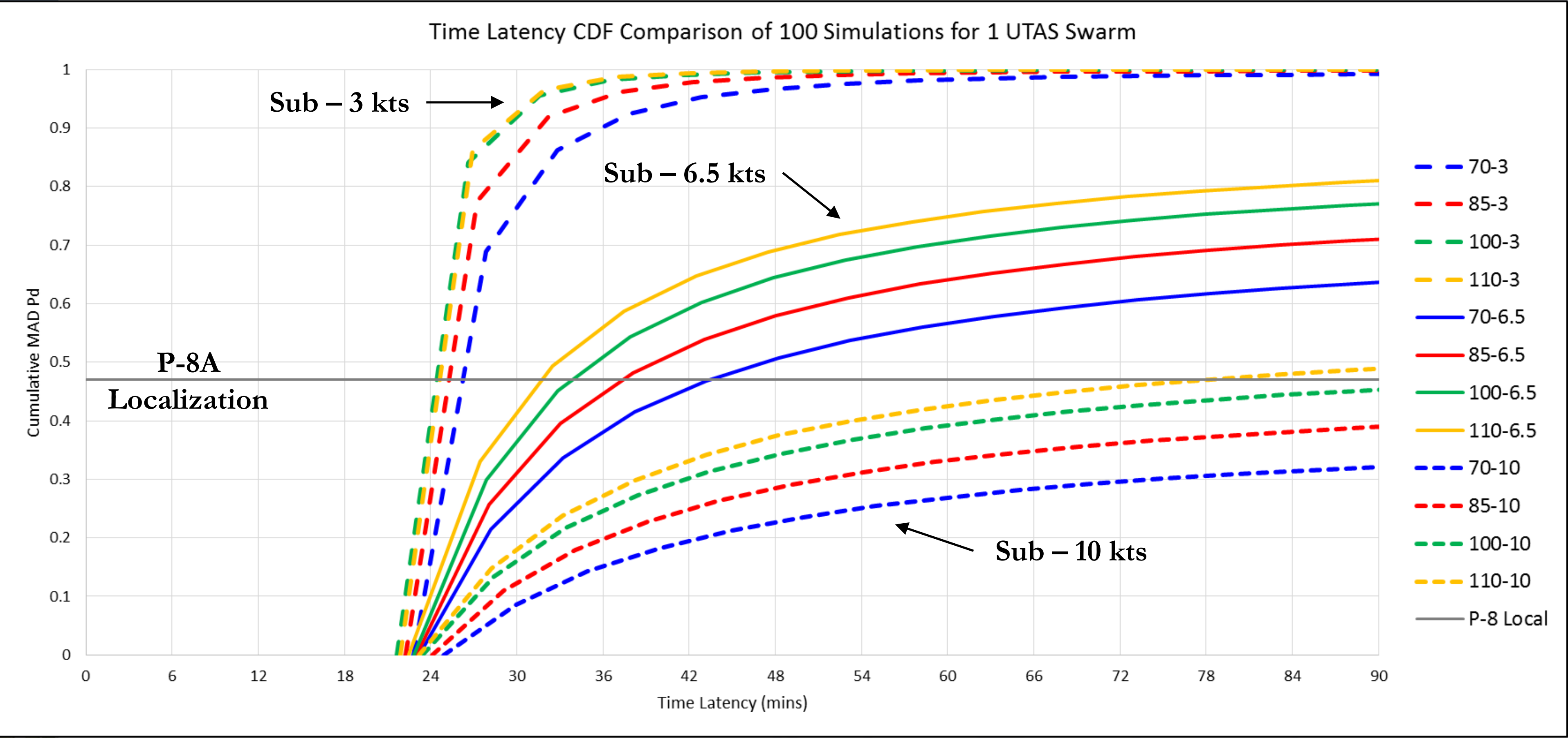

Comparison for 2x Swarm

