hackerspace global grid

world domination - one measurement at a time

hadez@hgg.aero, @hdznrrd armin@hgg.aero, @rel0c8

shackspace - devision for aerospace research and space exploration

10. Mai 2012

Caveat

- hgg is, at its heart, a *very* technical project
- Fear not! This presentation will give you a general overview and keep technicalities to a minimum

Caveat

- hgg is, at its heart, a *very* technical project
- Fear not! This presentation will give you a general overview and keep technicalities to a minimum

CCCamp 2011

- Nick Farr, Lars Weiler, Jens Ohlig propose a *Hacker Space Program*
  - Ambitious goal: 23 years to put a hacker on the moon!
- Three hackers from shackspace immediately brainfart
- "This is awesome!"
- "Let's do it!"
- P.S.: hgg is a small part in the bigger scheme of the *Hacker Space Program*

CCCamp 2011

- Nick Farr, Lars Weiler, Jens Ohlig propose a *Hacker Space Program*
  - Ambitious goal: 23 years to put a hacker on the moon!
- Three hackers from shackspace immediately brainfart
- "This is awesome!"
- "Let's do it!"
- P.S.: hgg is a small part in the bigger scheme of the *Hacker Space Program*

CCCamp 2011

- Nick Farr, Lars Weiler, Jens Ohlig propose a *Hacker Space Program*
  - Ambitious goal: 23 years to put a hacker on the moon!
- Three hackers from shackspace immediately brainfart
- "This is awesome!"
- "Let's do it!"
- P.S.: hgg is a small part in the bigger scheme of the *Hacker Space Program*

CCCamp 2011

- Nick Farr, Lars Weiler, Jens Ohlig propose a *Hacker Space Program*
  - Ambitious goal: 23 years to put a hacker on the moon!
- Three hackers from shackspace immediately brainfart
- "This is awesome!"
- "Let's do it!"
- P.S.: hgg is a small part in the bigger scheme of the *Hacker Space Program*

CCCamp 2011

- Nick Farr, Lars Weiler, Jens Ohlig propose a *Hacker Space Program*
  - Ambitious goal: 23 years to put a hacker on the moon!
- Three hackers from shackspace immediately brainfart
- "This is awesome!"
- "Let's do it!"
- P.S.: hgg is a small part in the bigger scheme of the *Hacker Space Program*

CCCamp 2011

- Nick Farr, Lars Weiler, Jens Ohlig propose a *Hacker Space Program*
  - Ambitious goal: 23 years to put a hacker on the moon!
- Three hackers from shackspace immediately brainfart
- "This is awesome!"
- "Let's do it!"
- P.S.: hgg is a small part in the bigger scheme of the *Hacker Space Program*

The first idea

- Short term: Understand how satellite communication works
- Mid term: Setup something so we can receive sat comm
  - Make it simple. Each *hackerspace* should have one.
  - Each Hackerspace means it's global
  - Network the ground stations and build a grid
- Long term: Add something so we can also send signals

The first idea

- Short term: Understand how satellite communication works
- Mid term: Setup something so we can receive sat comm
  - Make it simple. Each *hackerspace* should have one
  - Each Hackerspace means it's *global*
  - Network the ground stations and build a *grid*
- Long term: Add something so we can also send signals

The first idea

- Short term: Understand how satellite communication works
- Mid term: Setup something so we can receive sat comm
  - Make it simple. Each *hackerspace* should have one
  - Each Hackerspace means it's *global*
  - Network the ground stations and build a *grid*
- Long term: Add something so we can also send signals

The first idea

- Short term: Understand how satellite communication works
- Mid term: Setup something so we can receive sat comm
  - Make it simple. Each *hackerspace* should have one
  - Each Hackerspace means it's *global*
  - Network the ground stations and build a *grid*
- Long term: Add something so we can also send signals

The first idea

- Short term: Understand how satellite communication works
- Mid term: Setup something so we can receive sat comm
  - Make it simple. Each *hackerspace* should have one
  - Each Hackerspace means it's *global*
  - Network the ground stations and build a *grid*
- Long term: Add something so we can also send signals

The first idea

- Short term: Understand how satellite communication works
- Mid term: Setup something so we can receive sat comm
  - Make it simple. Each *hackerspace* should have one
  - Each Hackerspace means it's *global*
  - Network the ground stations and build a *grid*
- Long term: Add something so we can also send signals

