This packet is the reference for Quiz 10: the questions cite its tables and figures by number. The questions and their answer boxes are in Gradescope, and you may read this packet ahead of time.

1 Scenario Description

Following your recent assessment of the communications architecture, the Vice Chairman of the Joint Chiefs of Staff (VCJCS) expressed strong confidence in your recommendations. Your ability to analyze complex systems and propose meaningful improvements has gained the attention of senior leadership.

Before directing the System Program Offices (SPOs) and their System Program Directors (SPDs) to move forward with implementation, the VCJCS has asked for your expertise on a new task. Specifically, you have been asked to evaluate a newly defined reference mission scenario, focusing on how our systems perform in the domains of radar, electronic warfare, and the defeat of an Integrated Air Defense System (IADS).

To complete this evaluation, you will need to leverage technical data and operational requirements provided by the Joint Requirements Oversight Council (JROC) and the SPOs. Your objective is to determine how well current and proposed capabilities meet mission demands, assess vulnerabilities, and identify opportunities to disrupt or penetrate advanced air defense networks. Your findings will help shape the VCJCS's final decision and guide future program direction across the Department of Defense's modernization efforts.

Figure 1 presents the same communications architecture previously evaluated. An Integrated Air Defense System (IADS), consisting of Early Warning, Acquisition, and Fire Control Radars, as well as Surface-to-Air Missiles (SAMs) housed in their Transporter Erector Launchers (TELs), has been overlaid based on intelligence data. The IADS employs both fiber optic links (black) and radio frequency (RF) links (pink) for communication.

Intelligence indicates the presence of an S-Band (3.00 GHz) communications jammer, which may interfere with the F-47 data link. It is anticipated that Air Intercept fighters will be launched for target defense.

New U.S. assets include a Low Earth Orbit (LEO) Synthetic Aperture Radar (SAR) platform, tasked with final target confirmation and geolocation. Additionally, the RQ-170 will conduct post-strike battle damage assessment.

