

CLOAR Overview

&

F-18 CLOAR Benefits Study

for

Navy Mission Planning OAG

Agenda

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- **CLOAR Overview**
- **F-18 E/F LO Planning Study**
- **Planning with CLOAR (CONOPS)**
- **CLOAR Enhancements for Navy Tactics**
- **CLOAR Planning Demo & Discussions**

Overview - What is CLOAR?

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Common Low Observable AutoRouter

- **CLOAR is a Low Observable Mission Planning Toolbox - AFMSS Based (now)**
- **Supports fully automatic or manual 3-D multiple route generation, analysis, and deconfliction**
- **On-the-fly defense penetration analysis using platform to threats LO signature (RCS) presentation**

CLOAR Toolbox

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- ***AUTOROUTER:*** Takes user-set priorities and constraints and automatically finds a least cost flyable route
- ***TARGET AREA PLANNING:*** Finds ingress and egress routes that meet user-set priorities and weapon delivery constraints with threat exposure
- ***MANUAL ROUTE EDITING, AND ANALYSIS TOOLS:*** Graphical tools allow the planner to manipulate the route with threat exposure displayed
- ***CONFLICT IDENTIFICATION TOOL :*** *Graphical & text display of multi-route user defined route conflicts*

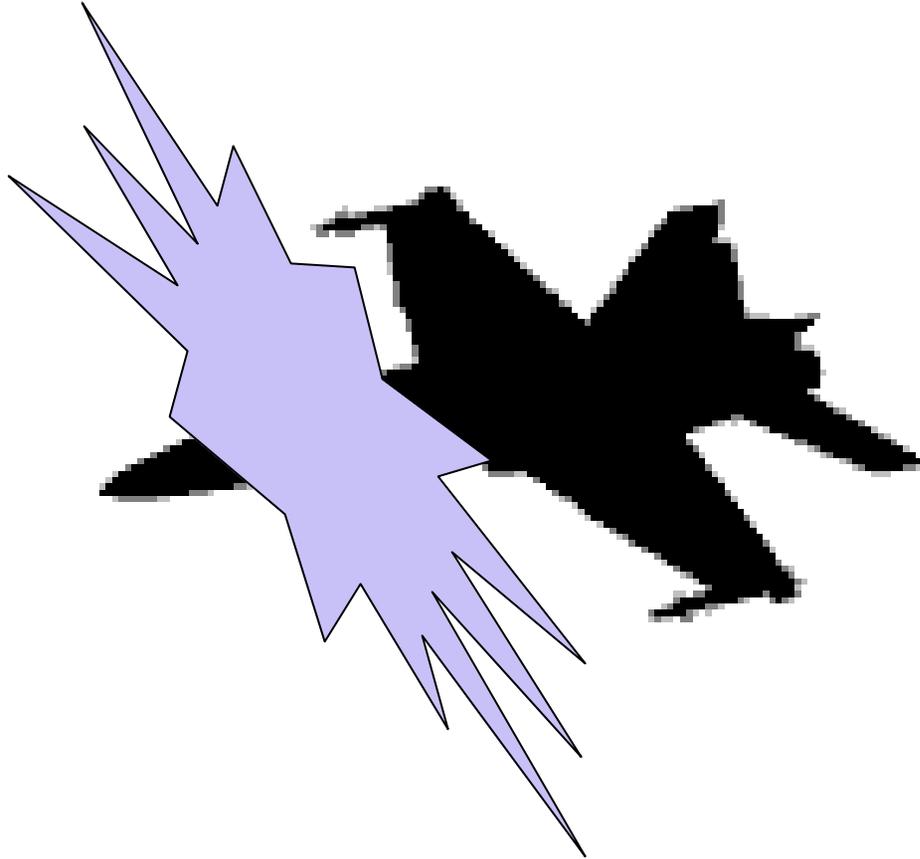
CLOAR Status to Date

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- **Approved for tactical planning for the F-117A**
 - CLOAR threat analysis validated by LMSW
- **Integrated into the B-2 MPS (in test Whiteman AFB, MO)**
- **Integration underway into the ARMS / APS SIOP Planning System**
- **Integration underway for JASSM**
- **Supporting JSF planning analysis - Pax / Boeing / LM**
- **China Lake study underway for F-18 tactics analysis**
- **Flown on F-117A demonstrating onboard autorouting**

RCS - So What ?

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WHY CONSIDER RCS MANAGEMENT ?

RCS Management

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Sample Radar Cross Sections

Sq Meters	.0001	.001	.01	.1	1	10	100	1000	10000
dBsm	- 40	- 30	- 20	- 10	0	10	20	30	40
Example	Insects	Birds			Small A/C	Large A/C	Ships		

RCS Management

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Maximum Detection Range as a function of RCS (FAA ARSR-2 Radar)

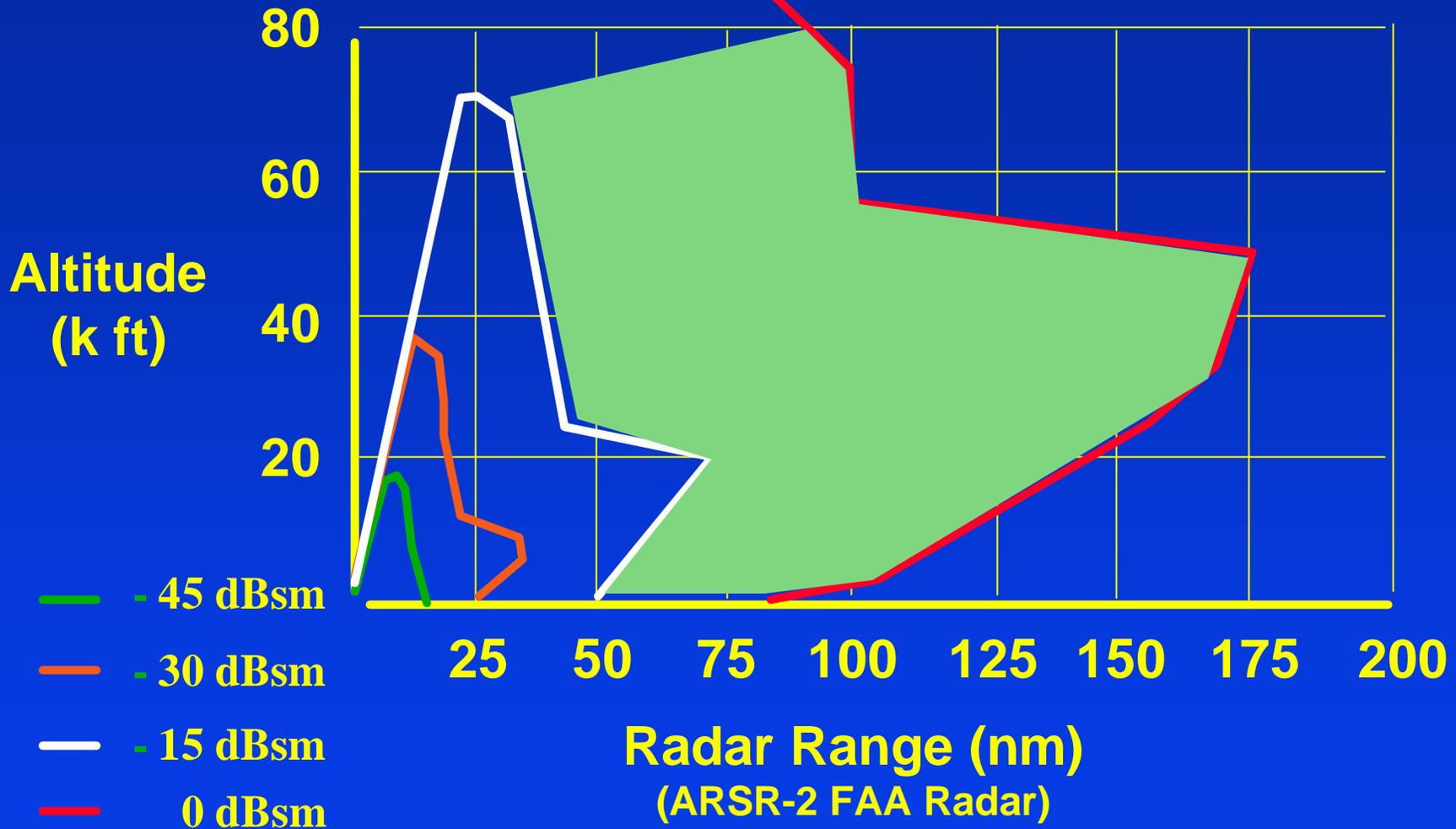
RCS (sq meters)	.001	.01	.1	1	10	100
Detection Rmax (nm)	32	57	101	180	320	569



44 %

Why RCS Management ?