Joining up w/ Constellation

- Andreas Hornig of AerospaceResearch.net ends up giving a talk on Constellation at shackspace
- Both sides immediately notice the similarity in his DGSN and our HGG idea
- We join forces

Joining up w/ Constellation

- Andreas Hornig of AerospaceResearch.net ends up giving a talk on Constellation at shackspace
- Both sides immediately notice the similarity in his DGSN and our HGG idea
- We join forces

Joining up w/ Constellation

- Andreas Hornig of AerospaceResearch.net ends up giving a talk on Constellation at shackspace
- Both sides immediately notice the similarity in his DGSN and our HGG idea
- We join forces

"Call to arms"talk at 28c3

- After the initial research and proof of concepts we thought it would be nice to have 3 to 5 more folks helping us
- So we handed in a talk for 28c3
- Press feedback was never the same...

"Call to arms"talk at 28c3

- After the initial research and proof of concepts we thought it would be nice to have 3 to 5 more folks helping us
- So we handed in a talk for 28c3
- Press feedback was never the same...

"Call to arms"talk at 28c3

- After the initial research and proof of concepts we thought it would be nice to have 3 to 5 more folks helping us
- So we handed in a talk for 28c3
- Press feedback was never the same...

Press feedback

- "Hacker aus Stuttgart - Mit dem Lötkolben ins Weltall"
  – *Stuttgarter Zeitung*
- "Hacking im Weltraum - Hacker arbeiten an eigenem Satellitennetzwerk"
  – *Golem*
- "Hackers send internet into space"
  – *UK Metro*
- "Hackers plan space satellites to combat censorship"
  – *bbc*
- "Hacking confab conjures visions of space-borne 'SOPA Wars'"
  – *cnet*

Press feedback

- "Hacker aus Stuttgart - Mit dem Lötkolben ins Weltall"
  – *Stuttgarter Zeitung*
- "Hacking im Weltraum - Hacker arbeiten an eigenem Satellitennetzwerk"
  – *Golem*
- "Hackers send internet into space"
  – *UK Metro*
- "Hackers plan space satellites to combat censorship"
  – *bbc*
- "Hacking confab conjures visions of space-borne 'SOPA Wars'"
  – *cnet*

Press feedback

- "Hacker aus Stuttgart - Mit dem Lötkolben ins Weltall"
  – *Stuttgarter Zeitung*
- "Hacking im Weltraum - Hacker arbeiten an eigenem Satellitennetzwerk"
  – *Golem*
- "Hackers send internet into space"
  – *UK Metro*
- "Hackers plan space satellites to combat censorship"
  – *bbc*
- "Hacking confab conjures visions of space-borne 'SOPA Wars'"
  – *cnet*

Press feedback

- "Hacker aus Stuttgart - Mit dem Lötkolben ins Weltall"
  – *Stuttgarter Zeitung*
- "Hacking im Weltraum - Hacker arbeiten an eigenem Satellitennetzwerk"
  – *Golem*
- "Hackers send internet into space"
  – *UK Metro*
- "Hackers plan space satellites to combat censorship"
  – *bbc*
- "Hacking confab conjures visions of space-borne 'SOPA Wars'"
  – *cnet*

Press feedback

- "Hacker aus Stuttgart - Mit dem Lötkolben ins Weltall"
  – *Stuttgarter Zeitung*
- "Hacking im Weltraum - Hacker arbeiten an eigenem Satellitennetzwerk"
  – *Golem*
- "Hackers send internet into space"
  – *UK Metro*
- "Hackers plan space satellites to combat censorship"
  – *bbc*
- "Hacking confab conjures visions of space-borne 'SOPA Wars'"
  – *cnet*

What hgg definitely isn't

- The *Hacker Space Program's* aim is to have communication infrastructure in place at some point
- *Hackespace Global Grid / hgg* is working on the very basics of this (distributed ground station network)
- However, we (as in hgg) are *not* building an alternative internet at the moment
- We are working on getting something out there which can be used as a platform and starting point to seed other projects and ideas

What hgg definitely isn't

- The *Hacker Space Program's* aim is to have communication infrastructure in place at some point
- *Hackespace Global Grid / hgg* is working on the very basics of this (distributed ground station network)
- However, we (as in hgg) are *not* building an alternative internet at the moment
- We are working on getting something out there which can be used as a platform and starting point to seed other projects and ideas

