Hence:

$$B(\theta)u = J \cdot X_{t-1} + \underbrace{B(\theta_0)u - JX_0}_{b}$$

Hence:

$$X_t = AX_{t-1} + JX_{t-1} + B(\theta_0)u - JX_0 + \eta$$

$$X_t = AX_{t-1} + J(\mu_{t-1})X_{t-1} + B(\mu_{t-1})u - J(\mu_{t-1}) \cdot \mu_{t-1} + \eta$$

Find μ_{X_t}: $\mu_{X_t} = E\{X_t\} = E\{AX_{t-1} + J(\mu_{t-1})X_{t-1} + B(\mu_{t-1})u - J(\mu_{t-1})\mu_{t-1} + \eta\} =$

$$= A\mu_{X_{t-1}} + \cancel{J(\mu_{X_{t-1}})\mu_{X_{t-1}}} + B(\mu_{X_{t-1}})u - \cancel{J(\mu_{X_{t-1}})\mu_{X_{t-1}}} + \mu_\eta =$$

$$= A\mu_{X_{t-1}} + B(\mu_{X_{t-1}})u + \mu_\eta$$

$$\mu_{X_t} = A\mu_{X_{t-1}} + B(\mu_{X_{t-1}})u + \mu_\eta$$

Covariance propagation:

Uncorrelated.

$$\Sigma_{X_t} = (A+J)\Sigma_{X_{t-1}}(A+J)^T + \Sigma_\eta + \cancel{2\Sigma_{X_{t-1}\eta}}$$