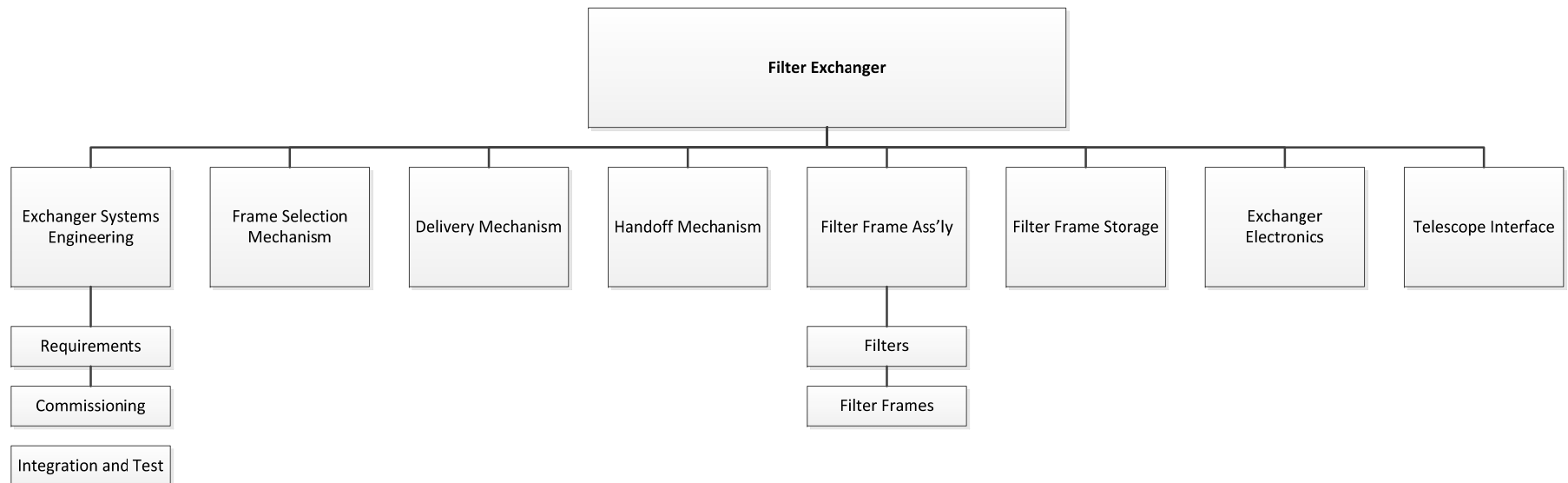


ZTF Filter Exchanger Planning

Work Breakdown Structure



WBS comparison

Rail

- 3 custom mechanisms
 - Larger design effort
 - Larger I&T effort
 - Larger software control effort
 - Delayed start to motion control software

Robot

- 2 COTS mechanisms (or 1 COTS + 1 custom gripper)
 - Higher-level software for motion control
 - More mature diagnostics, safety and fault recovery
- Integration & Test
 - Earlier access to mechanisms to begin lab testing
 - Earlier software start results in more I&T time within exchanger schedule

Exchanger Plan

5	[-] Filter Exchanger	3,787 hrs	11%	Fri 4/3/15	Fri 12/23/16	\$698,090
5.1	[+] Filter Exchanger Requirements	112 hrs	100%	Fri 5/15/15	Mon 1/25/16	\$15,136
5.2	[+] Filter Exchanger Conceptual Design	267 hrs	100%	Tue 11/17/15	Wed 1/20/16	\$28,594
5.3	[+] Filter Exchanger Preliminary Design	592 hrs	0%	Wed 1/20/16	Thu 4/21/16	\$61,696
5.4	[+] Filter Exchanger Detailed Design	1,164 hrs	0%	Thu 4/21/16	Thu 10/20/16	\$118,300
5.5	[+] Filter Exchanger Hardware	744 hrs	6%	Fri 4/3/15	Thu 12/8/16	\$386,284
5.6	[+] Filter Exchanger Integration and Test	580 hrs	0%	Fri 8/19/16	Fri 12/23/16	\$52,220
5.7	[+] Filter Exchanger Commissioning	328 hrs	0%	Wed 10/5/16	Fri 11/25/16	\$35,860