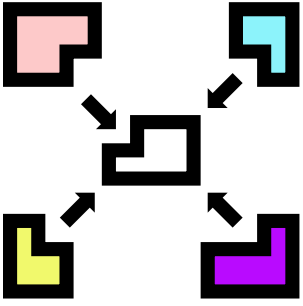
What hgg definitely isn't

- The *Hacker Space Program's* aim is to have communication infrastructure in place at some point
- *Hackespace Global Grid / hgg* is working on the very basics of this (distributed ground station network)
- However, we (as in hgg) are *not* building an alternative internet at the moment
- We are working on getting something out there which can be used as a platform and starting point to seed other projects and ideas

What hgg definitely isn't

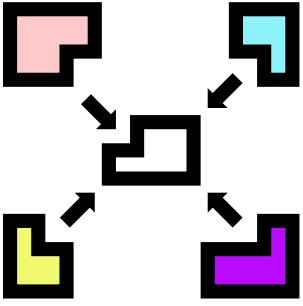
- The *Hacker Space Program's* aim is to have communication infrastructure in place at some point
- *Hackespace Global Grid / hgg* is working on the very basics of this (distributed ground station network)
- However, we (as in hgg) are *not* building an alternative internet at the moment
- We are working on getting something out there which can be used as a platform and starting point to seed other projects and ideas

Build a modular system



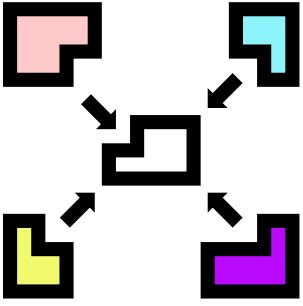
- Easier to develop
- Easier to extend
- Easier to improve

Build a modular system



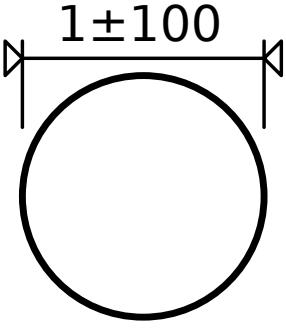
- Easier to develop
- Easier to extend
- Easier to improve

Build a modular system



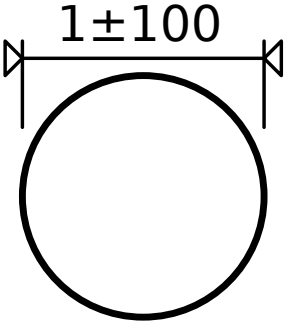
- Easier to develop
- Easier to extend
- Easier to improve

Make it as accurate as possible



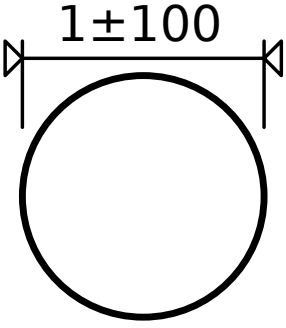
- One second resolution is "boring"
- Let's aim for 100 ns
- Allow scaling up to "ridiculous"

Make it as accurate as possible



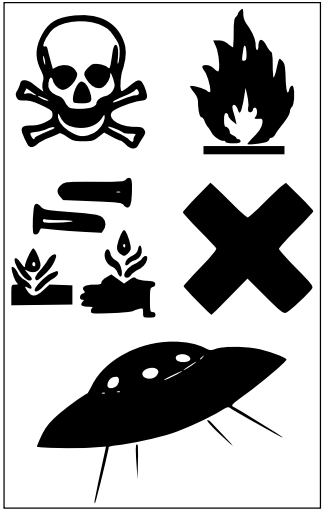
- One second resolution is "boring"
- Let's aim for 100 ns
- Allow scaling up to "ridiculous"

Make it as accurate as possible



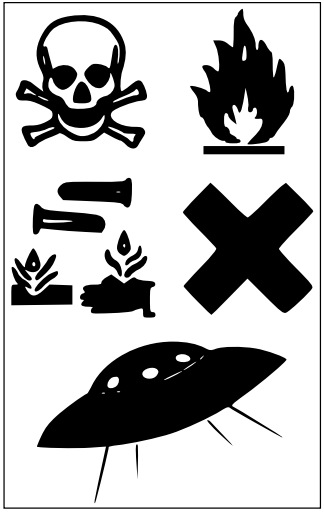
- One second resolution is "boring"
- Let's aim for 100 ns
- Allow scaling up to "ridiculous"