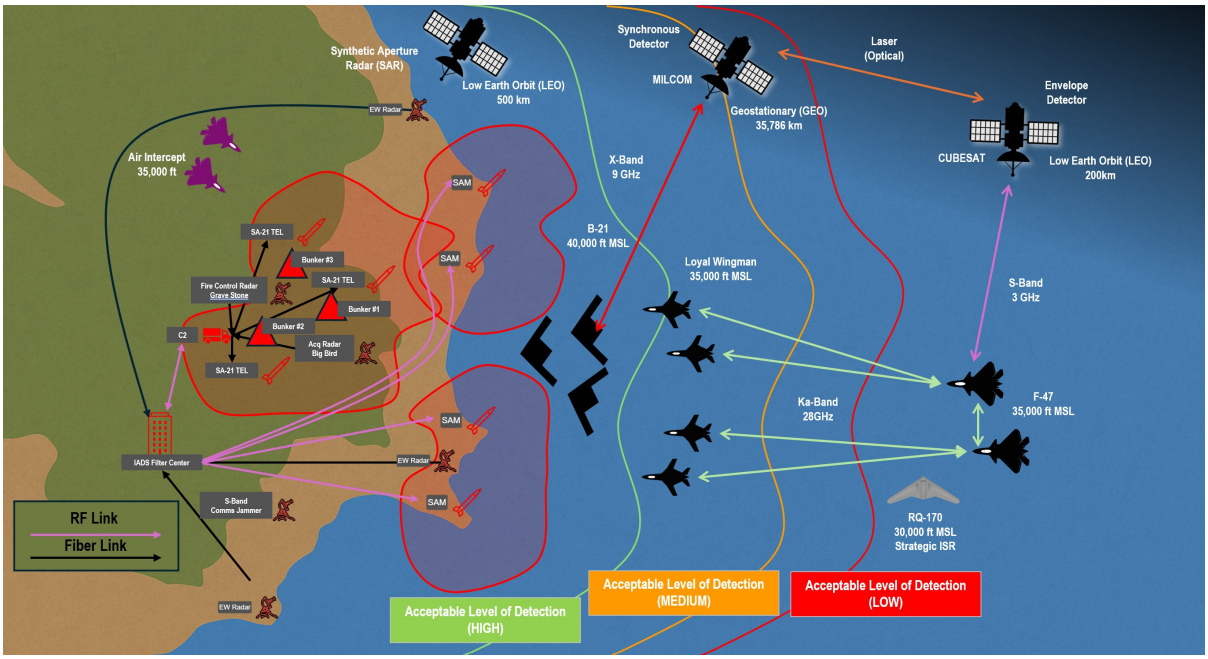


Figure 1: JROC Design Reference Mission

2 Operational Requirements and Technical Specifications

1. Radar Cross Section (RCS) Intelligence Data

   The intelligence assessment of Radar Cross Section (RCS) values for both the bunkers and associated radar systems is provided in Table 1 and illustrated in Figure 2.

Table 1: Radar Cross Section (RCS) Intelligence Data

Description	**Value**
RCS $_{\text{SA-21 TEL}}$	100 m^2
RCS $_{\text{Big Bird}}$	200 m^2
RCS $_{\text{Grave Stone}}$	150 m^2
RCS $_{\text{Bunker}}$	500 m^2

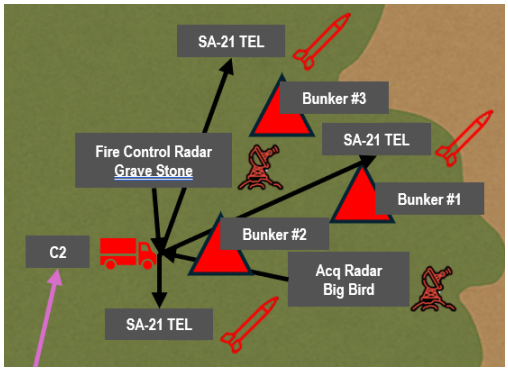


Figure 2: Targets and Radar Threats

2. Integrated Air Defense System (IADS) Intelligence Data

   The intelligence assessment of the threat radar systems is provided in Table 2.

Table 2: Integrated Air Defense System (IADS) Threat Data

Parameter	**Early Warning (VHF)**	**Acquisition (Big Bird)**	**Fire Control (Grave Stone)**	**Air Intercept**
Power $_{\text{Transmitter}}$	700 kW	55.0 kW	25.0 kW	15.0 kW
Sensitivity $P_{R,min}$	8.00 fW	8.00 fW	8.00 fW	8.00 fW
SNR $_{\text{Min}}$	2.00	2.00	2.00	2.00
Gain $_{\text{Transmitter}}$	1,500	2,000	8,000	550
Frequency	175 MHz	2.00 GHz	12.0 GHz	9.20 GHz
Altitude	Surface	Surface	Surface	35,000 ft MSL

Every receiver in this table is specified at a system noise temperature of $T_{sys} = 290$K and a bandwidth of $BW = 1.00$MHz. A radar has **one** detection threshold: its sensitivity is simply the received power that puts a return exactly at that threshold, $P_{R,min} = SNR_{min} \cdot k \cdot T_{sys} \cdot BW$.

3. S-Band (3.00 GHz) Jammer Technical Data

   The intelligence assessment of the S-Band (3.00 GHz) jammer system is provided in Table 3.

Table 3: S-Band (3.00 GHz) Jammer System Specifications

Specification	**Value**
Power $_{\text{Jammer}}$	2 kW
Frequency	3.00 GHz
Gain $_{\text{Jammer}}$	80
Range to CUBESAT	250 mi

4. Synthetic Aperture Radar (SAR) Low Earth Orbit (LEO) Technical Data

   The on-orbit Synthetic Aperture Radar (SAR) operating in Low Earth Orbit (LEO) is defined by the system specifications provided in Table 4.

