

$$\begin{pmatrix} F_1 \\ F_2 \\ F_3 \end{pmatrix}_i = \begin{pmatrix} x \\ y \\ z \end{pmatrix}_i - \lambda M \begin{pmatrix} x \\ y \\ z \end{pmatrix}_i - \begin{pmatrix} t_x \\ t_y \\ t_z \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

30-1

$$\frac{\partial F_{1i}}{\partial x_i} = 1 \quad \frac{\partial F_{1i}}{\partial y_i} = 0 \quad \frac{\partial F_{1i}}{\partial z_i} = 0$$

$$\frac{\partial F_{2i}}{\partial x_i} = 0 \quad \frac{\partial F_{2i}}{\partial y_i} = 1 \quad \frac{\partial F_{2i}}{\partial z_i} = 0$$

$$\frac{\partial F_{3i}}{\partial x_i} = 0 \quad \frac{\partial F_{3i}}{\partial y_i} = 0 \quad \frac{\partial F_{3i}}{\partial z_i} = 1$$

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$$\begin{pmatrix} x \\ y \\ z \end{pmatrix}_i - \lambda M \begin{pmatrix} x \\ y \\ z \end{pmatrix}_i - \begin{pmatrix} t_x \\ t_y \\ t_z \end{pmatrix}$$

Every expression evaluated at  
CURRENT value of approx

$$\frac{\partial F_{1i}}{\partial x_i} = -\lambda m_{11} \quad \frac{\partial F_{1i}}{\partial y_i} = -\lambda m_{12} \quad \frac{\partial F_{1i}}{\partial z_i} = -\lambda m_{13}$$

$$-\lambda m_{21} \quad -\lambda m_{22} \quad -\lambda m_{23}$$

$$-\lambda m_{31} \quad -\lambda m_{32} \quad -\lambda m_{33}$$

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$x_1, y_1, z_1, \dots, x_n, y_n, z_n$     ②    ③    ...    ⑧

1 2 3	I	$-\lambda M$			
			I		$\emptyset$
			$-\lambda M$	I	
		$\emptyset$		$-\lambda M$	...
					I
					$-\lambda M$

$x_1, x_2, x_3, \dots, x_n, y_1$

$A$      $n \times n = 8$

$C, n$      $3 \times 3$

$C = 24$

$n = 48$

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$B$      $B$

$C, n$      $24, 7$

$\lambda, \omega, \phi, k, t_x, t_y, t_z$

$\uparrow$      $\uparrow$

$\begin{pmatrix} x \\ y \\ z \end{pmatrix} - \lambda M \begin{pmatrix} X \\ Y \\ Z \end{pmatrix} - \begin{pmatrix} t_x \\ t_y \\ t_z \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$

$\begin{pmatrix} \frac{\partial F_1}{\partial \lambda} \\ \frac{\partial F_2}{\partial \lambda} \\ \frac{\partial F_3}{\partial \lambda} \end{pmatrix} = -M \begin{pmatrix} x_i \\ y_i \\ z_i \end{pmatrix}$

30-4

$\begin{pmatrix} \frac{\partial F_1}{\partial \omega} \\ \frac{\partial F_2}{\partial \omega} \\ \frac{\partial F_3}{\partial \omega} \end{pmatrix} = -\lambda M_k M_\phi \frac{\partial M_\omega}{\partial \omega} \begin{pmatrix} x_i \\ y_i \\ z_i \end{pmatrix}$

$\uparrow$

$M_\omega = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \omega & \sin \omega \\ 0 & \sin \omega & \cos \omega \end{bmatrix}$

$\frac{\partial M_\omega}{\partial \omega} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & -\sin \omega & \cos \omega \\ 0 & \cos \omega & -\sin \omega \end{bmatrix}$

(3,1)

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$$\frac{\partial F}{\partial \varphi} = -\lambda M_K \frac{\partial M_\varphi}{\partial \varphi} M_w \begin{pmatrix} x_i \\ y_i \\ z_i \end{pmatrix} \quad M_\varphi = \begin{pmatrix} \cos \varphi & 0 & -\sin \varphi \\ 0 & 1 & 0 \\ \sin \varphi & 0 & \cos \varphi \end{pmatrix} \quad \begin{matrix} 30 \\ 5 \end{matrix}$$

$$\frac{\partial M_\varphi}{\partial \varphi} = \begin{pmatrix} -\sin \varphi & 0 & -\cos \varphi \\ 0 & 0 & 0 \\ \cos \varphi & 0 & -\sin \varphi \end{pmatrix}$$

$$\frac{\partial F}{\partial k} = -\lambda \frac{\partial M_K}{\partial k} M_\varphi M_w \begin{pmatrix} x_i \\ y_i \\ z_i \end{pmatrix} \quad M_K = \begin{pmatrix} \cos k & \sin k & 0 \\ -\sin k & \cos k & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\frac{\partial M_K}{\partial k} = \begin{pmatrix} -\sin k & \cos k & 0 \\ -\cos k & -\sin k & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

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shifts  $\begin{pmatrix} x \\ y \\ z \end{pmatrix} - \lambda M \begin{pmatrix} x \\ y \\ z \end{pmatrix} - \begin{pmatrix} t_1 \\ t_2 \end{pmatrix}$

30-6

$$\frac{\partial F}{\partial T} = -\bar{I}$$

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	$\lambda$	$w$	$\varphi$	$k$	$t_x$	$t_y$	$t_z$	30-7
1	$-M \begin{pmatrix} x \\ Y \\ z \end{pmatrix}_1$	$-x M_k M_g \frac{\partial M_g}{\partial w} \begin{pmatrix} x \\ Y \\ z \end{pmatrix}_1$	(1)	-	-	-1	0	0
2	$-M \begin{pmatrix} x \\ Y \\ z \end{pmatrix}_2$	.....	(2)	-	-	-1	0	0
⋮							0	-1
8								

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Right Side Vector 30-8

$$f = -F^0 - A (\overline{l - l^0})$$

$\uparrow$  original       $\nwarrow$  current estimate

$$f_{\text{point } i} = -F_{\text{point } i}^0 - A_i \times \begin{bmatrix} x_i - x_i^0 \\ y_i - y_i^0 \\ z_i - z_i^0 \\ X_i - X_i^0 \\ Y_i - Y_i^0 \\ Z_i - Z_i^0 \end{bmatrix}$$

(3,1)                  3,1                  3,6                  6,1

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full NE, or elimination, solution

30-9

$$Q_e = AQA^T$$

$$V = QA^T k$$

$$Q = W^{-1}$$



$$W_e = Q_e^{-1}$$

$$X = X + \Delta$$

$$N = B^T W_e B$$

$$l^o = l + v$$

$$t = B^T W_e f$$

↑ new      ↑ origin 0      ↖ just computed

$$\Delta = N^{-1} t$$

$$k = W_e (f - B\Delta)$$

$$\Delta l = l_{new}^o - l_{old}^o$$

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2 way ranging  $t_2 - t_1 = \Delta t$  same clock 30-10

1 way ranging  $t_2 - t_1 = \Delta t$  different clocks

Basic clock 10.23 MHz

$$154 \times 10.23 \text{ MHz} = 1575.42 \text{ MHz } L1$$

$$120 \times 10.23 \text{ MHz} = 1227.60 \text{ MHz } L2$$



L-Band

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