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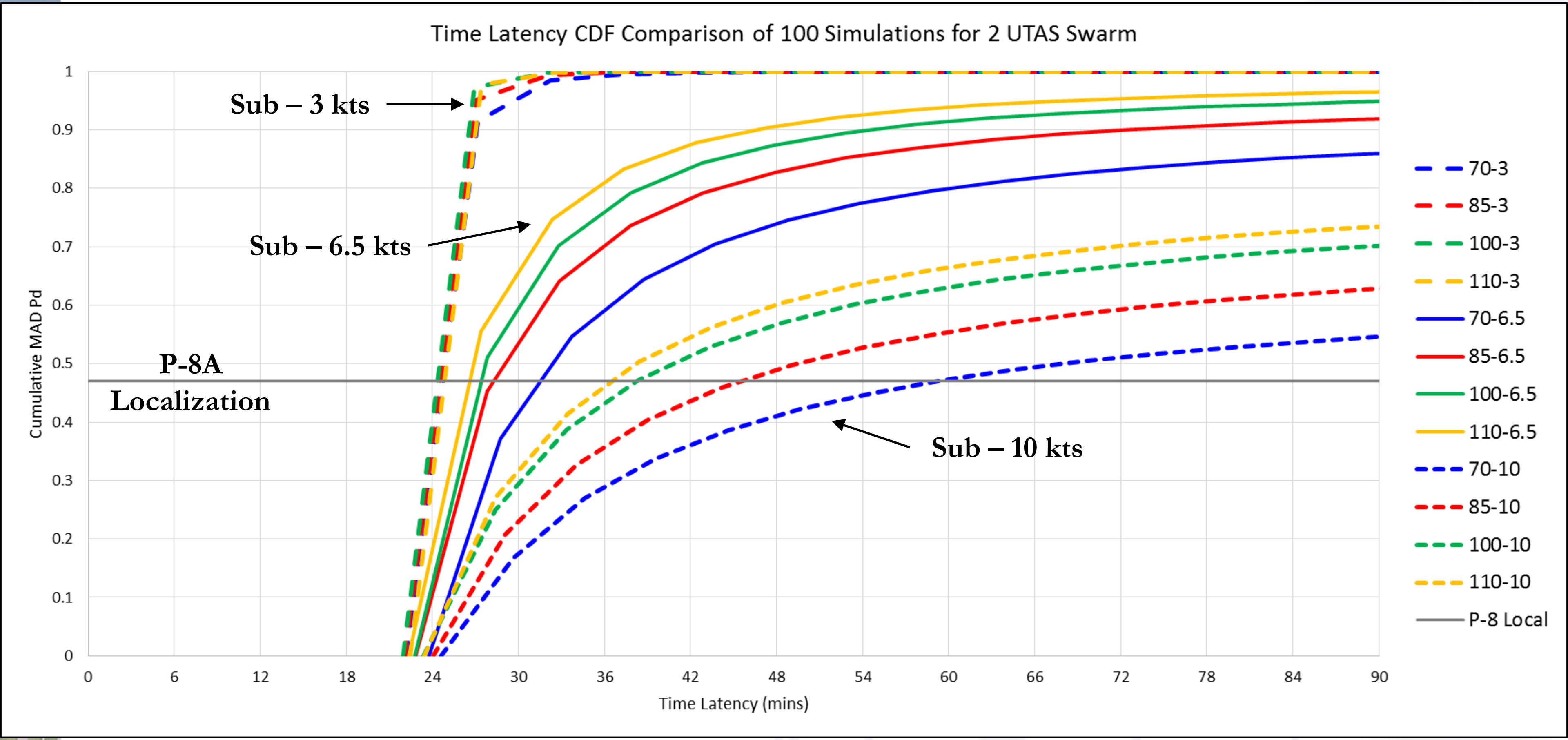
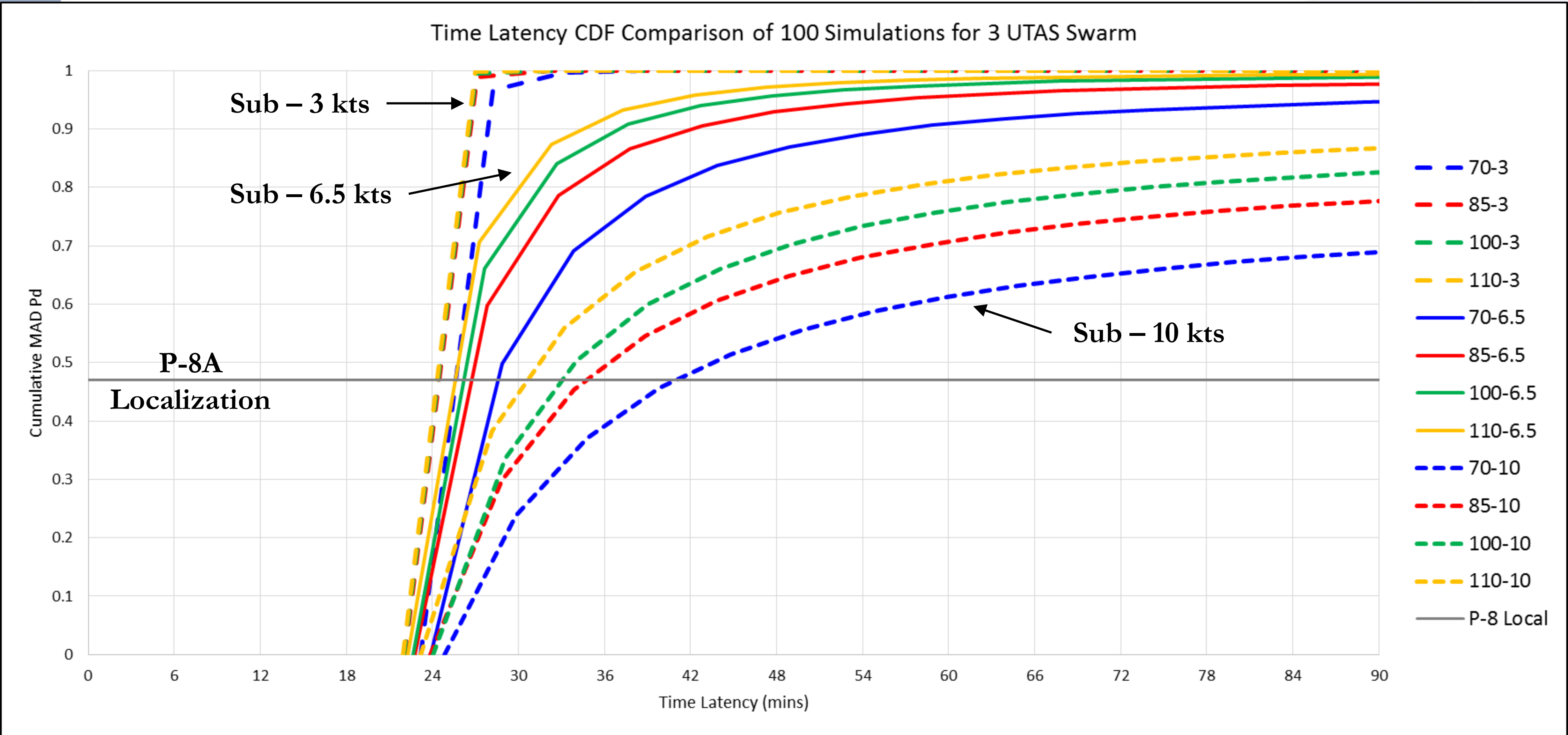


