c-Link Systems, Inc.
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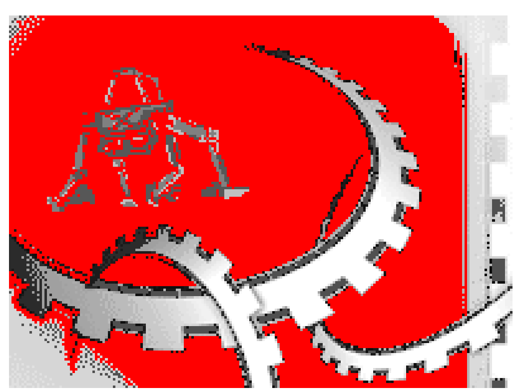
Technical Brief TB-1750

Tower System Robotic Applications



Date: 15/09/09

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Introduction

This Technical Brief (TB) will demonstrate the integration and usage of Freescale Semiconductors Tower Systems [1]. The brief contains 2 sections; first one is for experimental and second is for a commercial application. The TB will also introduce some new board level products for the Tower System.

Major Components

CUBE-BEC[2] – (CUBE-Bi-tracked Experimental Chassis)

CUBIC-BEC is a welded, tracked, aluminum chassis that contains a Freescale Semiconductor Tower System. The system includes a Tower System Kit that is augmented with a motor card (cLS-FSTS-MC2-5), Zig-Bee communications (cLS-FSTS-COMM) and a GPS receiver (cLS-FSTS-GPS) from c-Link Systems. The top covers are aluminum to allow for user mounting of 3rd party attachments. For protection the center section, where the Tower System is located, has a Lexan™ cover to protect the electronics.

Specifications:

Overall length:	24inches (60.96cm)
Overall height:	6inches (15.24cm)
Overall width:	15.5inches (39.37cm)
Vehicle Weight:	20lbs (9.1kg) w/Batteries
Vehicle Payload:	10-15 pound
Track Drive Motors:	7.2V @ 5.4A, 600RPM with a 2-stage gearbox
Battery Pack:	7.2V Li-ion, rechargeable

Forager-ARV[3] – (Forager Autonomous Robotic Vehicle)

Forager-ARV is an Omni-chassis autonomous robotic vehicle (ARV) from c-Link Systems, Inc. The Omni-chassis creates the ability to build upon a unified drive chassis with different end-usage systems. The Forager Omni-chassis contains a locomotion system, a power plant and all the control electronics. The chassis itself is constructed of high-grade aluminum.
Locomotion is achieved through 10" wide electrically powered tracks. Steering is accomplished through the use of the industry standard "skid-steer".
The main power plant is 300Ah – 900Ah battery system based on Li-FePO battery banks.
The electronics system is comprised of a multi-processor core block, based on Freescale Semi-

conductor's Tower System, which includes the entire external sensor interface for autonomous motion, drive locomotion system, guidance system, payload control system/interface and communications.

Specification:

Overall length:	72inches (182.88cm)
Overall height:	21inches (53.34cm)
Overall width:	51inches (129.54cm)
Gross Vehicle Weight:	1200lbs (544.3kg)

Freescale Tower System

Further information at http://www.freescale.com/webapp/sps/site/overview.jsp?code=TOWER_HOME&fsrch=1

Configuration Example 1-1

Brief

CUBE-BEC was created as a test and development platform for the Tower System. This low cost tracked platform allows for an infinite number of concepts. This first example is a very basic test of controllability. This configuration uses the complete Tower System Kit from Freescale Semiconductor with the addition of a 2-axis motor controller board. See Figure 1.

This basic system contains Freescale TWR-SER which allows communications with the TWR-51CN MCU card. For the first time user, testing can be a daunting task, it is usually better to run the unit on a tether cable. This allows for direct control and information feedback. The programming code is also similar and smaller in size. The cLS-FSTS-MC2-5 is the 2-axis card used to control the track drive motors. It is controlled directly from the TWR-51CN and has advanced safety feedback features that can be used as the control software becomes more complex.

Directional control is also enhanced by the use of the 3-axis accelerometer on the TWR-51CN. Additional range sensors can be added via the TWR-SER card.

