dist < 50m

dist < risolu in dist

$\Delta_1 = R_1 - R_0$

Prestazioni di rivelazione su impulso singolo Target fluttuante

$$A_0 e^{j\phi_0} e^{j\frac{2\pi}{\lambda}2R_0} e^{j\rho_0} + A_1 e^{j\phi_0} e^{j\frac{2\pi}{\lambda}2R_1} e^{j\rho_1}$$

$$\sum_n A_n e^{j\phi_0} e^{-j\frac{2\pi}{\lambda}2R_n} e^{j\varphi_n}$$

$$R_n = R_0 + \Delta_n \qquad \Delta_0 = 0$$

$$\sum_n A_n e^{j\phi_0} e^{j\frac{4\pi}{\lambda}R_0} e^{j\frac{4\pi}{\lambda}\Delta_n} e^{j\varphi_n}$$

$$\boxed{e^{j\phi_0} e^{j\frac{4\pi}{\lambda}R_0}} \underbrace{\left(\sum_n A_n e^{j\varphi_n} e^{j\frac{4\pi}{\lambda}\Delta_n}\right)}_{x+jy}$$

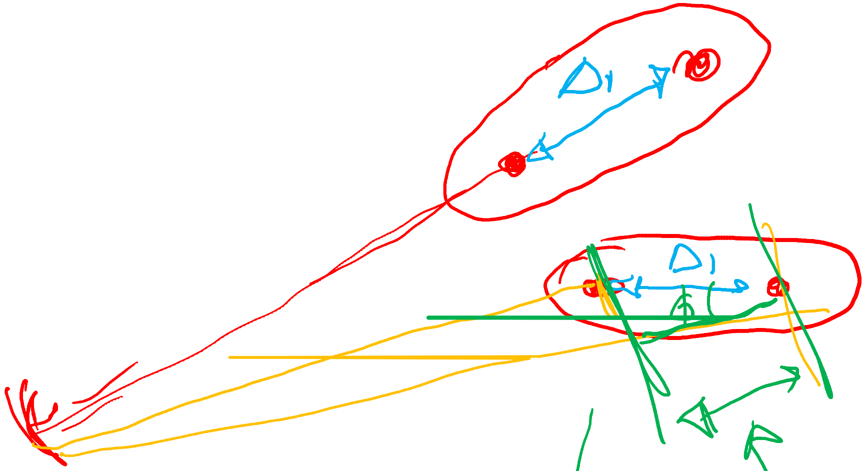
$$\boxed{\left|\sum_n A_n e^{j\rho_n} e^{j\frac{4\pi}{\lambda}\Delta_n}\right|}$$

$\underline{A_n = A_0}$ $\qquad$ $\underline{\rho_n = \rho_0}$ $\qquad$ $RCS = \underline{10\,m^2}$?

$$A_0 \cdot \left|\underbrace{\sum_n e^{j\frac{4\pi}{\lambda}\Delta_n}}\right|$$

$N = 2 \qquad (n = 0, 1)$

$$A_0 \left| 1 + e^{j \frac{4\pi}{\lambda} \Delta_1} \right| = \begin{cases} 2A_0 & \Delta_1 = \frac{\lambda}{2} \\ \emptyset & \Delta_1 = \frac{\lambda}{4} \\ \emptyset & \Delta_1 = \frac{7}{4}\lambda \\ 2A_0 & = 6\lambda \end{cases}$$