Comparison for 3x Swarm



Comparison for 4x Swarm

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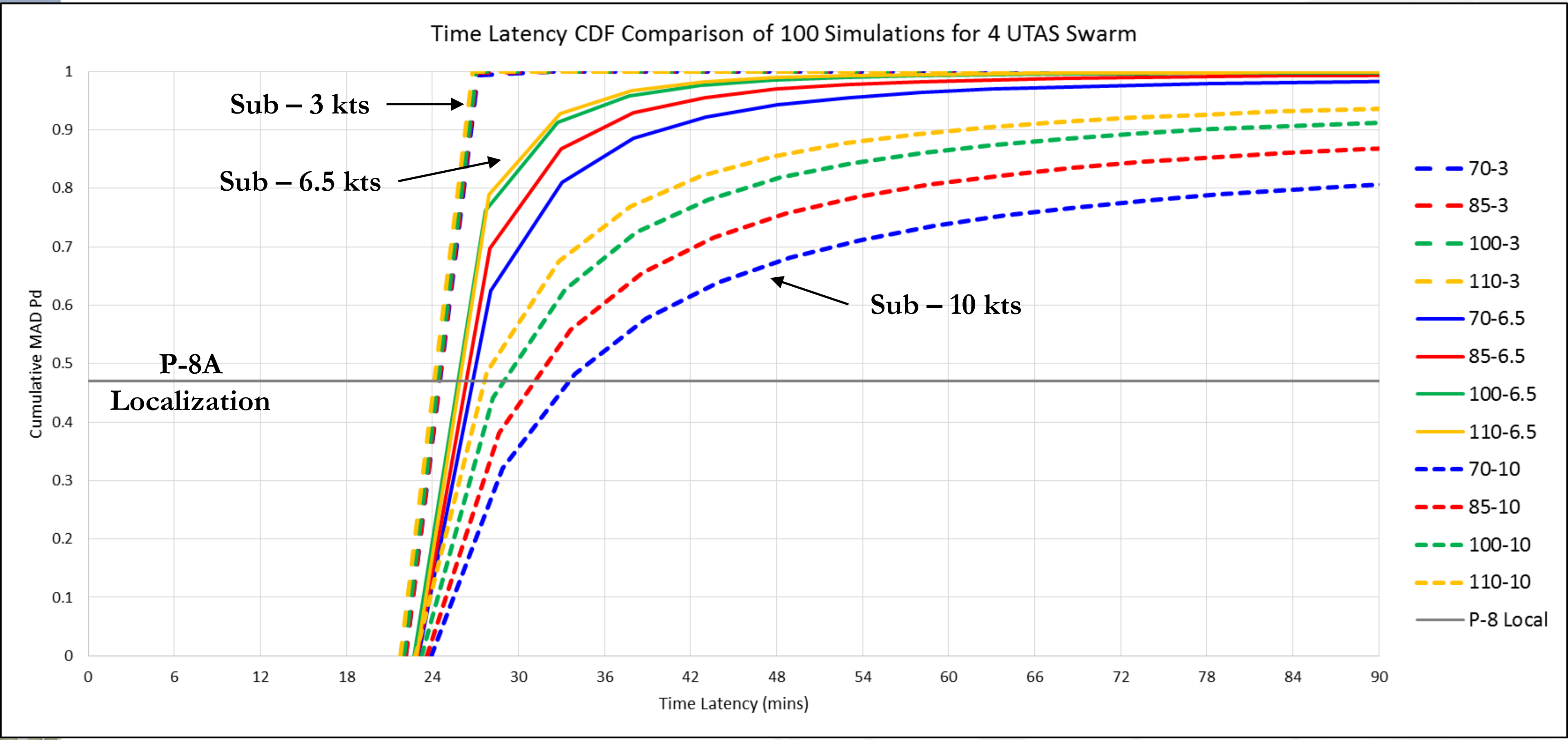