Measure stuff



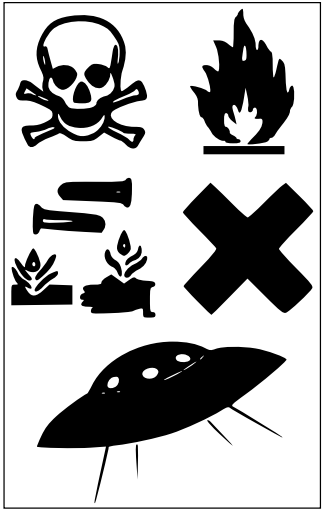
- Airplanes
- Satellites
- Background radiation
- Or even just the temperate

Measure stuff



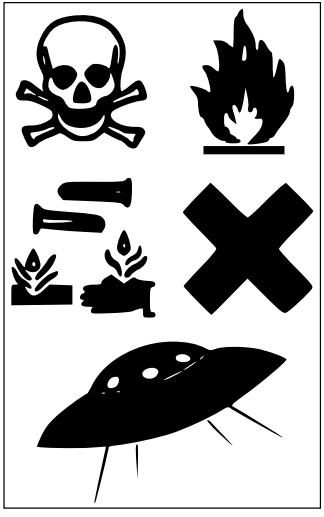
- Airplanes
- Satellites
- Background radiation
- Or even just the temperate

Measure stuff



- Airplanes
- Satellites
- Background radiation
- Or even just the temperate

Measure stuff



- Airplanes
- Satellites
- Background radiation
- Or even just the temperate

Make it a distributed system

- Many simple measurement stations
- networked together
- providing geo-coded data

Make it a distributed system

- Many simple measurement stations
- networked together
- providing geo-coded data

Make it a distributed system

- Many simple measurement stations
- networked together
- providing geo-coded data

Make it easy to use

- Ideal: build your own
- Realistic: assemble a kit
- Lazy: buy it, plug it in, forget about it

Make it easy to use

- Ideal: build your own
- Realistic: assemble a kit
- Lazy: buy it, plug it in, forget about it

Make it easy to use

- Ideal: build your own
- Realistic: assemble a kit
- Lazy: buy it, plug it in, forget about it

Who's behind it?

- Just a bunch of folks, really
  - reloc0 & hadez & saeugetier working on hgg
  - -horn- working on Constellation
  - Paweł, Isaac, and a few others working on various projects
- No company or governments
- By hackers, for everyone

Who's behind it?

- Just a bunch of folks, really
  - reloc0 & hadez & saeugetier working on hgg
  - -horn- working on Constellation
  - Paweł, Isaac, and a few others working on various projects
- No company or governments
- By hackers, for everyone

Who's behind it?

- Just a bunch of folks, really
  - reloc0 & hadez & saeugetier working on hgg
  - -horn- working on Constellation
  - Paweł, Isaac, and a few others working on various projects
- No company or governments
- By hackers, for everyone

Who's behind it?

- Just a bunch of folks, really
  - reloc0 & hadez & saeugetier working on hgg
  - -horn- working on Constellation
  - Paweł, Isaac, and a few others working on various projects
- No company or governments
- By hackers, for everyone

Who's behind it?

- Just a bunch of folks, really
  - reloc0 & hadez & saeugetier working on hgg
  - -horn- working on Constellation
  - Paweł, Isaac, and a few others working on various projects
- No company or governments
- By hackers, for everyone

Who's behind it?

- Just a bunch of folks, really
  - reloc0 & hadez & saeugetier working on hgg
  - -horn- working on Constellation
  - Paweł, Isaac, and a few others working on various projects
- No company or governments
- By hackers, for everyone

Consolidating existing and new information

- There is already *a lot* of information available
  - HAM radio community
  - Amateur satellite community
  - Hackers & makers
- We're collecting information relevant to the ask
- Try to make it easier to understand where certain details aren't documented well
- Document our findings, results and failures for others to learn from

Consolidating existing and new information

- There is already *a lot* of information available
  - HAM radio community
  - Amateur satellite community
  - Hackers & makers
- We're collecting information relevant to the ask
- Try to make it easier to understand where certain details aren't documented well
- Document our findings, results and failures for others to learn from