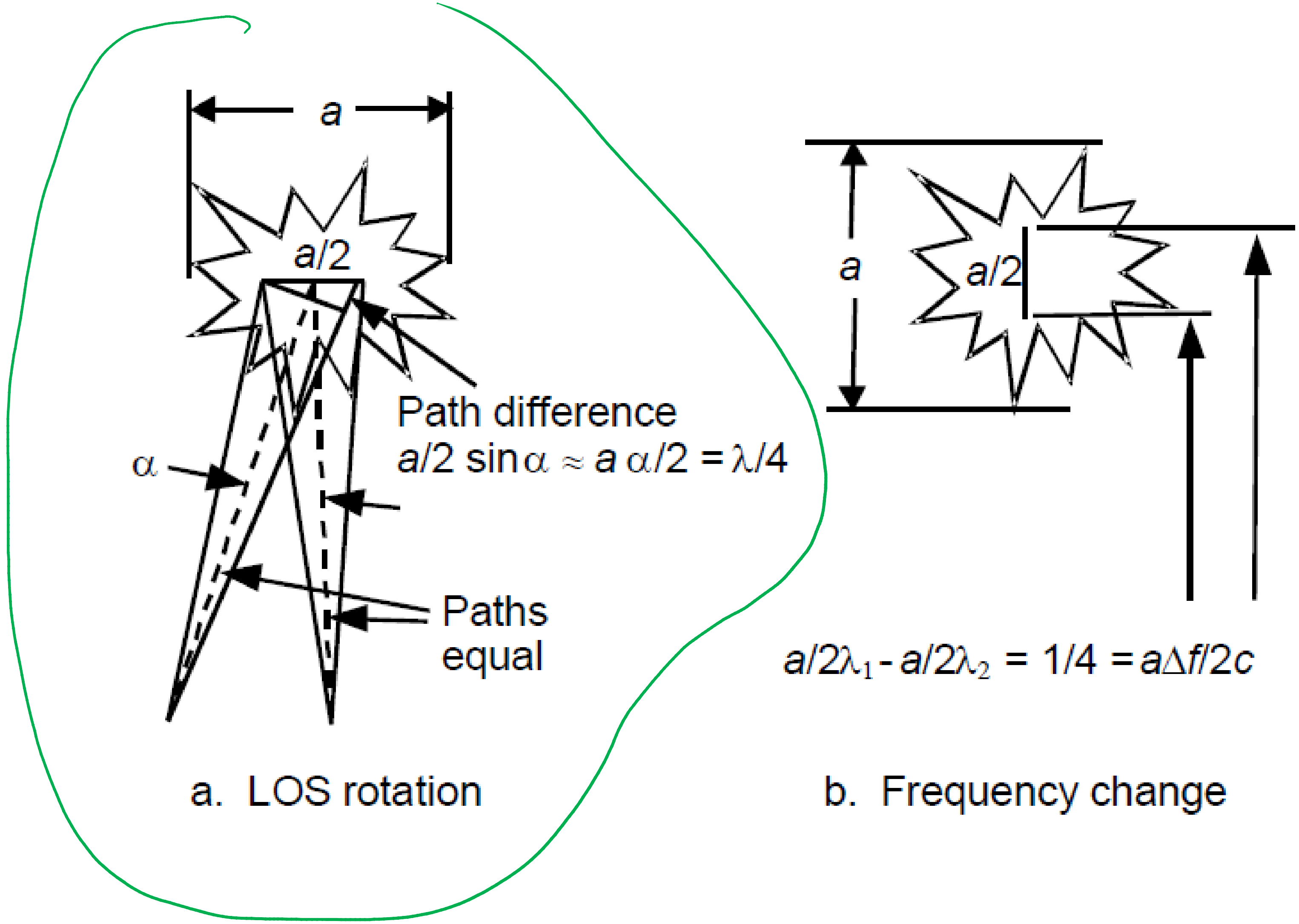
$\Delta_1 \cos\phi$

$$A_0 \left| 1 + e^{j\frac{4\pi}{\lambda}\Delta_1 \cos\phi} \right|$$

Bersagli fluttuanti (I)

- RCS Is the Ratio of Power Density Scattered by the Target in the Direction of the Radar, to the Power Density Incident on the Target
- RCS Generally Related To Target Size, but
  - Flat or Cylindrical Surfaces Produce Large Specular Returns
  - Corner Reflectors Produce Large Monostatic RCS
  - Stealth Techniques (Shaping, RAM, and Non-metallic Materials Can Reduce RCS)
- RCS of Large Complex Objects With Dimension a Can
  - Vary With Viewing Aspect (LOS) $\geq \lambda / 2a$
  - Vary With Radar Frequency Changes $\geq c / 2a$
- RCS of Targets Smaller Than λ / π
  - Does Not Vary With LOS or Frequency Changes
  - Is Said to Be in the Raleigh Region
  - Varies With λ^{-4}