Components

TWR-MF51CN-KIT

cLS-FSTS-MC2-5

CUBE-BEC chassis

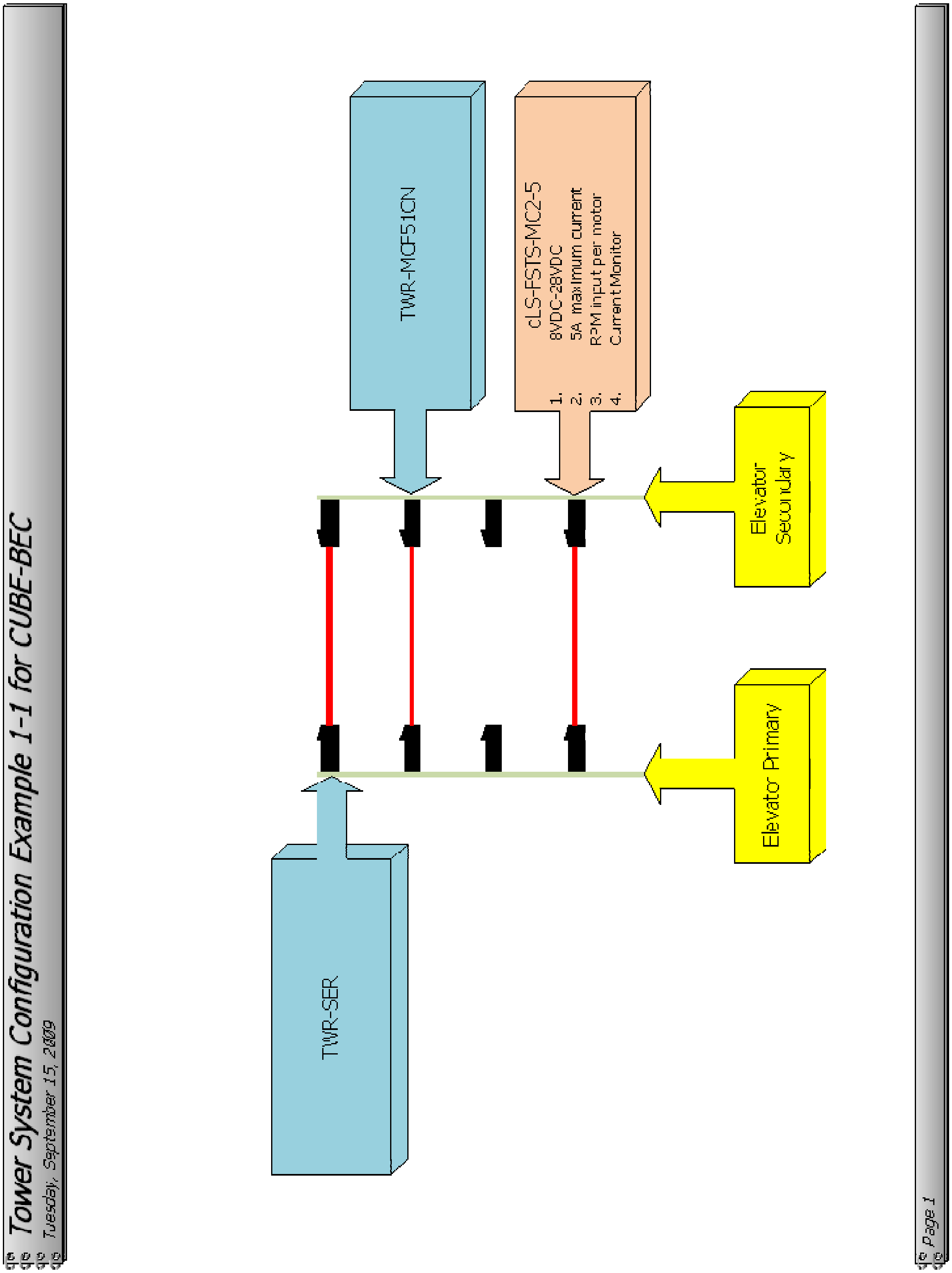
Tower System Configuration Example 1-1 for CUBE-BEC
Tuesday, September 15, 2009
TWR-MCF51CN
cLS-FSTS-MC2-5
1. 8VDC-28VDC
2. 5A maximum current
3. PWM input per motor
4. Current Monitor
Elevator Secondary
Elevator Primary
TWR-SER
Page 1

Figure 1

Configuration Example 1-2

Brief

This example builds on the prior configuration. We will add a GPS module board (cLS-FSTS-GPS) that interfaces with the TWR-MF51CN board. This maintains a single micro controller environment and allows for simpler code enhancement. The GPS board uses a passive antenna which can be attached to the exterior of the chassis. The cable is then screwed on to the mating connector. See Figure 2 for system configuration.