Consolidating existing and new information

- There is already *a lot* of information available
  - HAM radio community
  - Amateur satellite community
  - Hackers & makers
- We're collecting information relevant to the ask
- Try to make it easier to understand where certain details aren't documented well
- Document our findings, results and failures for others to learn from

Consolidating existing and new information

- There is already *a lot* of information available
  - HAM radio community
  - Amateur satellite community
  - Hackers & makers
- We're collecting information relevant to the ask
- Try to make it easier to understand where certain details aren't documented well
- Document our findings, results and failures for others to learn from

Consolidating existing and new information

- There is already *a lot* of information available
  - HAM radio community
  - Amateur satellite community
  - Hackers & makers
- We're collecting information relevant to the ask
- Try to make it easier to understand where certain details aren't documented well
- Document our findings, results and failures for others to learn from

Consolidating existing and new information

- There is already *a lot* of information available
  - HAM radio community
  - Amateur satellite community
  - Hackers & makers
- We're collecting information relevant to the ask
- Try to make it easier to understand where certain details aren't documented well
- Document our findings, results and failures for others to learn from

Consolidating existing and new information

- There is already *a lot* of information available
  - HAM radio community
  - Amateur satellite community
  - Hackers & makers
- We're collecting information relevant to the ask
- Try to make it easier to understand where certain details aren't documented well
- Document our findings, results and failures for others to learn from

Learning the basics

- PCB design
- FPGA programming in VHDL
- Microcontroller programming in C
- Antenna design

Learning the basics

- PCB design
- FPGA programming in VHDL
- Microcontroller programming in C
- Antenna design

Learning the basics

- PCB design
- FPGA programming in VHDL
- Microcontroller programming in C
- Antenna design

Learning the basics

- PCB design
- FPGA programming in VHDL
- Microcontroller programming in C
- Antenna design

Open source everything

- Code available at github.com/shackspace/hgg
- Documentation and planning at hgg.aero/

Open source everything

- Code available at github.com/shackspace/hgg
- Documentation and planning at hgg.aero/

What is it actually good for?

- Public access to all measurement results (don't get cheated)
- Access to infrastructure to deploy own (measurement) equipment

What is it actually good for?

- Public access to all measurement results (don't get cheated)
- Access to infrastructure to deploy own (measurement) equipment

What about applications?

- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live track background radiation levels
  - Spot minute changes in the electromagnetic spectrum
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more...

What about applications?

- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live track background radiation levels
  - Spot minute changes in the electromagnetic spectrum
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more

What about applications?

- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live-track background radiation levels
  - Spot minute changes in the electromagnetic spectrum
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more...

What about applications?

- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live-track background radiation levels
  - Spot minute changes in the environment over time
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more

What about applications?

- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live-track background radiation levels
  - Spot minute changes in the environment over time
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more

What about applications?

- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live-track background radiation levels
  - Spot minute changes in the environment over time
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more

What about applications?

- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live-track background radiation levels
  - Spot minute changes in the environment over time
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more

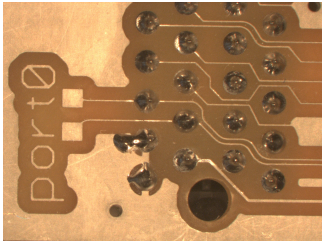
What about applications?

- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live-track background radiation levels
  - Spot minute changes in the environment over time
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more

What about applications?

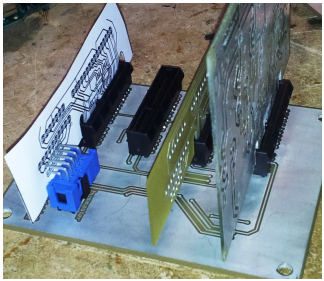
- Constellation
  - Track amateur satellites
  - Using pseudo-ranging w/ multiple receiver stations
- Once ground stations start gathering and publishing data, the possibilities are endless
  - Live-track background radiation levels
  - Spot minute changes in the environment over time
  - Accurate, geo-referenced time
  - Basis for assisted GPS solutions
  - and many, many more

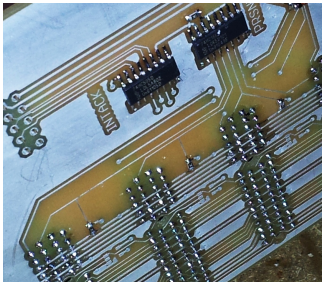
Specification of physical interface between modules