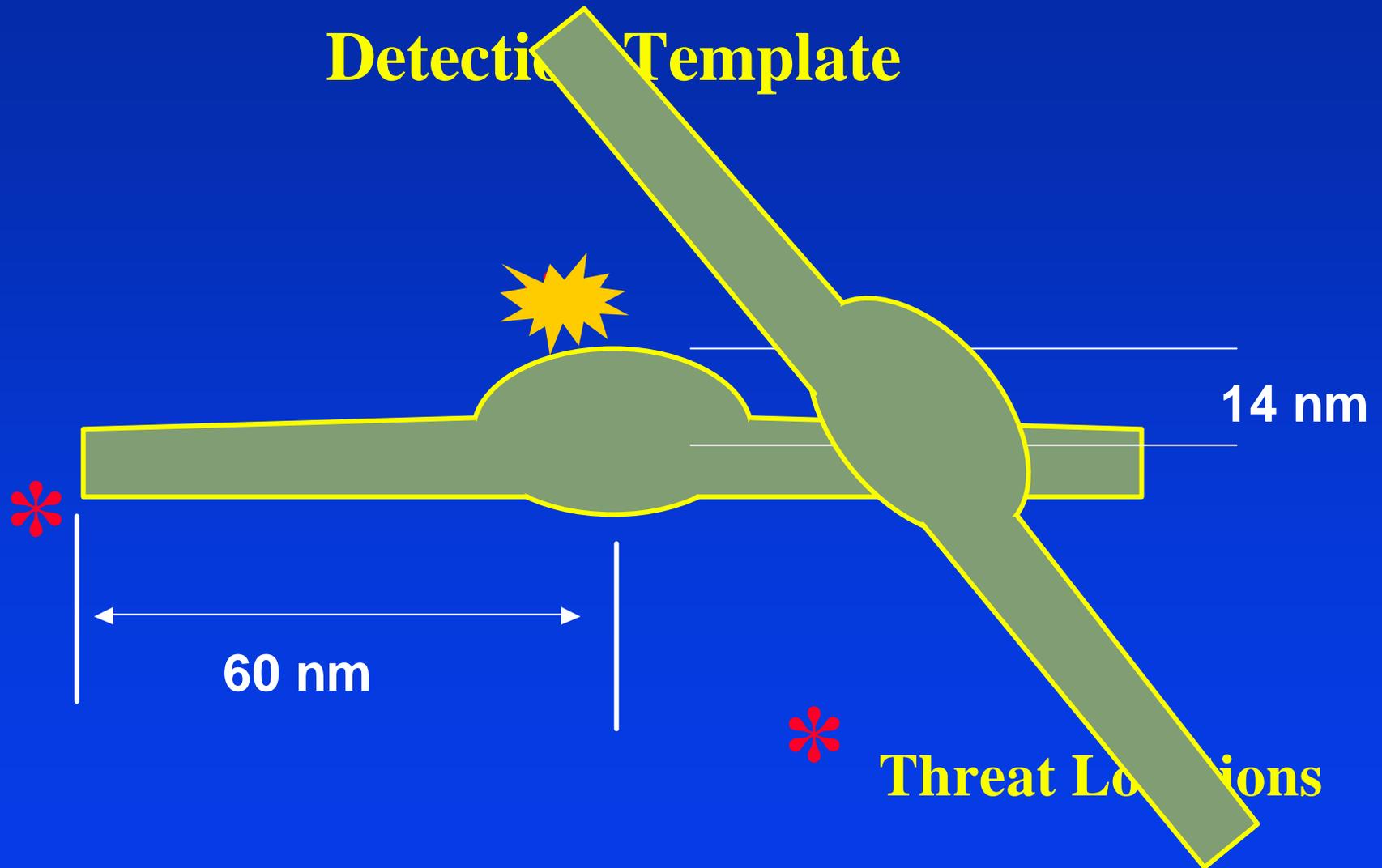
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Sample RCS Exploit

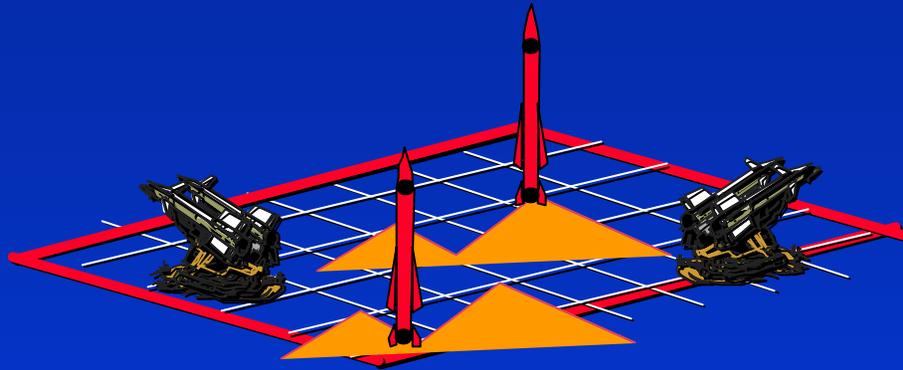
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Detection Template