The addition of GPS enhances the motion capability coupled with advancing the overall system to autonomous status. The unit can now be given a coordinate and told to move. With the tether still attached, sending it long distances means lots of walking or running. The GPS board can also feedback position as it moves. This information, coupled with the accelerometer feedback, can actually be used to map the terrain as a topographical map does.

Components

TWR-MF51CN-KIT

cLS-FSTS-MC2-5

cLS-FSTS-GPS

CUBE-BEC chassis

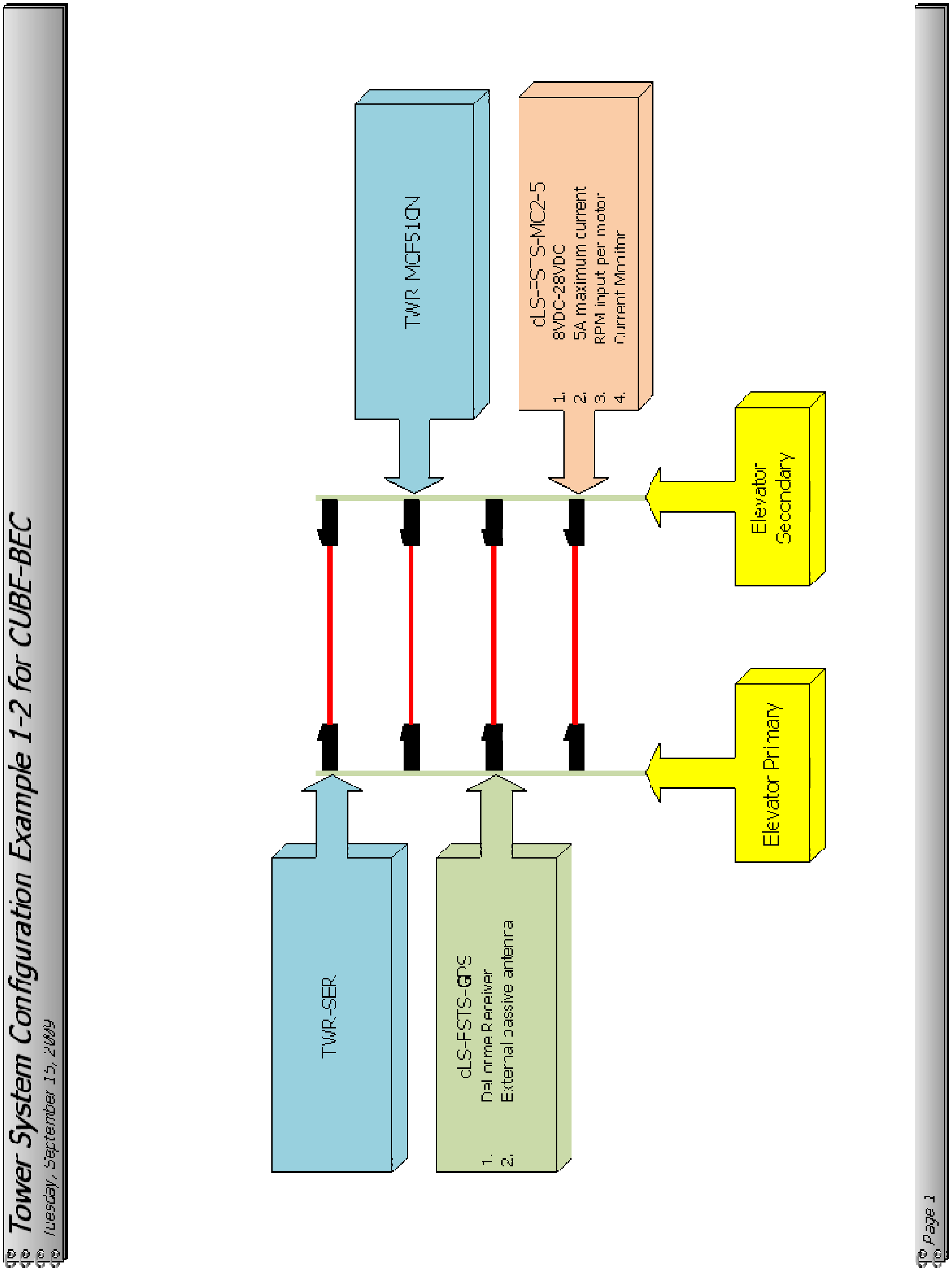
Tower System Configuration Example 1-2 for CUBE-BEC
Tuesday, September 15, 2009
TWR MCF51CN
8VDC-28VDC
5A maximum current
RPM input per motor
Elevator Secondary
TWR-SER
cLS-FSTS-GPS
Elevator Primary
Page 1