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Comparison for 8x Field

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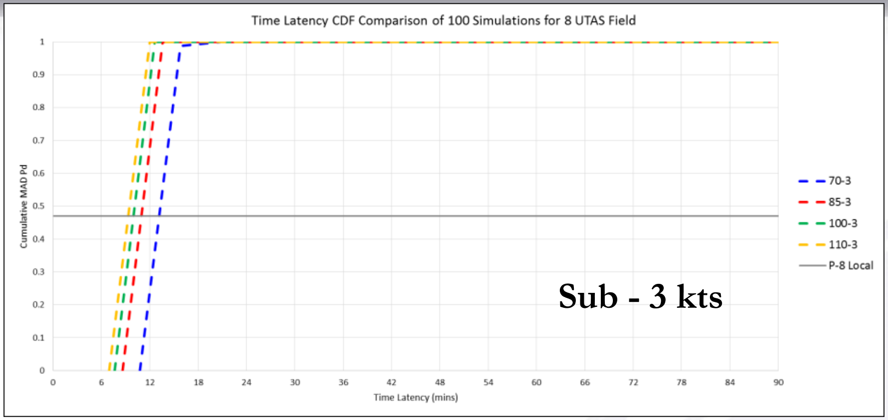

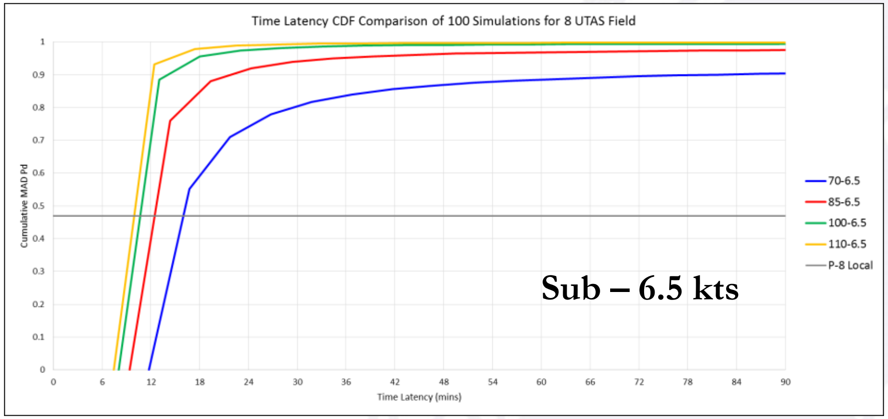

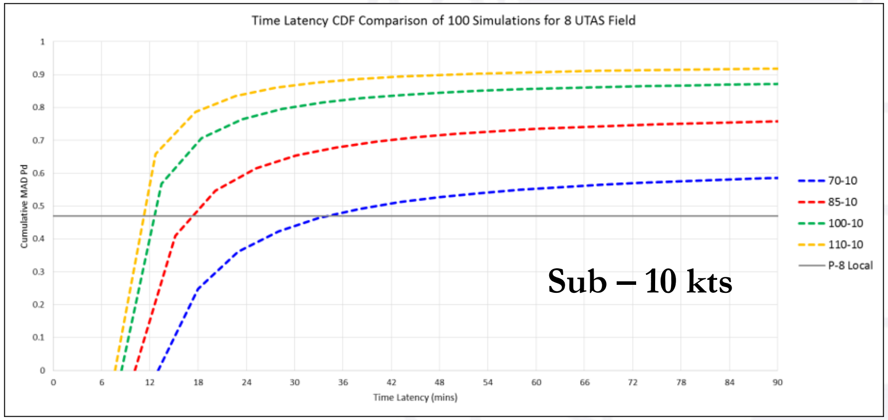

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Comparison for 12x Field

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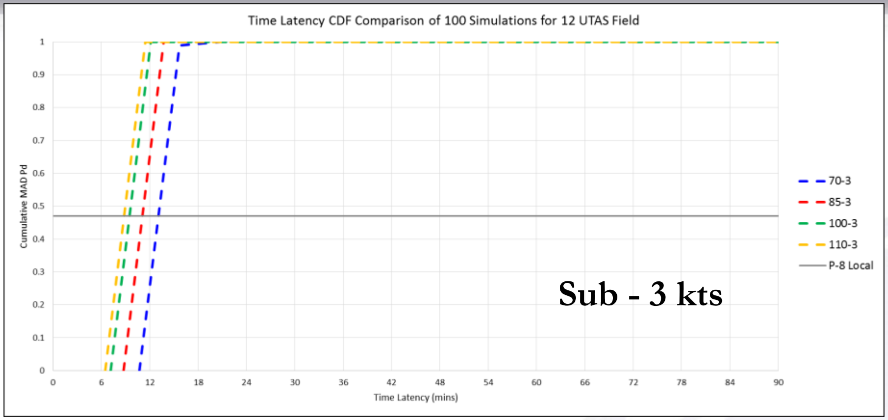