CLOAR is Data Driven

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A/C Performance Data

CLOAR

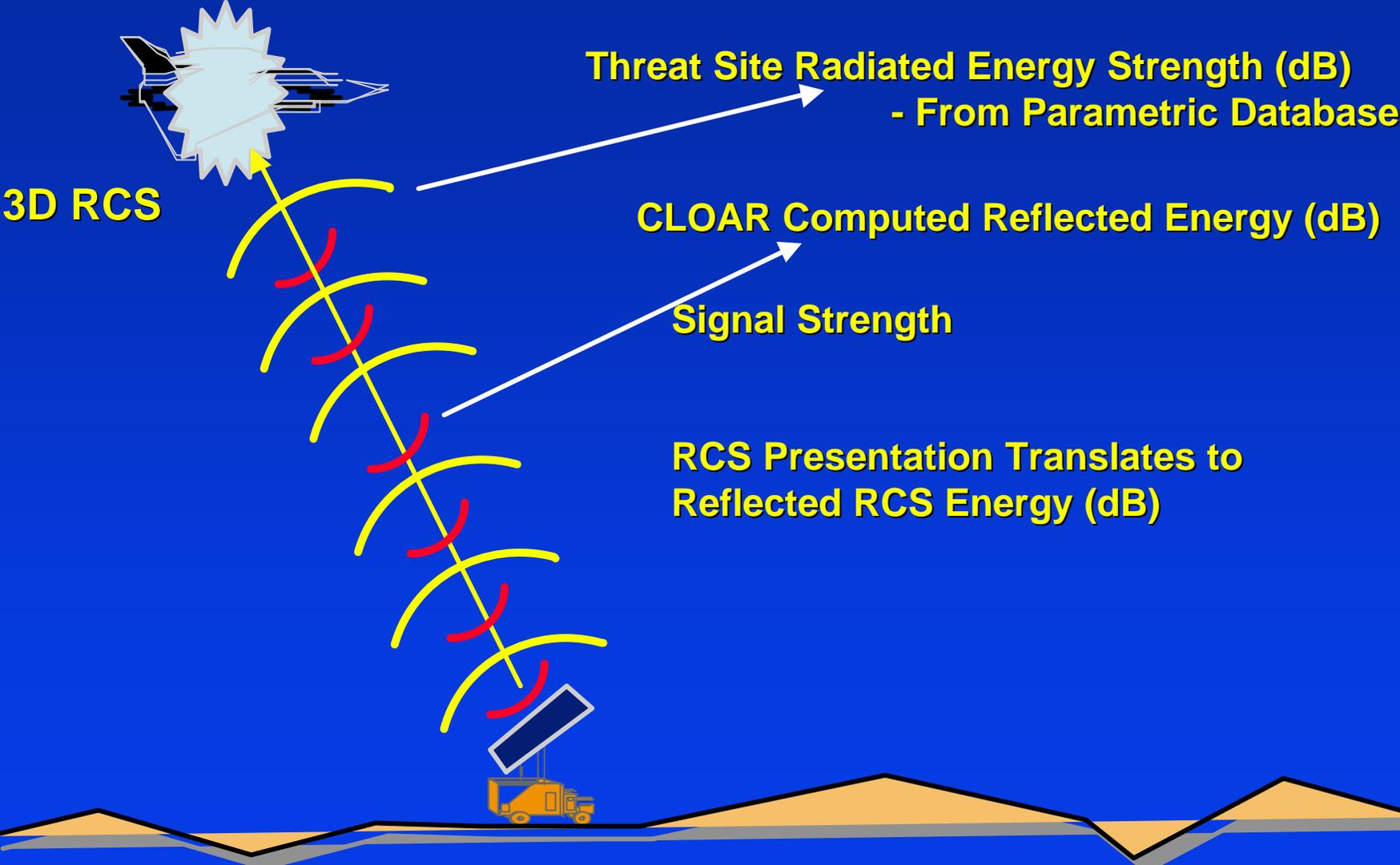
Vehicle 3D RCS

- EOB

- Treat Parametrics

- DTED

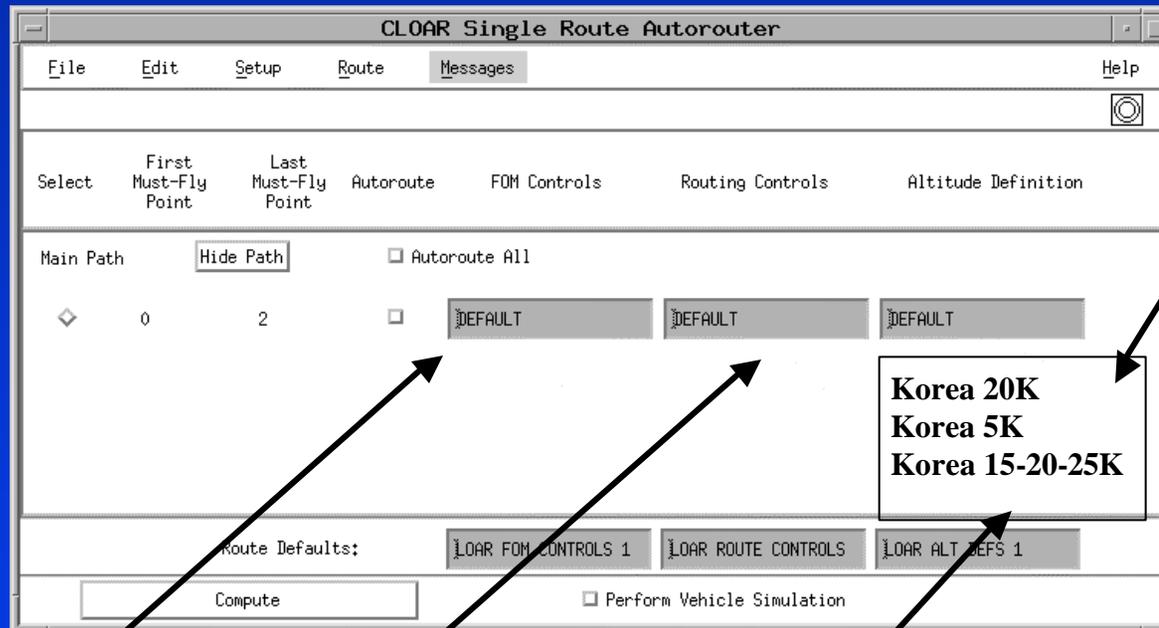
How CLOAR Works



How CLOAR Works - Settings

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CLOAR autorouter settings selected from default tables



FOM Settings, Routing Controls, Altitude Definitions

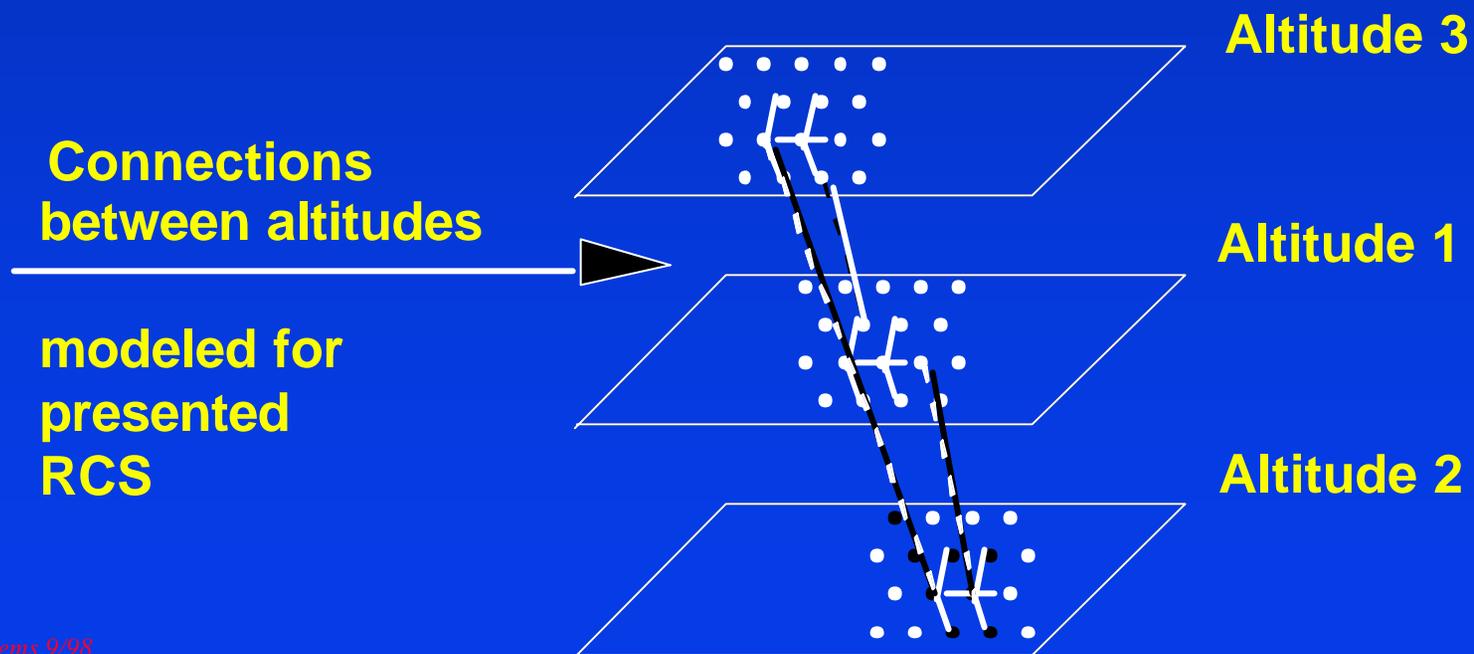
Routing Controls

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- **Routing Controls Determine Network Fidelity**
 - Network size can be limited by fuel
- **Routing Controls Support Tactics and SOP**
 - Max time on single altitude
 - Max time holding single heading
 - Max heading change for each new leg
- **Options may be pre- defined prior to planning sessions**

Altitude Definitions

- User can specify 1-10 specific altitudes or altitude bands
- 2-D networks are generated for each user selected altitude
- Valid connections between altitudes are evaluated during autorouting subject to:
 - PM determined climb and descent data



FOM Discussion

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- **FOM = Figure of Merit**
 - Which threat events are measured
- **SAM, AAA, Avoidance Zones, EW/GCI**