5	[-] Filter Exchanger	3,787 hrs	11%	Fri 4/3/15	Fri 12/23/16	\$698,090
5.1	[+] Filter Exchanger Requirements	112 hrs	100%	Fri 5/15/15	Mon 1/25/16	\$15,136
5.2	[+] Filter Exchanger Conceptual Design	267 hrs	100%	Tue 11/17/15	Wed 1/20/16	\$28,594
5.3	[+] Filter Exchanger Preliminary Design	592 hrs	0%	Wed 1/20/16	Thu 4/21/16	\$61,696
5.4	[+] Filter Exchanger Detailed Design	1,164 hrs	0%	Thu 4/21/16	Thu 10/20/16	\$118,300
5.5	[-] Filter Exchanger Hardware	744 hrs	6%	Fri 4/3/15	Thu 12/8/16	\$386,284
5.5.1	[-] Filter Exchanger	600 hrs	8%	Fri 4/3/15	Thu 12/8/16	\$370,196
5.5.1.1	[+] Filter Ass'lies	128 hrs	38%	Fri 4/3/15	Mon 11/21/16	\$157,448
5.5.1.2	[+] Filter Exchanger Mechanical Assembly Fixtures_	24 hrs	0%	Wed 9/7/16	Fri 9/23/16	\$12,400
5.5.1.3	[-] Filter Exchanger Fabrication	320 hrs	0%	Mon 1/25/16	Mon 11/7/16	\$190,772
5.5.1.3.1	[+] Filter Exchanger Robot_	112 hrs	0%	Mon 1/25/16	Thu 3/31/16	\$80,384
5.5.1.3.2	[+] Filter Exchanger Gripper_	92 hrs	0%	Thu 5/26/16	Tue 8/16/16	\$37,960
5.5.1.3.3	[+] Filter Exchanger Storage_	92 hrs	0%	Thu 5/26/16	Tue 8/16/16	\$40,028
5.5.1.3.4	[+] Filter Exchanger Robot Mount_	24 hrs	0%	Thu 10/20/16	Mon 11/7/16	\$32,400
5.5.1.4	Filter Exchanger Gripper and Storage Cleaning	24 hrs	0%	Mon 11/21/16	Tue 11/29/16	\$1,656
5.5.1.5	Filter Exchanger Gripper and Storage Assembly	104 hrs	0%	Mon 11/21/16	Thu 12/8/16	\$7,920
5.5.2	[+] Filter Exchanger Electronics	144 hrs	0%	Thu 4/21/16	Mon 8/22/16	\$16,088
5.6	[+] Filter Exchanger Integration and Test	580 hrs	0%	Fri 8/19/16	Fri 12/23/16	\$52,220
5.7	[+] Filter Exchanger Commissioning	328 hrs	0%	Wed 10/5/16	Fri 11/25/16	\$35,860

Exchanger Plan

5	[-] Filter Exchanger	3,787 hrs	11%	Fri 4/3/15	Wed 12/14/16	\$697,858
5.1	[+] Filter Exchanger Requirements	112 hrs	100%	Fri 5/15/15	Mon 1/25/16	\$15,136
5.2	[+] Filter Exchanger Conceptual Design	267 hrs	100%	Tue 11/17/15	Wed 1/20/16	\$28,594
5.3	[-] Filter Exchanger Preliminary Design	592 hrs	0%	Wed 1/20/16	Tue 4/12/16	\$61,464
5.3.1	Robot Selection	16 hrs	0%	Wed 1/20/16	Mon 1/25/16	\$1,600
5.3.2	Robot Path Planning	64 hrs	0%	Mon 1/25/16	Thu 2/4/16	\$6,528
5.3.3	Gripper Preliminary Design	108 hrs	0%	Thu 2/4/16	Wed 3/2/16	\$11,088
5.3.4	Filter Storage Preliminary Design	92 hrs	0%	Thu 2/4/16	Mon 3/7/16	\$10,048
5.3.5	Robot / Telescope Interface Design	88 hrs	0%	Mon 3/7/16	Mon 3/21/16	\$9,040
5.3.6	Filter Latch Preliminary Design	80 hrs	0%	Mon 3/21/16	Thu 4/7/16	\$8,000
5.3.7	Gripper Prototyping	80 hrs	0%	Thu 2/4/16	Fri 2/5/16	\$8,000
5.3.8	Filter Exchanger PDR	64 hrs	0%	Thu 4/7/16	Tue 4/12/16	\$7,160
5.4	[-] Filter Exchanger Detailed Design	1,164 hrs	0%	Tue 4/12/16	Tue 10/11/16	\$118,300
5.4.1	Gripper Detailed Design	160 hrs	0%	Tue 4/12/16	Tue 5/17/16	\$16,000
5.4.2	Filter Frame Interface Detailed Design	100 hrs	0%	Tue 4/12/16	Tue 5/3/16	\$10,000
5.4.3	Filter Storage Detailed Design	160 hrs	0%	Tue 5/17/16	Tue 6/21/16	\$17,440
5.4.4	Robot / Telescope Interface Detailed Design	144 hrs	0%	Tue 6/21/16	Mon 7/18/16	\$14,640
5.4.5	Filter Latch Detailed Design	80 hrs	0%	Mon 7/18/16	Wed 8/3/16	\$8,000
5.4.6	Filter Exchanger I&T Fixture Detailed Design	80 hrs	0%	Wed 8/3/16	Mon 8/22/16	\$8,000
5.4.7	Filter Exchanger DDR	80 hrs	0%	Wed 8/3/16	Wed 8/10/16	\$8,220
5.4.8	[+] Filter Exchanger Fabrication Drawings	360 hrs	0%	Wed 8/10/16	Tue 10/11/16	\$36,000
5.5	[+] Filter Exchanger Hardware	744 hrs	6%	Fri 4/3/15	Tue 11/29/16	\$386,284
5.6	[+] Filter Exchanger Integration and Test	580 hrs	0%	Wed 8/10/16	Wed 12/14/16	\$52,220
5.7	[+] Filter Exchanger Commissioning	328 hrs	0%	Mon 9/26/16	Wed 11/16/16	\$35,860