Table 4: SAR LEO System Specifications

Specification	Value
Power $_{\text{Transmitter}}$	5.00 kW
Sensitivity $P_{R,min}$	4.55 aW
Frequency	8.00 GHz
Gain $_{\text{Transmitter}}$	10,000
Altitude	500 km

5. Loyal Wingman System Specifications

   The Loyal Wingman specifications for its Radar Cross Section (RCS), Electronic Attack (EA) system, and Radar Warning Receiver (RWR) are provided in Figure 3, Table 5, and 6, respectively.

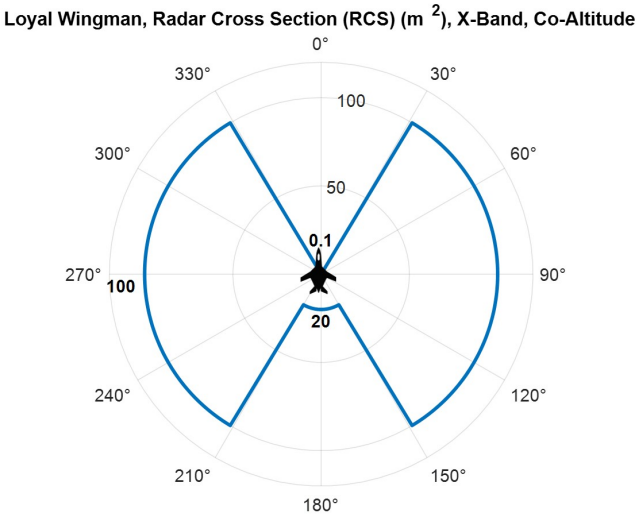


Figure 3: Loyal Wingman RCS X-Band (9.2 GHz)

Table 5: Loyal Wingman Electronic Attack (EA) Specifications

Specification	Value
Power $_{\text{Transmitter}}$	175 W
Frequency	175 MHz
Gain $_{\text{Transmitter}}$	30

Table 6: Loyal Wingman Radar Warning Receiver (RWR) Specifications

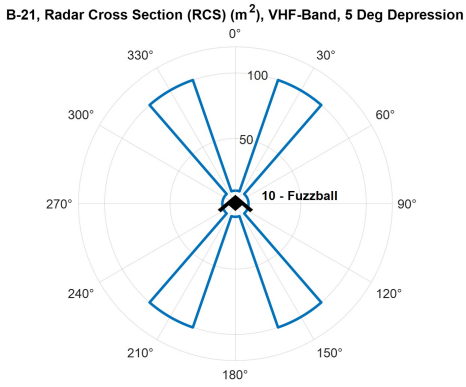
Specification	Value
Sensitivity $P_{R,min}$	2.50 nW
Frequency	9.20 GHz
Gain $_{\text{Receive}}$	0.01

6. B-21 System Specifications

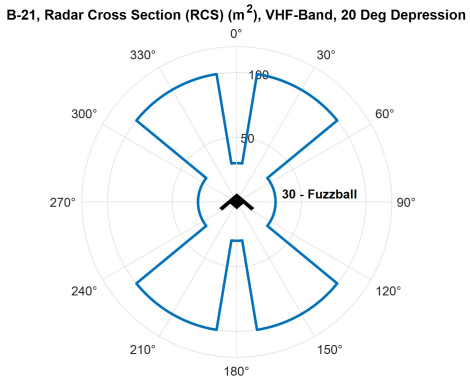
The B-21 system specifications for the reference mission are provided in Table 7 and Figures 4–5.