Options may be pre- defined prior to planning sessions

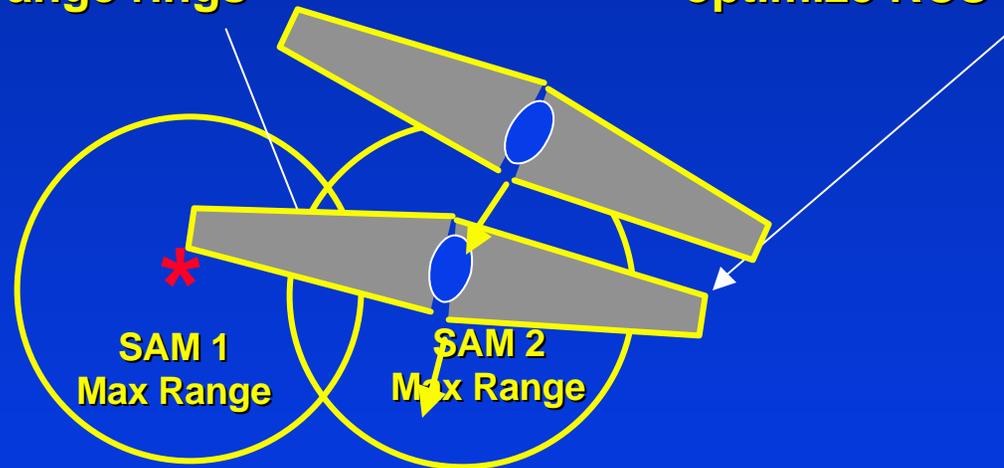
Planning with an LO RCS

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LO vs Conventional Aircraft Planning

Conventional planners plan the EOB from a set of max range rings

LO planners try to optimize RCS effectiveness



Near head-on approach to a SAM site reduces exposure and allows the LO jet to “sneak past” threat # 2 while presenting minimum exposure to threat # 1

Fallon Benefits Study

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Why ?

- **Optimizing an LO signature through an EOB is beyond a manual planner's ability for a dense EOB**
- **The CLOAR autorouter uses the 3-D vehicle RCS signature to plan optimized routes**
- **The Navy (PMA 265) funded this CLOAR benefits study at NSAWC Fallon, NV to obtain initial data about autorouting for the F-18 E/F**

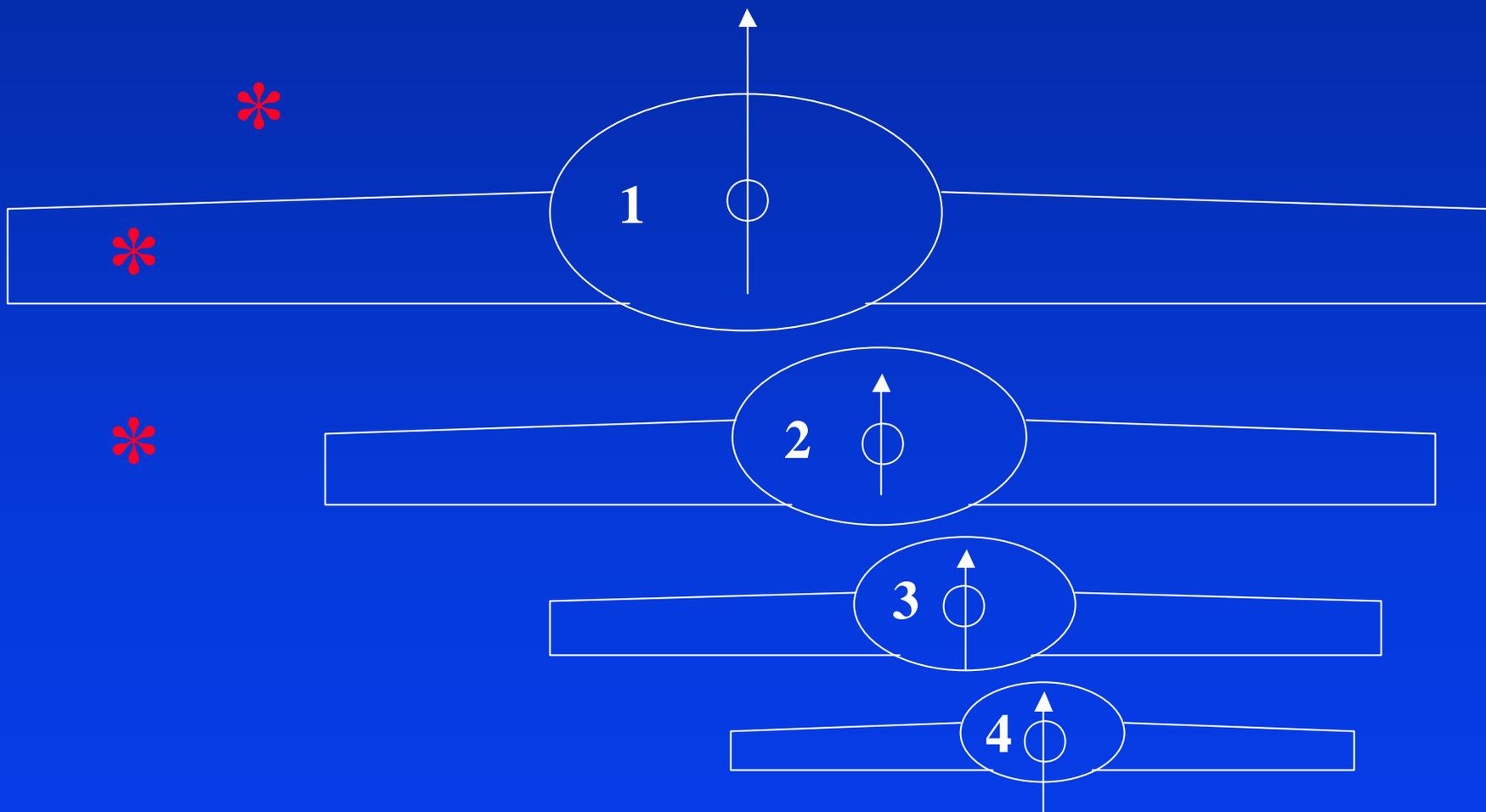
Benefits Study Objectives

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- **Compare CLOAR and Manually Planned Routes**
 - **Using NSAWC expert mission planners**
 - **Using Navy provided F-18 performance data**
 - **Using Navy provided F-18 E/F notional RCS data**
 - **Using an AFMSS based CLOAR mission planning system**
- **Compare Threat Exposure for the Manually Planned and the CLOAR Autorouted Routes**
- **Document NSAWC Planner's Comments Regarding CLOAR Tools Application for Mission Planning**