Exchanger Plan

5	[-] Filter Exchanger	3,787 hrs	11%	Fri 4/3/15	Fri 12/23/16	\$698,090
5.1	[+] Filter Exchanger Requirements	112 hrs	100%	Fri 5/15/15	Mon 1/25/16	\$15,136
5.2	[+] Filter Exchanger Conceptual Design	267 hrs	100%	Tue 11/17/15	Wed 1/20/16	\$28,594
5.3	[+] Filter Exchanger Preliminary Design	592 hrs	0%	Wed 1/20/16	Thu 4/21/16	\$61,696
5.4	[+] Filter Exchanger Detailed Design	1,164 hrs	0%	Thu 4/21/16	Thu 10/20/16	\$118,300
5.5	[-] Filter Exchanger Hardware	744 hrs	6%	Fri 4/3/15	Thu 12/8/16	\$386,284
5.5.1	[-] Filter Exchanger	600 hrs	8%	Fri 4/3/15	Thu 12/8/16	\$370,196
5.5.1.1	[+] Filter Ass'lies	128 hrs	38%	Fri 4/3/15	Mon 11/21/16	\$157,448
5.5.1.2	[+] Filter Exchanger Mechanical Assembly Fixtures_	24 hrs	0%	Wed 9/7/16	Fri 9/23/16	\$12,400
5.5.1.3	[-] Filter Exchanger Fabrication	320 hrs	0%	Mon 1/25/16	Mon 11/7/16	\$190,772
5.5.1.3.1	[+] Filter Exchanger Robot_	112 hrs	0%	Mon 1/25/16	Thu 3/31/16	\$80,384
5.5.1.3.2	[+] Filter Exchanger Gripper_	92 hrs	0%	Thu 5/26/16	Tue 8/16/16	\$37,960
5.5.1.3.3	[+] Filter Exchanger Storage_	92 hrs	0%	Thu 5/26/16	Tue 8/16/16	\$40,028
5.5.1.3.4	[+] Filter Exchanger Robot Mount_	24 hrs	0%	Thu 10/20/16	Mon 11/7/16	\$32,400
5.5.1.4	Filter Exchanger Gripper and Storage Cleaning	24 hrs	0%	Mon 11/21/16	Tue 11/29/16	\$1,656
5.5.1.5	Filter Exchanger Gripper and Storage Assembly	104 hrs	0%	Mon 11/21/16	Thu 12/8/16	\$7,920
5.5.2	[+] Filter Exchanger Electronics	144 hrs	0%	Thu 4/21/16	Mon 8/22/16	\$16,088
5.6	[+] Filter Exchanger Integration and Test	580 hrs	0%	Fri 8/19/16	Fri 12/23/16	\$52,220
5.7	[+] Filter Exchanger Commissioning	328 hrs	0%	Wed 10/5/16	Fri 11/25/16	\$35,860

Filter Exchanger Resourcing

- Michael Porter; Lead ME ~ 1550 hrs @ 100%
- Jeffrey Zolkower; Telescope ~ 280 hrs @ ~12%
- David Hale
 - Kuka Robot Software ~ 120 hrs @ ~30%
 - Robo-Z S/W for Exchanger ~ 300 hrs @ ~50%
- Reed Riddle; Robo-Z Software
- Christina Fuller; Kuka consult engineer (JPL)