- Modules are connected via a backplane
- PCIe 4x plug w/ custom pinout
- 2x RS485 lanes for inter-module communication
- SPI-ish time broadcast bus
- Differential clock signal for high-res timing signal
- Each module sports storage for calibration data

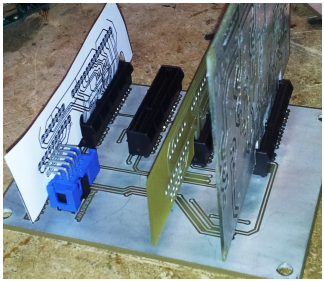
friendship0 backplane

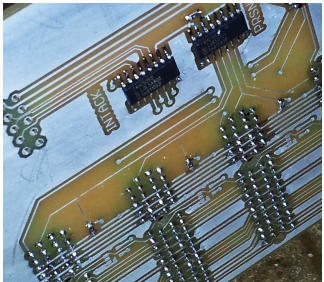




- Four modules slots, one dedicated to bus master module
- ICs for interrupt handling
- Can be easily scaled up, next step eight or nine slots

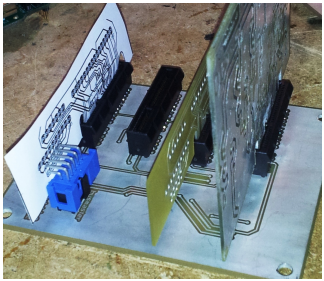
friendship0 backplane

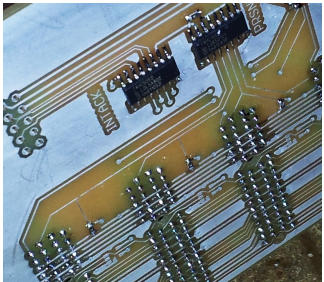




- Four modules slots, one dedicated to bus master module
- ICs for interrupt handling
- Can be easily scaled up, next step eight or nine slots

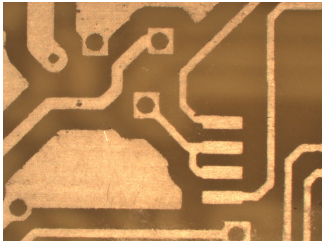
friendship0 backplane

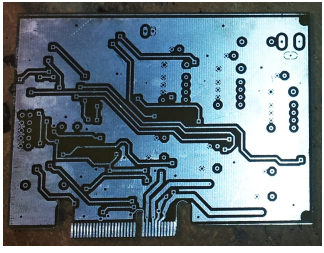




- Four modules slots, one dedicated to bus master module
- ICs for interrupt handling
- Can be easily scaled up, next step eight or nine slots

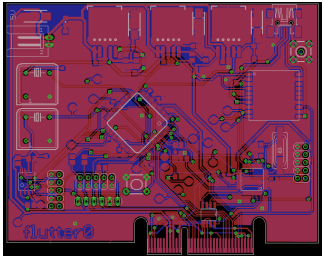
braeburn0 & 1 power supply module





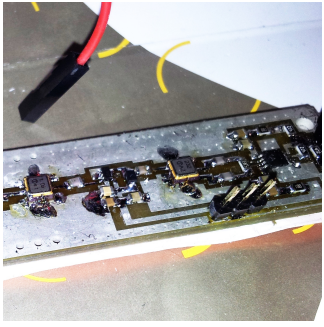
- Single external power source
- All voltages generated on-board, stabilized
- In-system voltage level monitoring
- braeburn1 using PC power supply

flutter0 high precision distributed time source module



- Spartan3 FPGA for high-res timing (<100 ns)
- ATmega 168 for lo-res timing (1 s to 1/10th s)
- Low cost GPS module w/ external antenna support

dash0 proof of concept



- ADS-B receiver based around miniADSB module
- Easily track commercial aircrafts
- Perfect for verifying pseudo ranging algorithms

celestia0 bus master module

- Manages interrupt requests by modules
- Arbitrates resources
- Enumeration of available modules

celestia0 bus master module

- Manages interrupt requests by modules
- Arbitrates resources
- Enumeration of available modules

celestia0 bus master module

- Manages interrupt requests by modules
- Arbitrates resources
- Enumeration of available modules

dash0 ADSB receiver module

- Built around the proof of concept
- Most likely CPLD-based decoding of Manchester-encoded signal
- Contributions by Pawel
- Perfect to test pseudo-ranging because ADSB signal contains GPS location data already (ground truth)
- Your own fligt tracking radar at home? Hell, yeah!