Figure 2

Configuration Example 1-3

Brief

This example not only builds on the prior configuration, but is the ultimate robotic vehicle system to construct. We will replace the TWR-SER board with a communications board. This communications board (cLS-FSTS-COMM) interfaces with the TWR-MF51CN board and communicates with your computer. This new configuration still maintains a single micro controller environment and allows for simpler code enhancement. The COMM board uses a passive antenna which is attached to the board, hence the reason it is on the top of the stack, see Figure 3.

The addition of the wireless communications opens up experimental possibilities. The first and foremost is not having to chase behind the chassis. For the inside person, one can sit at their desk and be in constant communications with the unit, providing it stays in range. As before the single MCU allows for code to be modularly added. Modular coding also allows for simpler debugging.

Components

TWR-MF51CN-KIT

cLS-FSTS-MC2-5

cLS-FSTS-GPS

cLS-FSTS-COMM

CUBE-BEC chassis

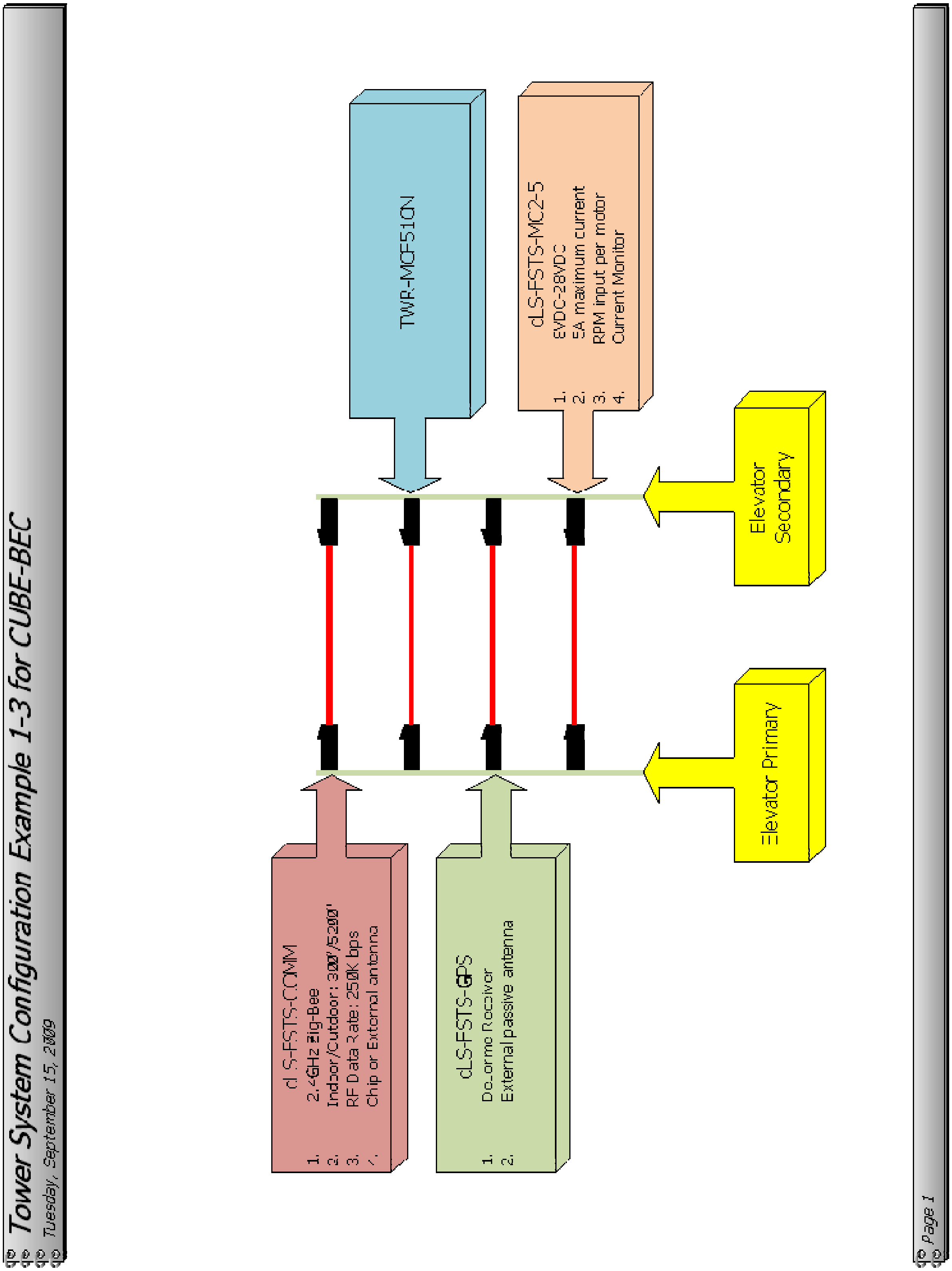
Tower System Configuration Example 1-3 for CUBE-BEC
Tuesday, September 15, 2009
TWR-MCF51CN
cLS-FSTS-MC2-5
1. 6VDC-28VDC
2. 5A maximum current
3. RPM input per motor
4. Current Monitor
Elevator Secondary
Elevator Primary
cLS-FSTS-COMM
1. 2.4GHz Zig-Bee
2. Indoor/Outdoor: 300'/5200'
3. RF Data Rate: 250K bps
4. Chip or External antenna
cLS-FSTS-GPS
2. External passive antenna
Page 1

Figure 3

Commercial Application Example 1 – Forager

Brief