Bersagli fluttuanti (II)



a. LOS rotation

b. Frequency change

Bersagli fluttuanti (III)

Requirements for RCS Decorrelation

Parameter	Value
Target Dimension (a)	2 m
Radar Frequency	9.5 GHz (X Band)
Wavelength (λ)	0.0316 m
LOS Rotation Required	8 mR ($\approx$ 0.5 deg)
Target Rotation Rate	5 deg/s
Decorrelation Time	100 ms
Frequency Change Required	75 MHz

Rotating Radar Example

Parameter	Value
PRF	200 Hz
Time Between Pulses	5 ms
Antenna Rotation Period	10 s
Antenna Beamwidth	1 deg
Time on Target	30 ms

- For Target in Pervious Example
  - LOS Rotation Provides Dwell-to-dwell RCS Decorrelation (Swerling 1 and 3)
  - Frequency Agility Needed to Provide Pulse-to-pulse RCS Decorrelation (Swerling 2 and 4)

Rivelazione per Bersagli fluttuanti (I)

Probabilità di rivelazione "istantanea" dipende dal valore di RCS "$\sigma=|a|^2$" che si sperimenta in quello specifico momento. E' di fatto una probabilità condizionata al valore di "$\sigma=|a|^2$":

$$\boxed{P_d(\sigma) = \mathrm{Prob}\{z > T \mid \sigma;\, H_1\} = \int_{T/\sigma_d}^{\infty} 2t \exp\left\{-t^2 - \frac{\sigma \cdot |\chi(\tau,\nu)|^2}{\sigma_d^2}\right\} \cdot I_0\left[\frac{2t\sqrt{\sigma} \cdot |\chi(\tau,\nu)|}{\sigma_d}\right] dt}$$

Probabilità di rivelazione globale si ottiene rimuovendo il condizionamento per saturazione tramite la DDP della variabile aleatoria σ:

$$\boxed{P_d = \int_0^{\infty} P_d(\sigma)\, p_\sigma(\sigma)\, d\sigma}$$

In generale risulta $P_d \neq P_d(\sigma_{av})$

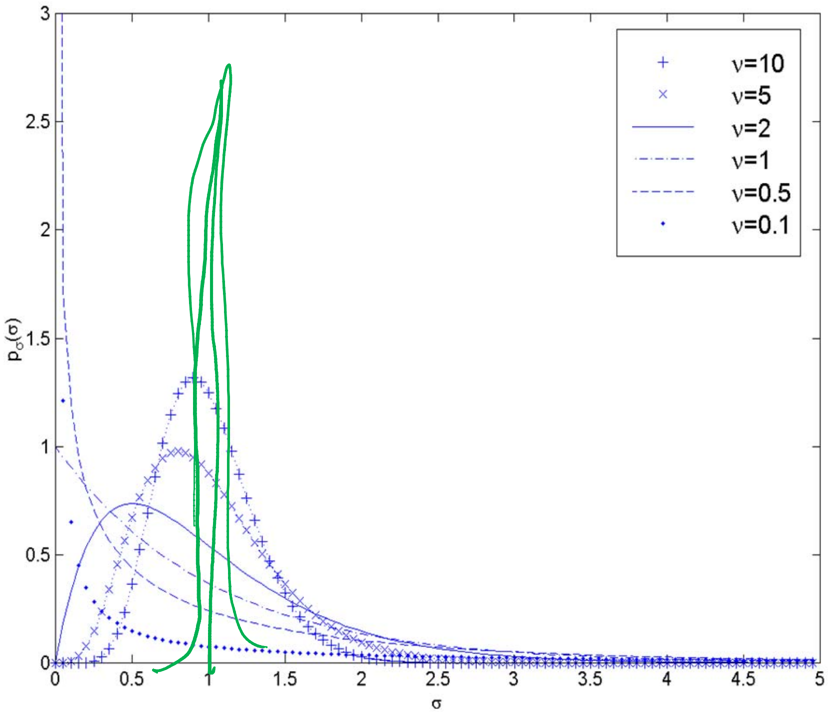
Solo se la DDP di σ è un Dirac (Bersaglio fisso) si ha: $P_d = P_d(\sigma_{av})$