dash0 ADSB receiver module

- Built around the proof of concept
- Most likely CPLD-based decoding of Manchester-encoded signal
- Contributions by Pawel
- Perfect to test pseudo-ranging because ADSB signal contains GPS location data already (ground truth)
- Your own fligt tracking radar at home? Hell, yeah!

dash0 ADSB receiver module

- Built around the proof of concept
- Most likely CPLD-based decoding of Manchester-encoded signal
- Contributions by Pawel
- Perfect to test pseudo-ranging because ADSB signal contains GPS location data already (ground truth)
- Your own fligt tracking radar at home? Hell, yeah!

dash0 ADSB receiver module

- Built around the proof of concept
- Most likely CPLD-based decoding of Manchester-encoded signal
- Contributions by Pawel
- Perfect to test pseudo-ranging because ADSB signal contains GPS location data already (ground truth)
- Your own fligt tracking radar at home? Hell, yeah!

dash0 ADSB receiver module

- Built around the proof of concept
- Most likely CPLD-based decoding of Manchester-encoded signal
- Contributions by Pawel
- Perfect to test pseudo-ranging because ADSB signal contains GPS location data already (ground truth)
- Your own fligt tracking radar at home? Hell, yeah!

magic0 bus protocol

- Protocol spoken between modules and master
- Handles data exchange and enumeration

magic0 bus protocol

- Protocol spoken between modules and master
- Handles data exchange and enumeration

Testing timing accuracy

- First level test: 2x ground stations w/ flutter module
- Second level test: 5 ground stations w/ flutter module

Testing timing accuracy

- First level test: 2x ground stations w/ flutter module
- Second level test: 5 ground stations w/ flutter module

Calibration

- High accuracy measurement requires diligent calibration
- Receiver, decoder, communication lags
- Phase error
- ...

Calibration

- High accuracy measurement requires diligent calibration
- Receiver, decoder, communication lags
- Phase error
- ...

Calibration

- High accuracy measurement requires diligent calibration
- Receiver, decoder, communication lags
- Phase error
- ...

Calibration

- High accuracy measurement requires diligent calibration
- Receiver, decoder, communication lags
- Phase error
- ...

Deploying 5+ systems

- Test pseudo ranging and timing
- This will decide whether tracking would already work with our timing resolution
- If not, timing resolution could be scaled up by factor 10 easily

Deploying 5+ systems

- Test pseudo ranging and timing
- This will decide whether tracking would already work with our timing resolution
- If not, timing resolution could be scaled up by factor 10 easily

Deploying 5+ systems

- Test pseudo ranging and timing
- This will decide whether tracking would already work with our timing resolution
- If not, timing resolution could be scaled up by factor 10 easily

Quality tests and review

- Review everything
- Make improvements where necessary
- Manufacture pre-series
- Hand ground stations out to other hackerspaces and interested subsubsectionies

Quality tests and review

- Review everything
- Make improvements where necessary
- Manufacture pre-series
- Hand ground stations out to other hackerspaces and interested subsubsectionies

Quality tests and review

- Review everything
- Make improvements where necessary
- Manufacture pre-series
- Hand ground stations out to other hackerspaces and interested subsubsectionies

Quality tests and review

- Review everything
- Make improvements where necessary
- Manufacture pre-series
- Hand ground stations out to other hackerspaces and interested subsubsectionies

More modules

- Arduino module
  - Probably the easiest way to prototype
  - Make it available to an already large community
- Environment sensors
  - Measure ALL the things
  - Temperature, humidity, barometric pressure, seismic waves, radiation, hardware stuff, ...
  - ...

More modules

- Arduino module
  - Probably the easiest way to prototype
  - Make it available to an already large community
- Environment sensors
  - Measure All The Things
  - Temperature, humidity, barometric pressure, seismic waves, radiation, hardware stuff, ...
  - ...