Forager is commercial unit so it requires a more complex approach to its electronic control system. Because humans are involved, a high percentage of the system processing is contained in safety sensors. Forager uses the Tower System concept, but due to the nature of board functionality the tower boards are all designed for a specific role. Most of the cards contain dedicated MCUs, creating a distributed processor network. See Figure 4.

In Figure 4 we have kept the TWR-ELEV cards and the COMM board from the CUBE-BEC examples. The COMM board is the only non-MCU based card within the stack. cLS-FSTS-COMM is used to relay information back to the operator or as a remote control function in the case of non-autonomous control. Forager was changed from 6-wheel drive to tracks for multiple reasons, one of which was the ability to remove a dedicated motor control card. The cLS-FSTS-MCU-CORE is the sovereign of the stack. It has the requirements of overall coordinator, the drive motor controller and overall decision maker. cLS-FSTS-GCE is also known by Guidance & Control Electronics, other words it is supposed to know at all times where Forager is in relation to where it was and where it is going. This card has its own MCU to calculate, via different mathematical filters, the positional data. The last card for the stack is cLS-FSTS-REMOTE; this card has a couple of standard low protocol intensive interface communications busses. These are used to attach to the periphery sensors. The major function of the periphery sensors is to protect humans while Forager is in motion or has a payload that is in motion. The sensors are constantly monitoring 360° and can be used to help Forager with motion, (at 300 pounds, driving into a building will most assuredly leave a mark).

Once testing is complete, example code and actual video will be released for those interested.