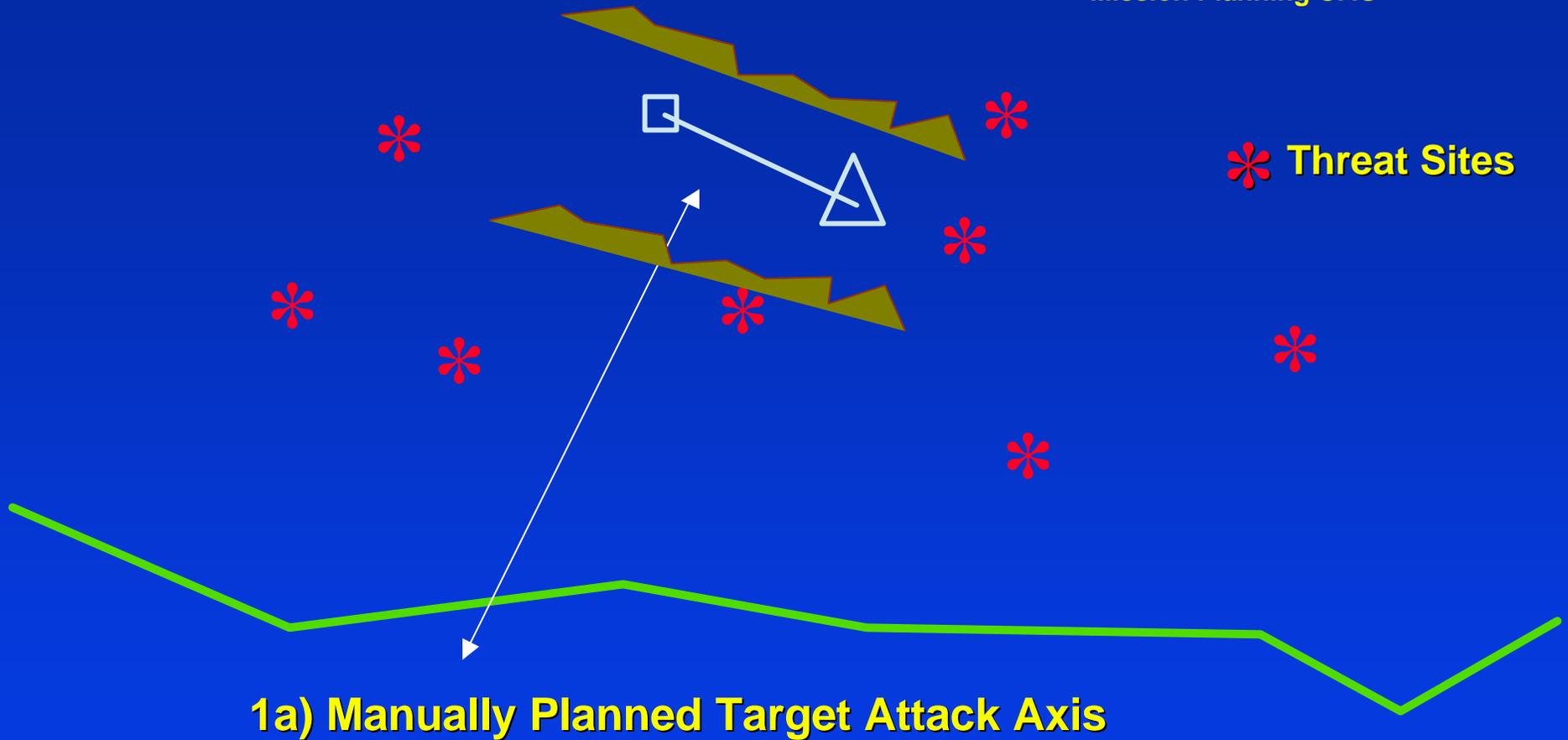
4 RCS Levels Provided

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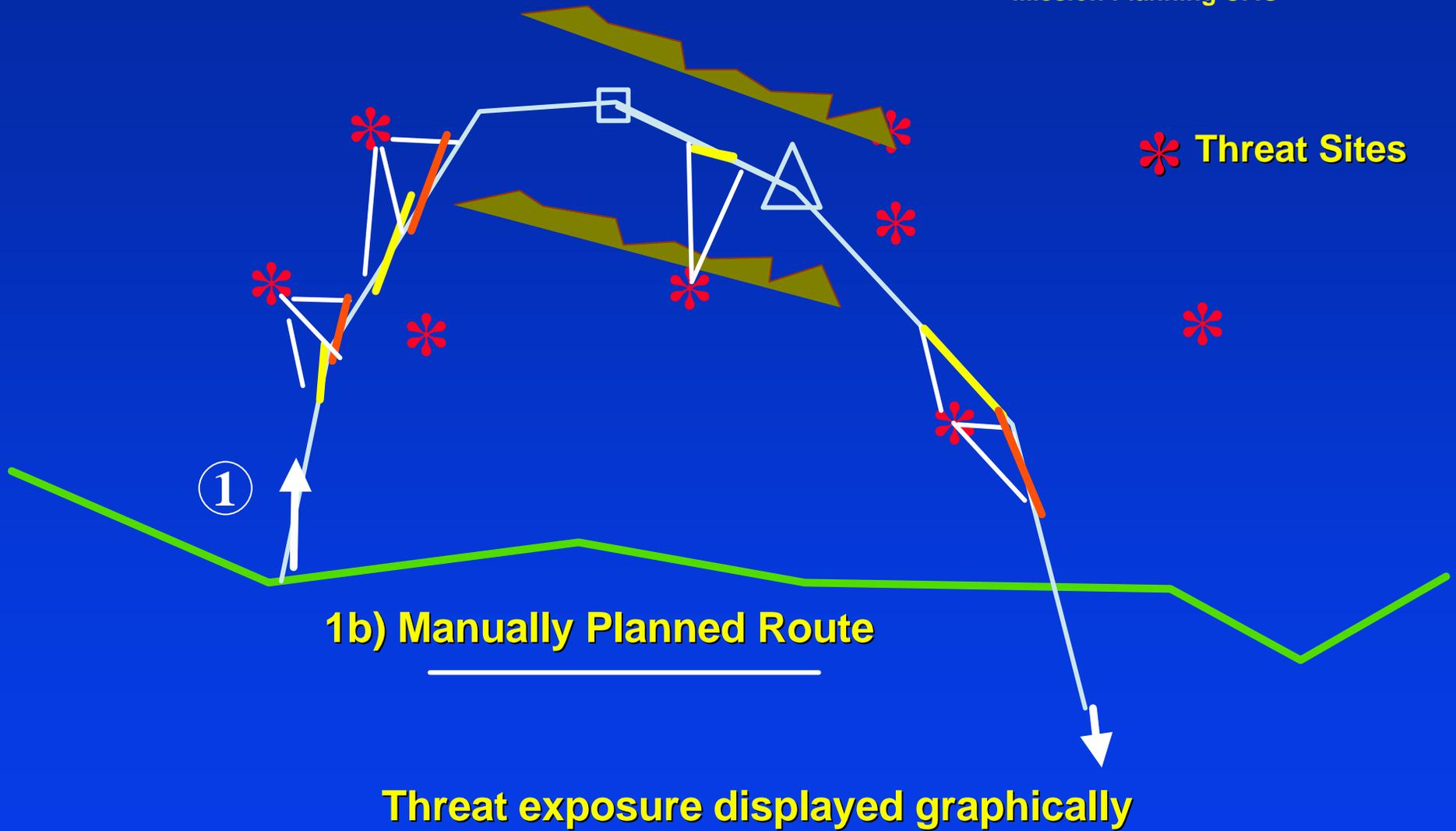
CLOAR Study Methodology