More modules

- Arduino module
  - Probably the easiest way to prototype
  - Make it available to an already large community
- Environment sensors
  - Measure ALL the things
  - Temperature, humidity, barometric pressure, seismic waves, radiation, landmark death rates, wind, ...

More modules

- Arduino module
  - Probably the easiest way to prototype
  - Make it available to an already large community
- Environment sensors
  - Measure ALL the things
  - Temperature, humidity, barometric pressure, seismic waves, radiation, tectonic drift, time, wind, ...

More modules

- Arduino module
  - Probably the easiest way to prototype
  - Make it available to an already large community
- Environment sensors
  - Measure ALL the things
  - Temperature, humidity, barometric pressure, seismic waves, radiation, tectonic drift, time, wind, ...

More modules

- Arduino module
  - Probably the easiest way to prototype
  - Make it available to an already large community
- Environment sensors
  - Measure ALL the things
  - Temperature, humidity, barometric pressure, seismic waves, radiation, tectonic drift, time, wind, ...

Satellites!

- Not impossible, though not really *our* goal

Why we have not asked for donations, yet

- Offers from heartwarming to ridiculous
- Still doing research and feasibility studies
- No guarantee that it'll ever work (chances are good, though)
- No money asked, no one disgruntled if it fails.

Why we have not asked for donations, yet

- Offers from heartwarming to ridiculous
- Still doing research and feasibility studies
- No guarantee that it'll ever work (chances are good, though)
- No money asked, no one disgruntled if it fails.

Why we have not asked for donations, yet

- Offers from heartwarming to ridiculous
- Still doing research and feasibility studies
- No guarantee that it'll ever work (chances are good, though)
- No money asked, no one disgruntled if it fails.

Why we have not asked for donations, yet

- Offers from heartwarming to ridiculous
- Still doing research and feasibility studies
- No guarantee that it'll ever work (chances are good, though)
- No money asked, no one disgruntled if it fails.

When we might ask for money

- After prototype works good enough
- Before rolling out on a bigger scale (think 10+)

When we might ask for money

- After prototype works good enough
- Before rolling out on a bigger scale (think 10+)

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com/
  - Issue tracking. Found a problem, raise an issue!
- Public mailing list
  - lists.stackspace.de/listinfo/hackerglobalgrid
  - Pretty low traffic at the moment, this might change in the foreseeable future.
- twitter
  - @hackerglobalgrid

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com/...
  - Issue tracking. Found a problem, raise an issue!
- Public mailing list
  - lists.stackspace.de/listinfo/hackerspaces
  - Pretty low traffic at the moment, this might change in the foreseeable future.
- twitter
  - @hackerspaces

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.shackspace.de/listinfo/torrentblitzen
  - Pretty low traffic at the moment, this might change in the foreseeable future.
- twitter
  - @hggblitzen

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.shackspace.de/listinfo/constellation
  - Fairly low traffic at the moment, this might change in the foreseeable future
- twitter
  - @hgglobalgrid

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.stackspace.de/listinfo/hackerspaceglobalgrid
  - Fairly low traffic at the moment, this might change in the foreseeable future.
- twitter
  - #hackerspaceglobalgrid

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.shackspace.de/listinfo/constellation
  - Fairly low traffic at the moment, this might change in the foreseeable future.
- twitter
  - @hggdotaero

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.shackspace.de/listinfo/constellation
  - Fairly low traffic at the moment, this might change in the foreseeable future.
- twitter
  - #hackstaatgvt

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.shackspace.de/listinfo/constellation
  - Fairly low traffic at the moment, this might change in the foreseeable future.
- twitter
  - @hggdotaero

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.shackspace.de/listinfo/constellation
  - Fairly low traffic at the moment, this might change in the foreseeable future.
- twitter
  - @hxglobalgrid

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.shackspace.de/listinfo/constellation
  - Fairly low traffic at the moment, this might change in the foreseeable future.
- twitter
  - @hxglobalgrid

Keep in touch

- Wiki
  - Edit away at http://hgg.aero/
  - There's a list of open tasks. Pick one or add one!
- GitHub
  - All source code, schematics and layouts available at github.com
  - Issue tracking. Find a problem, raise an issue!
- Public mailing list
  - lists.shackspace.de/listinfo/constellation
  - Fairly low traffic at the moment, this might change in the foreseeable future.
- twitter
  - @hxglobalgrid

Why we have not asked for donations, yet

Questions!

Pretty please :)