Components

TWR-ELEV

cLS-FSTS-COMM

cLS-FSTS-GCE

cLS-FSTS-REMOTE

cLS-FSTS-MCU-CORE

Forager-ARV

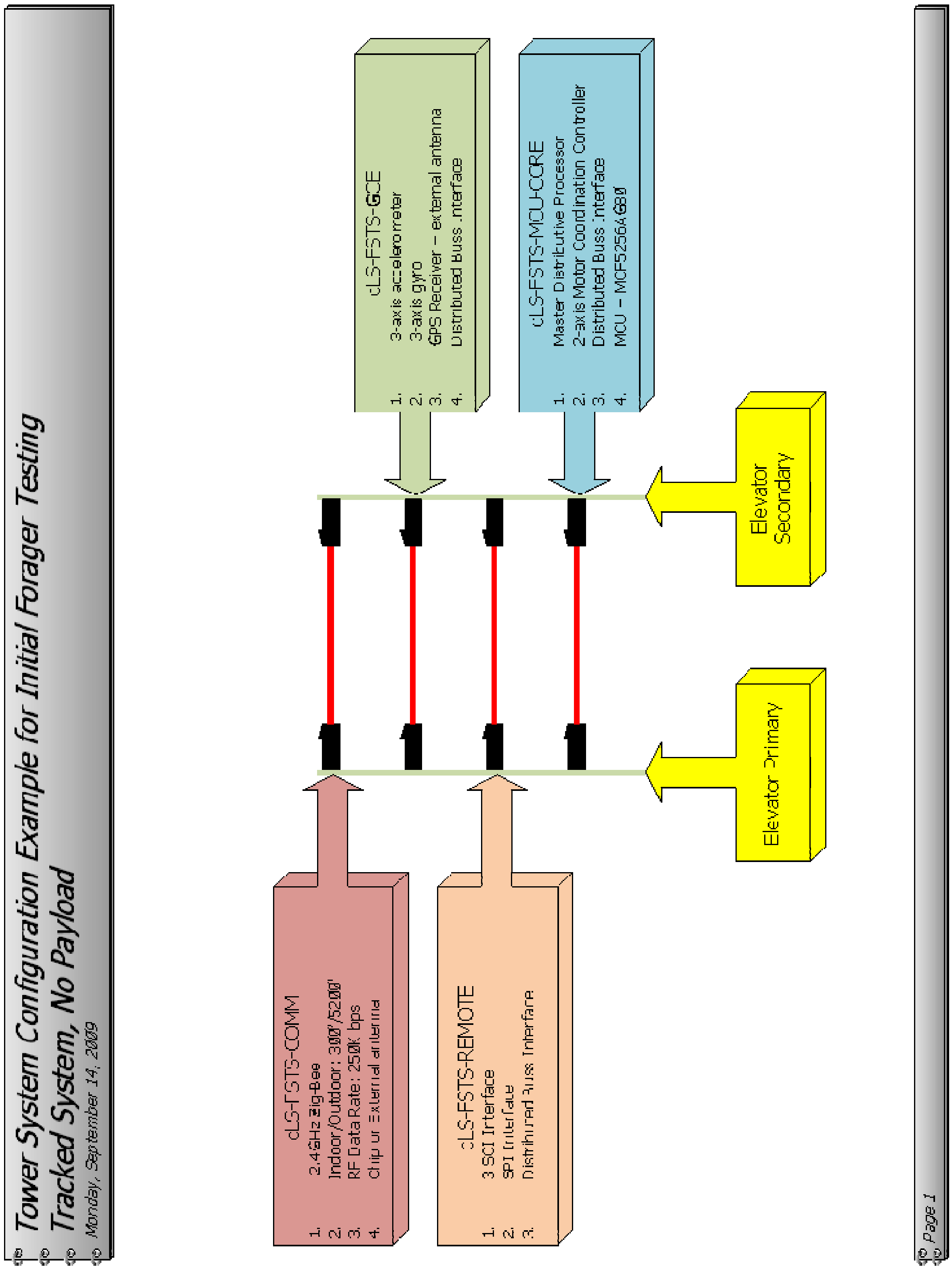
Tower System Configuration Example for Initial Forager Testing
Tracked System, No Payload
Monday, September 14, 2009
CLS-FSTS-GCE
1. 3-axis accelerometer
2. 3-axis gyro
3. GPS Receiver – external antenna
4. Distributed Buss Interface
CLS-FSTS-MCU-CORE
1. Master Distributive Processor
2. 2-axis Motor Coordination Controller
3. Distributed Buss Interface
4. MCU – MCF52564
Elevator Secondary
Elevator Primary
CLS-FSTS-COMM
1. 2.4GHz Zig-Bee
2. Indoor/Outdoor: 300'/5200'
3. RF Data Rate: 250K bps
4. Chip or External antenna
CLS-FSTS-REMOTE
1. 3 SCI Interface
2. SPI Interface
3. Distributed Buss Interface
Page 1