Table 7: B-21 System Specification

Specification	Value
Launch Acceptable Region (LAR)	20-25 mi from the target
Radar Cross Section (RCS)	See Figures 4 - 5

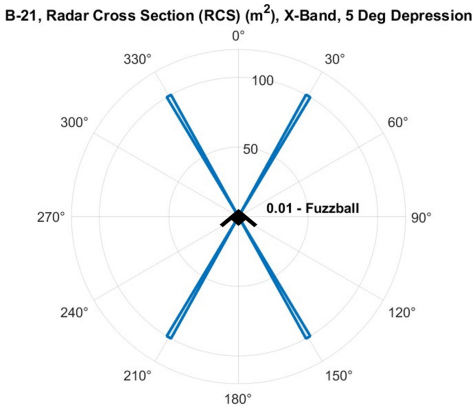


(a) B-21 RCS VHF 5° Depression

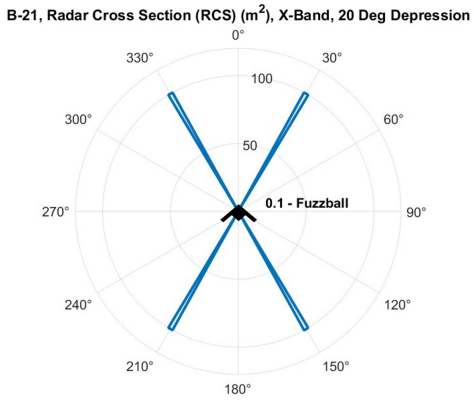


(b) B-21 RCS VHF 20° Depression

Figure 4: B-21 RCS VHF (175 MHz) for Different Depression Angles



(a) B-21 RCS X-Band 5° Depression



(b) B-21 RCS X-Band 20° Depression

Figure 5: B-21 RCS X-Band (12.0 GHz) for Different Depression Angles

7. F-47 Satellite Communications System Specifications

   The projected satellite communication specifications for the F-47 to the CUBESAT are provided in Table 8 and illustrated in Figure 6.

Table 8: F-47 Satellite Communications System Specifications

Specification	**Value**
Power $_{\text{Transmitter}}$	200 W
Sensitivity $_{P_{R,min}}$	22.0 pW
Frequency	3.00 GHz
Range to CUBESAT	189.33 km
Gain $_{\text{High Elevation}}$	See Figure 6
Gain $_{\text{Low Elevation}}$	See Figure 6

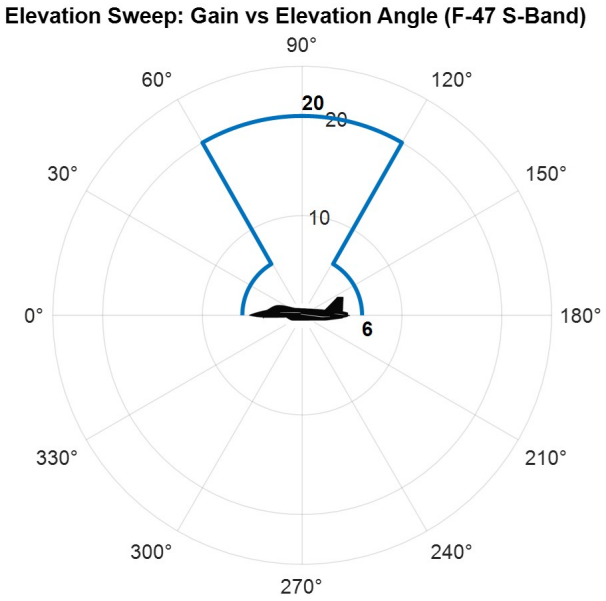


Figure 6: F-47 Satellite Gain Polar Plot

8. CUBESAT Communications System Specifications

   The projected communication specifications for the CUBESAT to the F-47 are provided in Table 9.

Table 9: CUBESAT Communications System Specifications

Specification	**Value**
Power $_{\text{Transmitter}}$	200 W
Sensitivity $_{P_{R,min}}$	20.0 fW
SNR $_{\text{Min}}$	2.4
Frequency	3.00 GHz
Gain (Omni)	3.00