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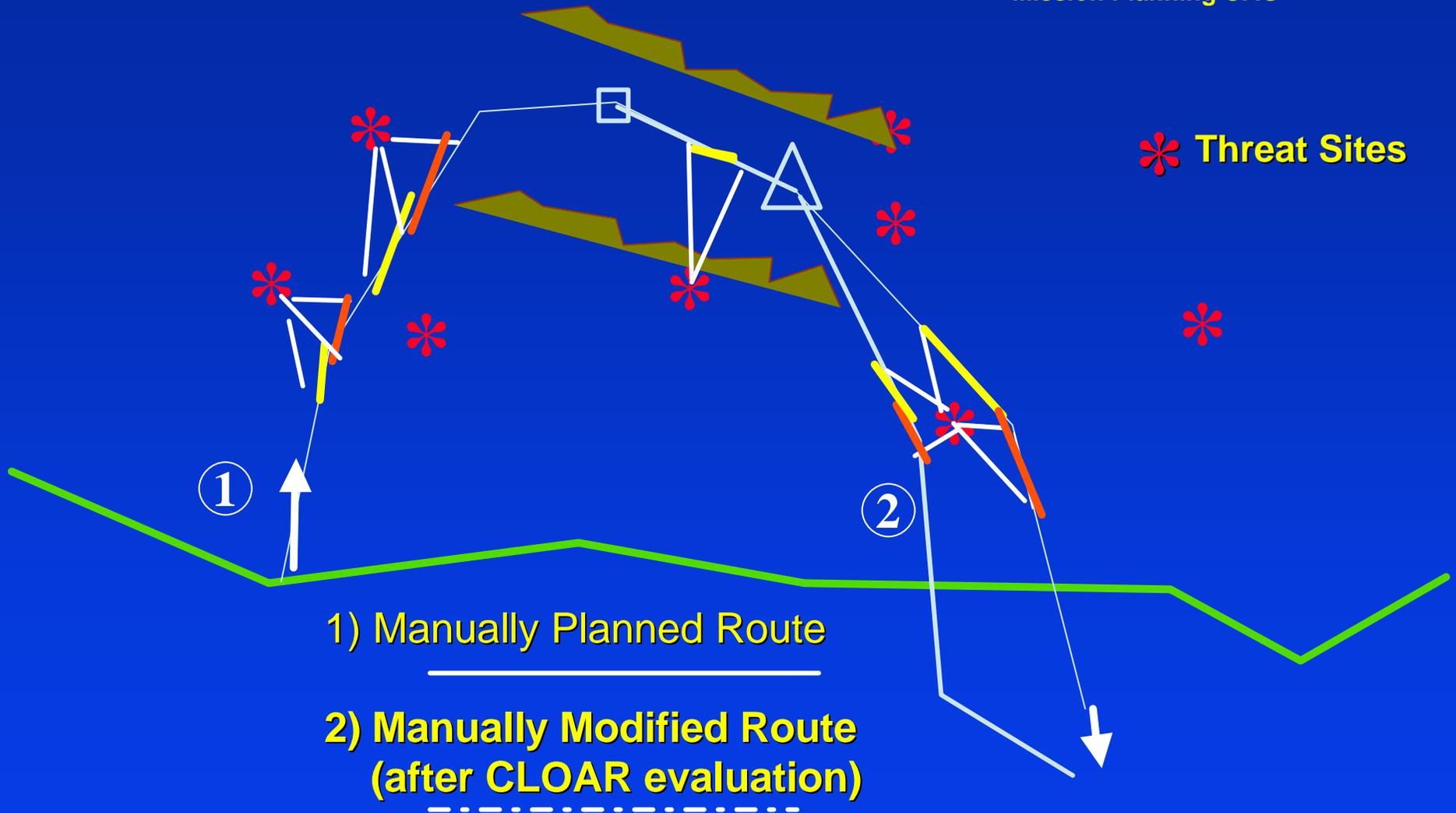
CLOAR Study Methodology

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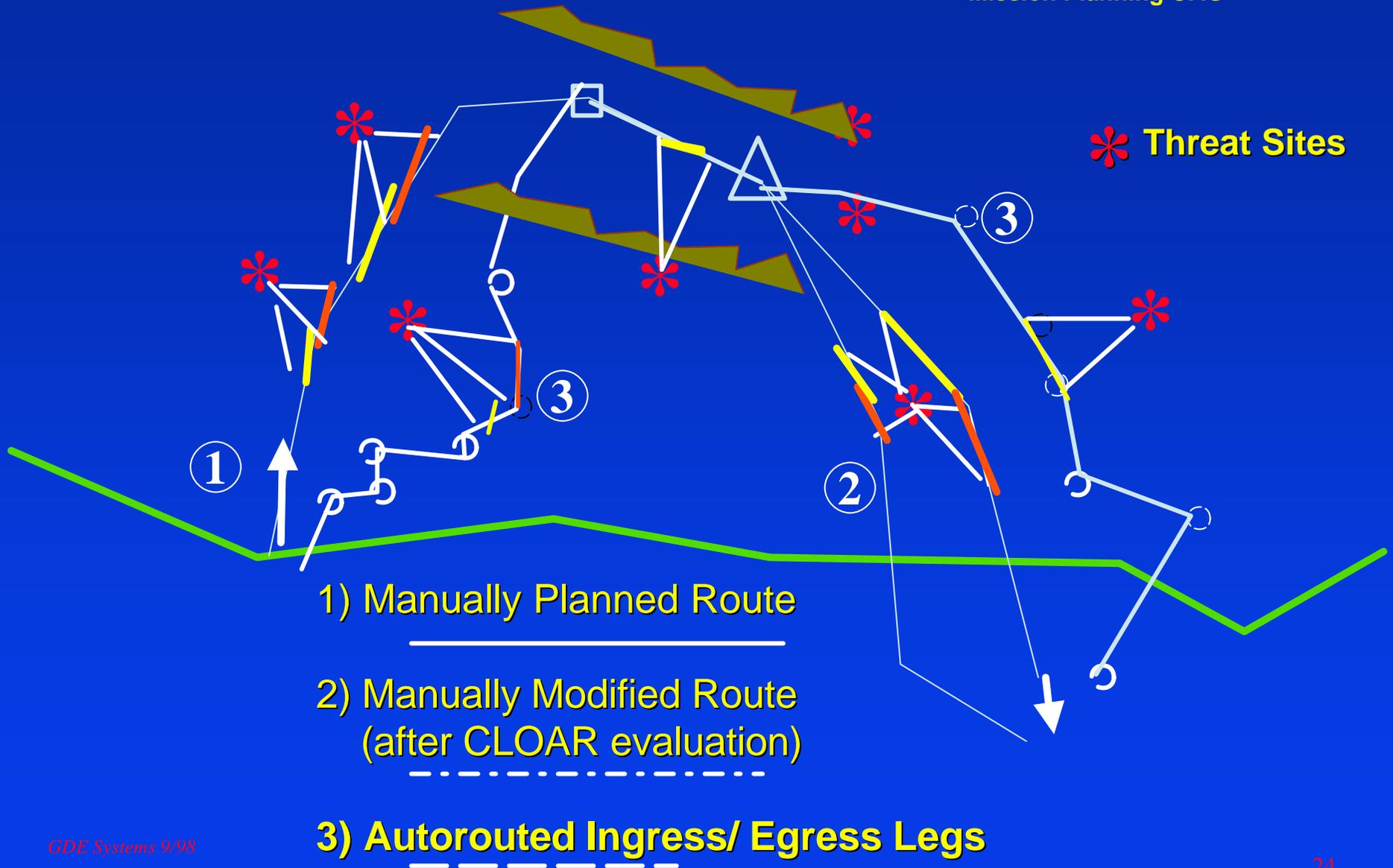
CLOAR Study Methodology

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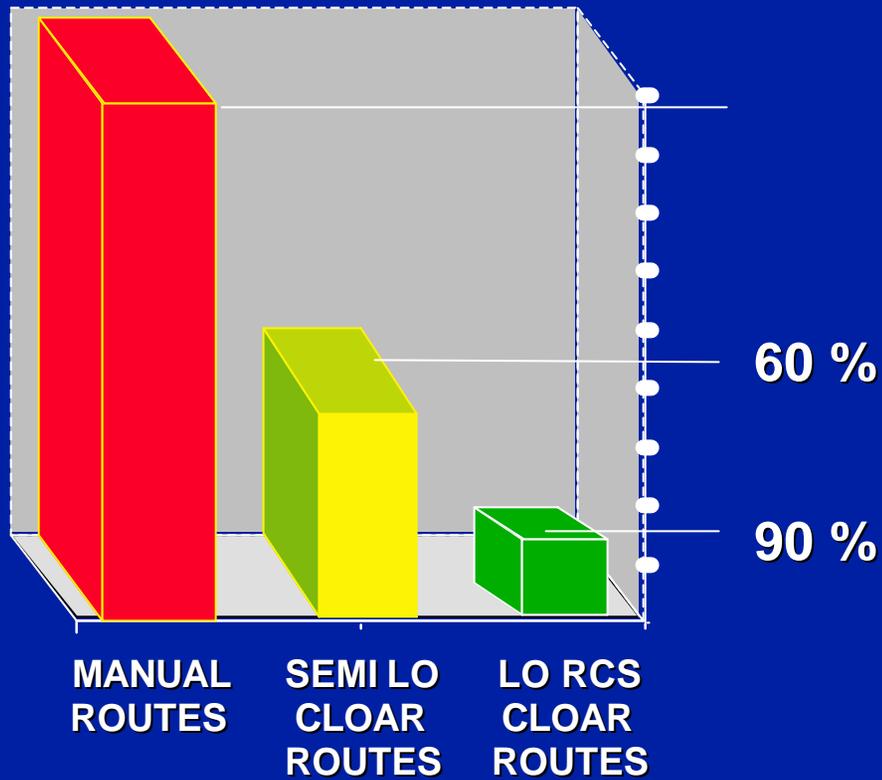
CLOAR Study Methodology