Figure 4

Commercial Application Example 2 – Forager

Brief

In this final example it should mentioned that the original TWR-ELEV boards have been replaced due to their limited size. Once all basic functions were tested the ultimate goal of full autonomous action was configured. This required more interfaces then could be configured in four boards. See Figure 5

The TWR-MF51CN-KIT has been changed out to an expanded version containing 8-slots and a plug-in power deck. The power deck (cLS-FSTSPD) not only supplies the elevators with their required voltages, but a cable edge connector also contains added voltages for other functions. The deck also interfaces to our battery management system (BMS). With the addition of more sensors to keep an “eye” on things a second cLS-FSTS-REMOTE card was added, allowing splitting the tasks between them, care should be given on how the tasks are split up. The primary board added in this application is the cLS-FSTS-LIDAR; this is a laser range finder used to paint a computer picture of what is in front of the finder. In this case it will be what is in front of Forager. Another add-in to the stack that can aid with motion is the cLS-FSTS-CCD which is a dual camera card that looks forward, but the cameras are mounted to facilitate tilt/ pan. We will be testing the RobotSee programming language on this card. Because Forager is an Omni-chassis there are a number of different payloads becoming available. The cLS-FSTS-C3 is an Altera Cyclone 3™ based configurable card. The card is setup so the MCU-CORE can down load a specific configuration for the payload unit. This configuration stays in place until changed.

There will video available once all testing has been completed.

Components

cLS-FSTS-E8
cLS-FSTS-PD
cLS-FSTS-COMM
cLS-FSTS-GCE
cLS-FSTS-REMOTE (2)
cLS-FSTS-LIDAR
cLS-FSTS-CCD
cLS-FSTS-C3
cLS-FSTS-MCU-CORE
Forager-ARV