Modello generale per la fluttuazione di RCS

Il modello di **RCS model** deve definire la DDP:

Un modello generale si ottiene usando la DDP gamma, con fattore di forma *m*:

$$p_\sigma(\sigma) = \frac{1}{(m-1)!}\left(\frac{m}{\sigma_{av}}\right)^m \sigma^{m-1} \exp\left[-\frac{m}{\sigma_{av}}\sigma\right]$$



m=1 Swerling I-II

m=2 Swerling III-IV

$m \to \infty$ Swerling 0 (oppure 5)

$$\langle \sigma^n \rangle = \left(\frac{\sigma_{av}}{m}\right)^n \frac{(m+n-1)!}{(n-1)!}$$

$$\frac{\operatorname{var}\sigma}{\sigma_{av}^2} = \frac{1}{m}$$

Rivelazione per Bersagli fluttuanti (II)

$$\boxed{P_d = \int_0^\infty P_d(\sigma) p_\sigma(\sigma) d\sigma = \int_0^\infty P_d(\sigma) \frac{1}{(m-1)!}\left(\frac{m}{\sigma_{av}}\right)^m \sigma^{m-1} \exp\left[-\frac{m}{\sigma_{av}}\sigma\right] d\sigma}$$

$$\boxed{P_d = \frac{e^{-\frac{T^2/\sigma_d^2}{1+SNR/m}}}{(1+SNR/m)^{m-1}} \sum_{n=0}^{m-1} \binom{m-1}{n} \left(\frac{SNR}{m}\right)^n \sum_{k=0}^{n} \frac{1}{k!} \left(\frac{T^2/\sigma_d^2}{1+SNR/m}\right)^k}$$

m=1: Swerling I-II $\qquad P_d = e^{-\frac{T^2}{\sigma_d^2\,(1+SNR)}} = P_{fa}^{\frac{1}{1+SNR}}$

$$\left[e^{-\frac{T^2}{\sigma_d^2}}\right]^{\frac{1}{1+SNR}}$$

m=2: Swerling III-IV $\qquad P_d = e^{-\frac{T^2/\sigma_d^2}{1+SNR/2}} \left[1 + \frac{T^2}{2\sigma_d^2} \frac{SNR}{(1+SNR/2)^2}\right]$

Rivelazione per Bersagli fluttuanti (III)

Via analitica semplice
***per m*=1:** **Swerling I-II**

$$z = |\tilde{z}| = \left| d_f(t) + a \cdot \chi(\tau,\nu) \right| > T$$

$X + jy$

$$e^{-\frac{T^2}{\sigma^2}}$$

Se "*a*" ha ampiezza Rayleigh e fase uniforme, è una v.a. gaussiana complessa con valor medio nullo e varianza σ_{av}

$$e^{-\frac{T^2}{\sigma^2+\sigma_T^2}}$$

Anche $\tilde{z}$ è una v.a. gaussiana complessa con valor medio nullo, e varianza $\sigma_{av} + \sigma_d^2$

$$= e^{-\frac{T^2}{\sigma^2\left(1+\frac{\sigma_T^2}{\sigma^2}\right)}}$$

$1 + SNR$

Dunque "z" ha DDP Rayleigh, come il solo disturbo in H_p H_0

$$\boxed{P_d = \Pr ob\{z > T \mid H_1\} = \int_T^{\infty} p_z(z|H_1)\,dz = e^{-\frac{T^2}{\sigma_d^2+\sigma_{av}}} = e^{-\frac{T^2}{\sigma_d^2\,(1+\sigma_{av}/\sigma_d^2)}} = e^{-\frac{T^2}{\sigma_d^2\,(1+SNR)}}}$$

$$P_d = e^{-\frac{T^2}{\sigma_d^2\,(1+SNR)}} = P_{fa}^{\frac{1}{1+SNR}}$$

Rivelazione per Bersagli fluttuanti (III)

Plots of S/N vs. PD and Swerling Type