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Study Results

Threat Exposure Comparison



Summary of 5 Autorouted Routes in Korea & Iraq

Planning Sessions Results

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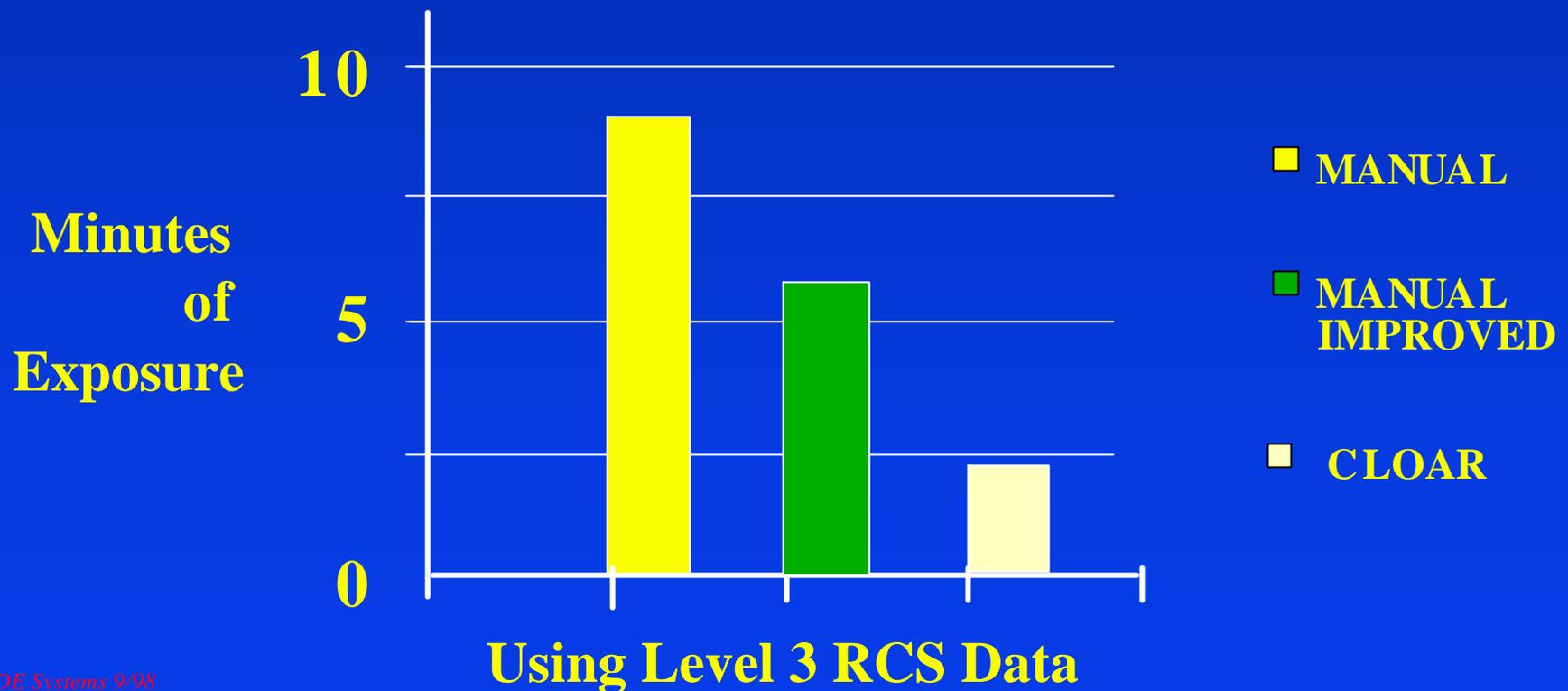
Total CLOAR Measured Exposure (minutes : sec)
All Routes - Five Missions / Two Theaters

FOM Type	# 1				# 2			
	1	2	3	4	1	2	3	4
RCS Levels								
Manual Totals	34:20	30:03	16:13	7:25	43:05	37:40	20:21	10:17
CLOAR Totals	15:15	14:57	4:57	0:04	24:16	24:24	11:19	1:42

Manual/Manual Improved/CLOAR

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Summary Graph - Two Routes with Manual Modifications
for
FOM # 1 (total minutes of exposure)



Study Results - NSA WC Comments

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- **Autorouting and route evaluation is essential to LO signature optimization**
- **CLOAR tools useful for developing initial concept plan supporting CAG laptop briefing**
- **CLOAR tools useful for definitive SEAD target selection and jammer placement & tactics planning**
- **CLOAR threat exposure displays are excellent for pilot situational awareness during briefing and flight**
- **CLOAR displays of aircraft sensor footprint-on-path very useful during target area planning**
- **CLOAR analysis needed for stand-off weapon planning such as JDAM, JSOW, SLAM-ER, TLAM, JASSM**
- **CLOAR displays useful for LO tactics training**

The Goal = Reduced Threat Exposure

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Increase combat effectiveness and reduce threat exposure
by optimizing the F-18 RCS

FOM	I	L
Manual 25k	2:31	4:48
CLOAR 25k	1:19	4:20
% Improve	48%	10%

Level 3 RCS

Level 1 RCS

FOM	I	L
Manual 25k	8:15	11:12
CLOAR 25k	5:24	8:47
CLOAR 1k _{AGL}	1:24	2:02
% Improve	35/85	