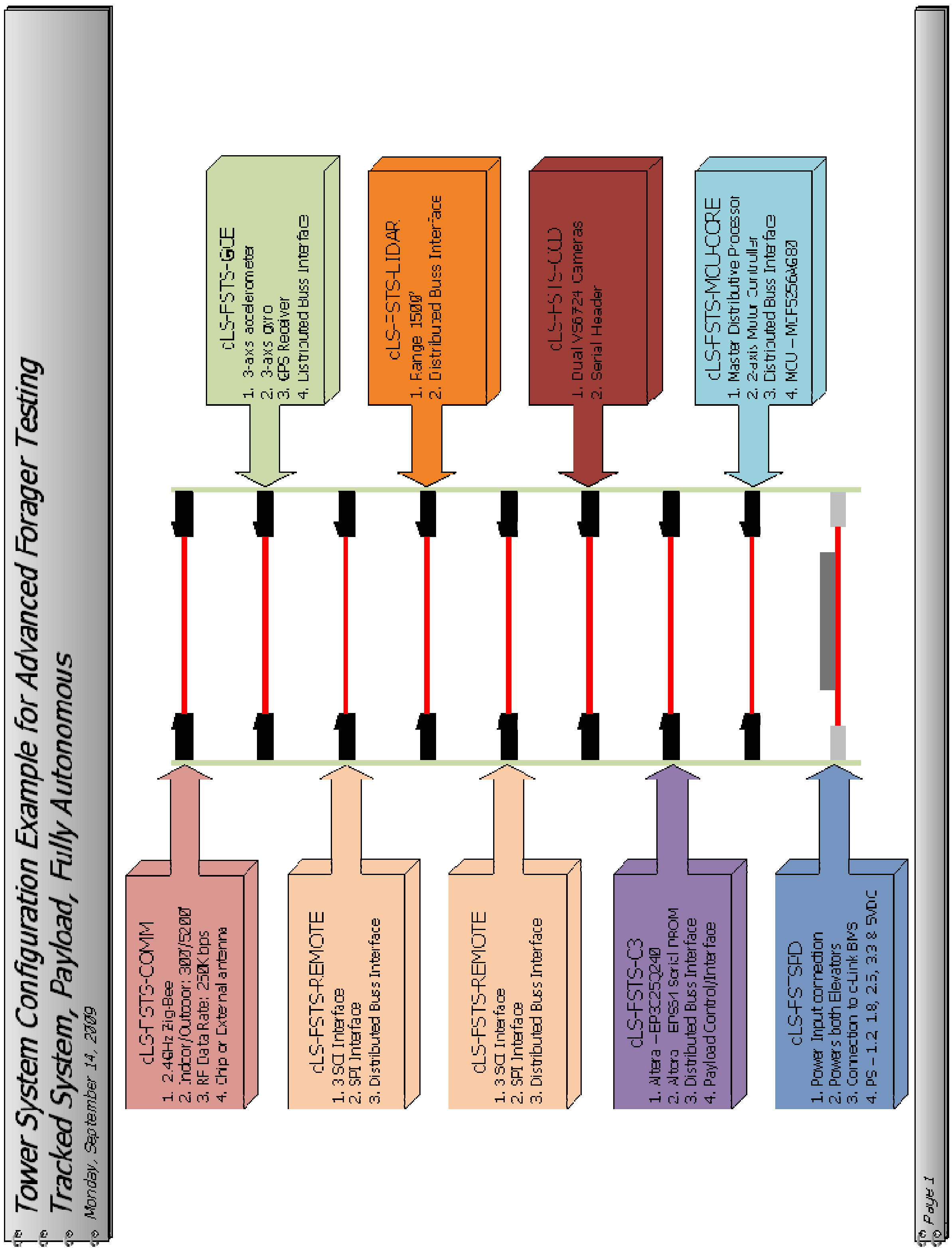
Tower System Configuration Example for Advanced Forager Testing
Tracked System, Payload, Fully Autonomous
Monday, September 14, 2009
cLS-FSTS-COMM
1. 2.4GHz Zig-Bee
2. Indoor/Outdoor: 300'/5200'
3. RF Data Rate: 250K bps
4. Chip or External antenna
cLS-FSTS-REMOTE
1. 3 SCI Interface
2. SPI Interface
3. Distributed Buss Interface
cLS-FSTS-REMOTE
1. 3 SCI Interface
2. SPI Interface
3. Distributed Buss Interface
cLS-FSTS-C3
1. Altera – EP3C25Q240
2. Altera EPCS4 Serial PROM
3. Distributed Buss Interface
4. Payload Control/Interface
cLS-FSTS-SPD
1. Power Input correction
2. Powers both Elevators
3. Connection to c-Link BMS
4. PS – 1.2, 1.8, 2.5, 3.3 & 5VDC
cLS-FSTS-GUE
1. 3-axis accelerometer
2. 3-axis gyro
3. GPS Receiver
4. Distributed Buss Interface
cLS-FSTS-LIDAR
1. Range 1500'
2. Distributed Buss Interface
cLS-FSTS-CCD
1. Dual VS6724 Cameras
2. Serial Header
cLS-FSTS-MCU-CORE
1. Master Distributive Processor
2. 2-axis Motor Controller
3. Distributed Buss Interface
4. MCU – MCF5256AG80
Page 1

Figure 5

Conclusion

The Freescale Tower System is one of the most versatile configurations in the last few years. It is also low cost, allowing more developers access to implementing new ideas.

Both of these robotic vehicles are used to further robotic control development and in the case of Forager enhance the work done by humans.

References

1. Tower System—Freescale Semiconductor, Inc.

http://www.freescale.com/webapp/sps/site/overview.jsp?code=TOWER_HOME&fsrch=1

2. CUBE-BEC—c-Link Systems, Inc.

3. Forager-ARV—c-Link Systems, Inc.

http://www.c-linksystems.com/sfarv.html

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