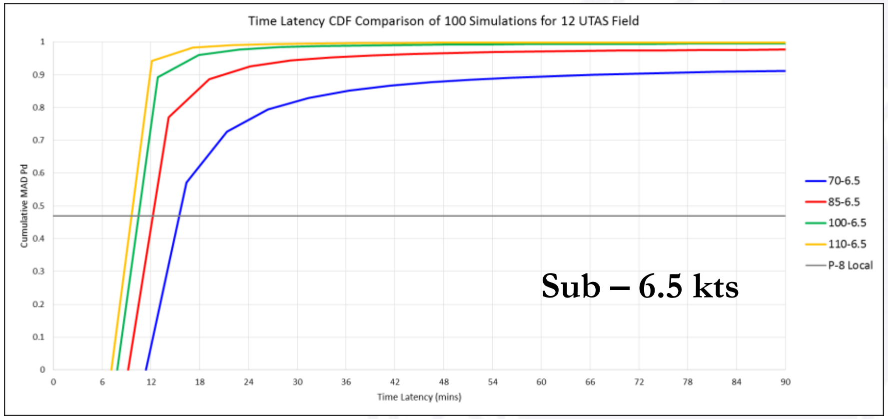

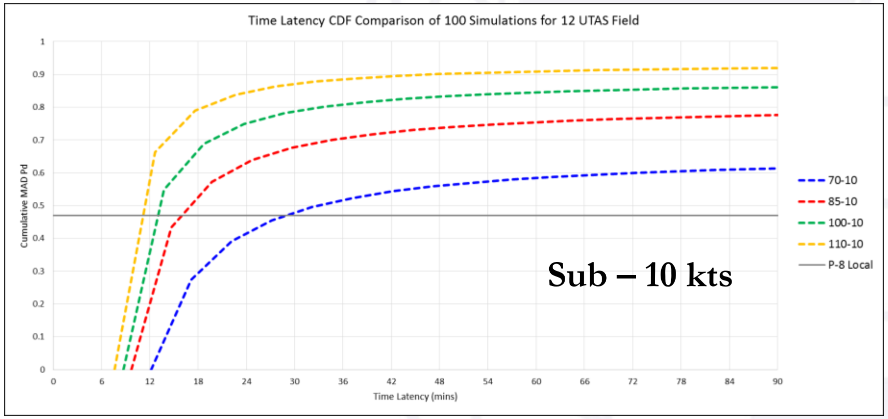

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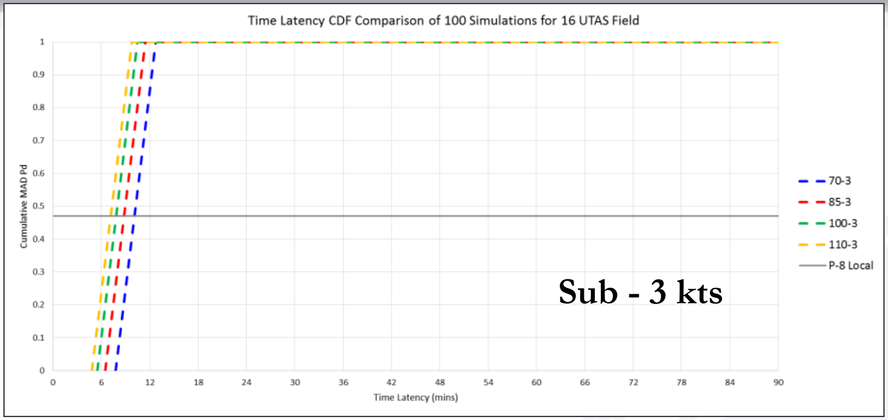
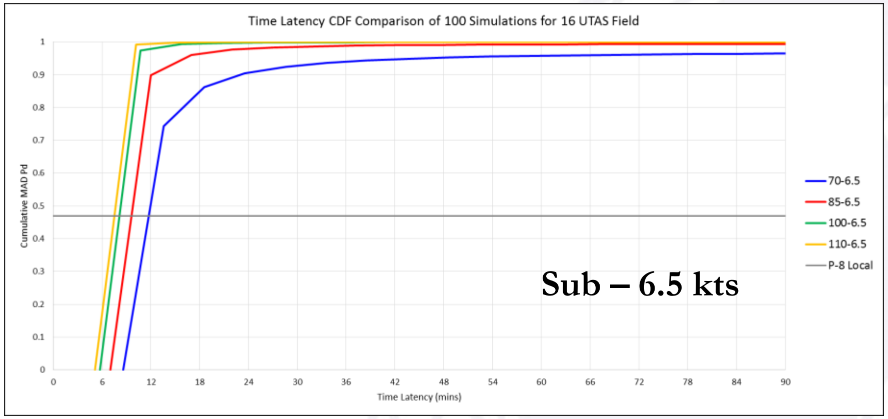
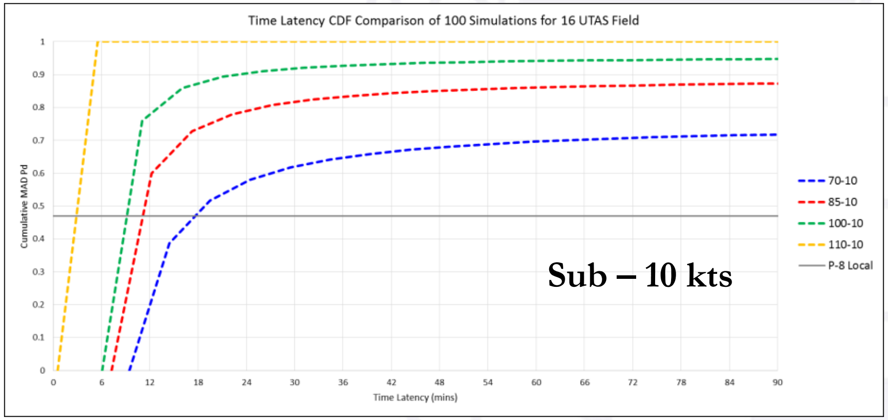
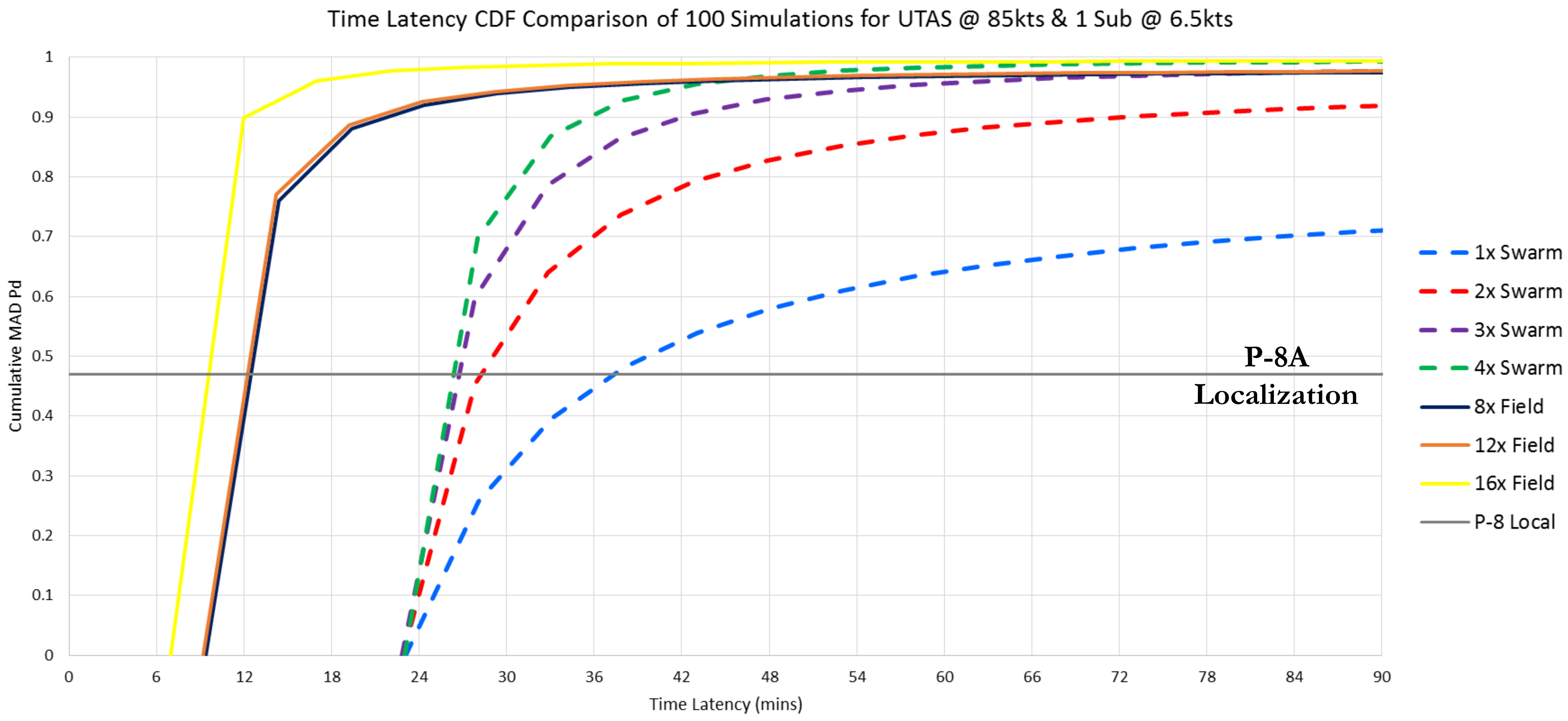
Comparison for 16x Field







Architecture Comparison



Future Analysis Goals

- (U) Incorporate UTAS Endurance into model & analysis
- (U) Incorporate multiple MAC "hits" into model & analysis
- (U) Utilize Minitab program for further analysis of time latency
- (U) Analyze impact of 2nd, 3rd, and 4th best UTAS employment
- (U) Complete minimization analysis to determine most effective UTAS positioning for each field architecture
- (U) Analyze the mean time to lay the MAC field
- (U) Complete architecture cost comparison analysis

Way Ahead

(U) Phase IV: Completion of Report/Analysis

- Validate Capability w/ Gap Analysis
- Build Decision Matrix of Alternatives
- Discuss POM Implications
- Complete Final Report

(U) Completion: 18 November 2016

Remaining Briefs

Initial Project Brief	(U) 03 June 2016
IPR #1	(U) 12 September 2016
IPR #2	(U) In Progress
FPR	(U) Mid-November

Questions?

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