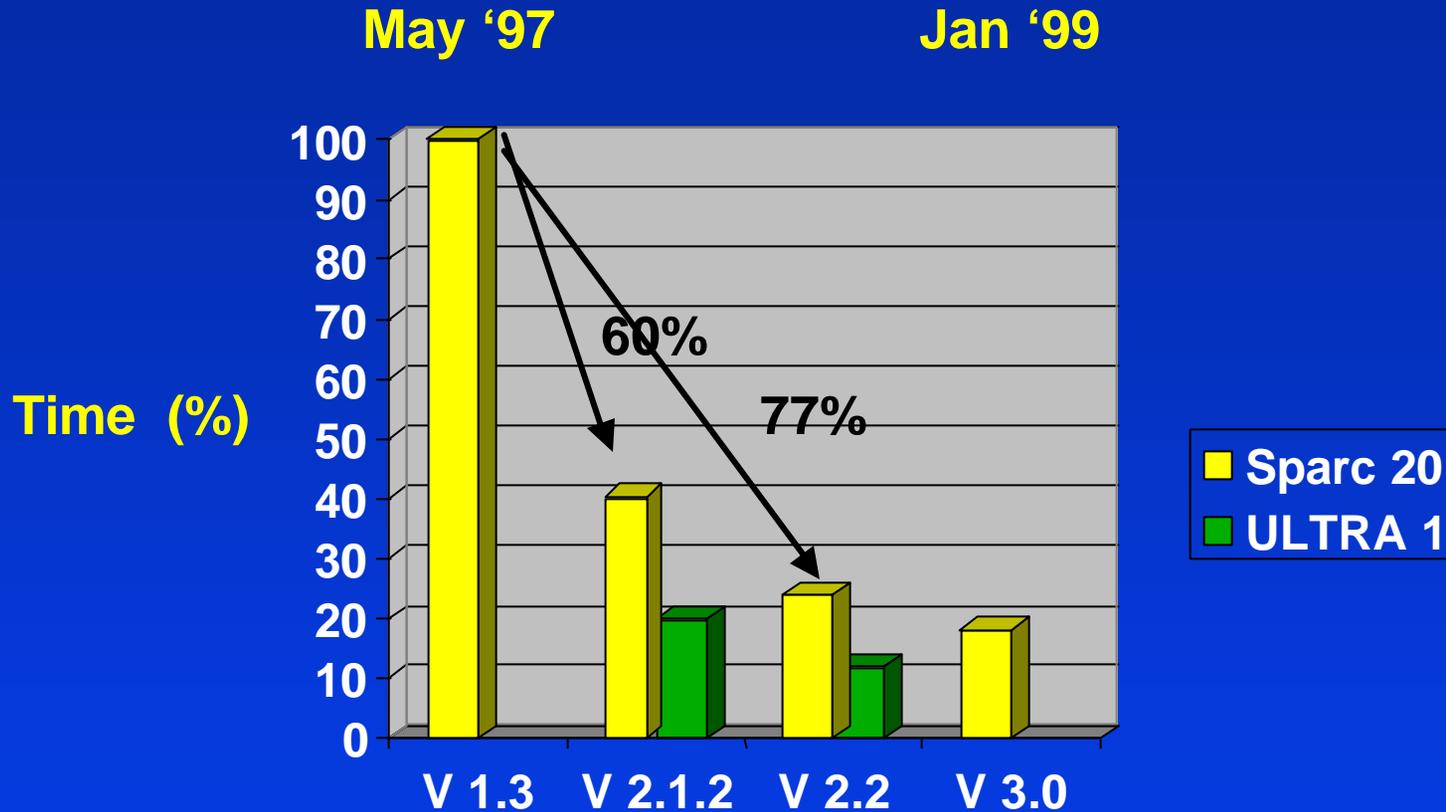
CLOAR Decision Aids

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- **Develop Concept Routes then Detailed Routes**
 - Autorouter assisted - ingress/egress/altitudes
 - CLOAR Altitude Analysis Tool
- **Analyze delivery - axis /LOS/exposure/weaps select/alt**
- **Develop SEAD Plan - High Threat SAMs**
- **Assist EA-6 Planning - SAM Site Selection**
- **Produce Briefing Materials**

CLOAR Run Time Improvements

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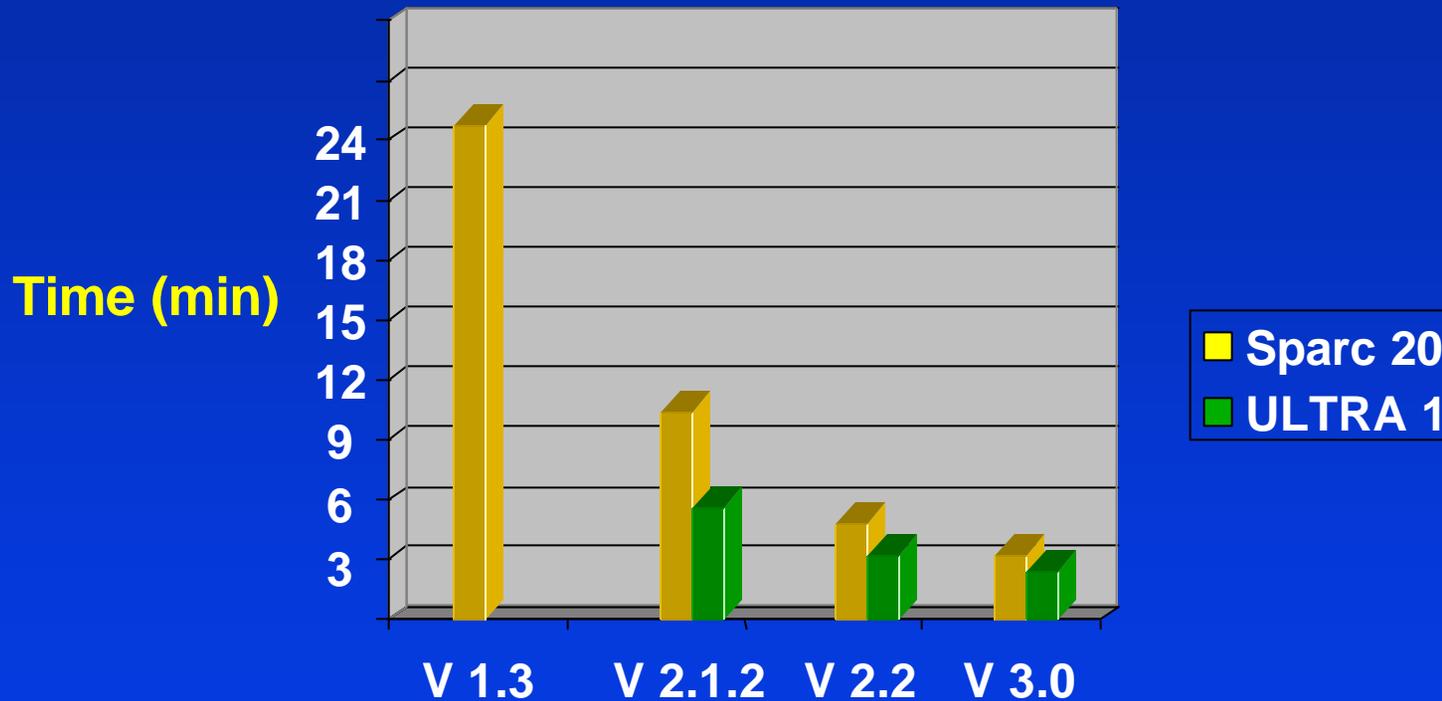


CLOAR Run Time Improvements

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May '97

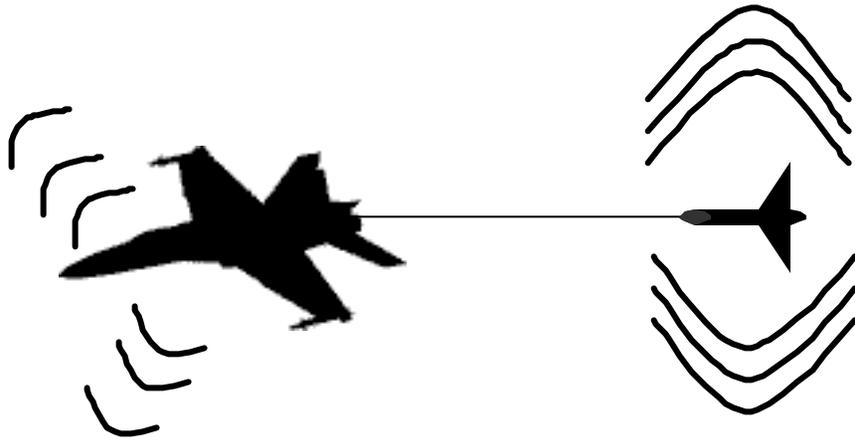
Jan '99



300 nm Autoroute in NK

CLOAR Enhancements for Hornet Tactics

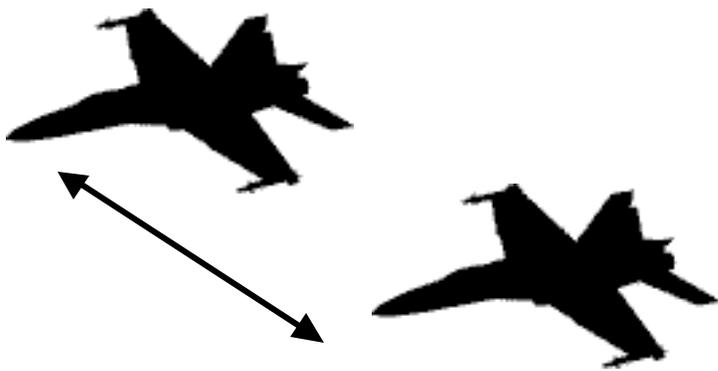
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PLANNING with DECM



**PLANNING for
THREAT JAMMING**



FORMATION of HORNETS



**RADAR on/off
WEAPON RELEASES
SCL vrs RCS TRADES**

Summary

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- **Threat exposure reduced by 60% to 90% for semi-LO to very LO RCS over traditional manual planning techniques**
- **CLOAR autoroutes 300 nm routes in < 3min in N Korea scenarios (and improving)**
- **CLOAR was well received by Navy planners at NSAWC Fallon, TAMPS OAG, TACAIR Symposium, HTAT**
- **CLOAR integration costs a fraction of aircraft program expense and total (USAF) CLOAR development costs**
- **Planning for F-18 Tactics requires enhancements to CLOAR**
- **CLOAR support to Navy LO tactics continues under study**

The Bottom Line - Mission Effectiveness

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Thank You

Questions ?