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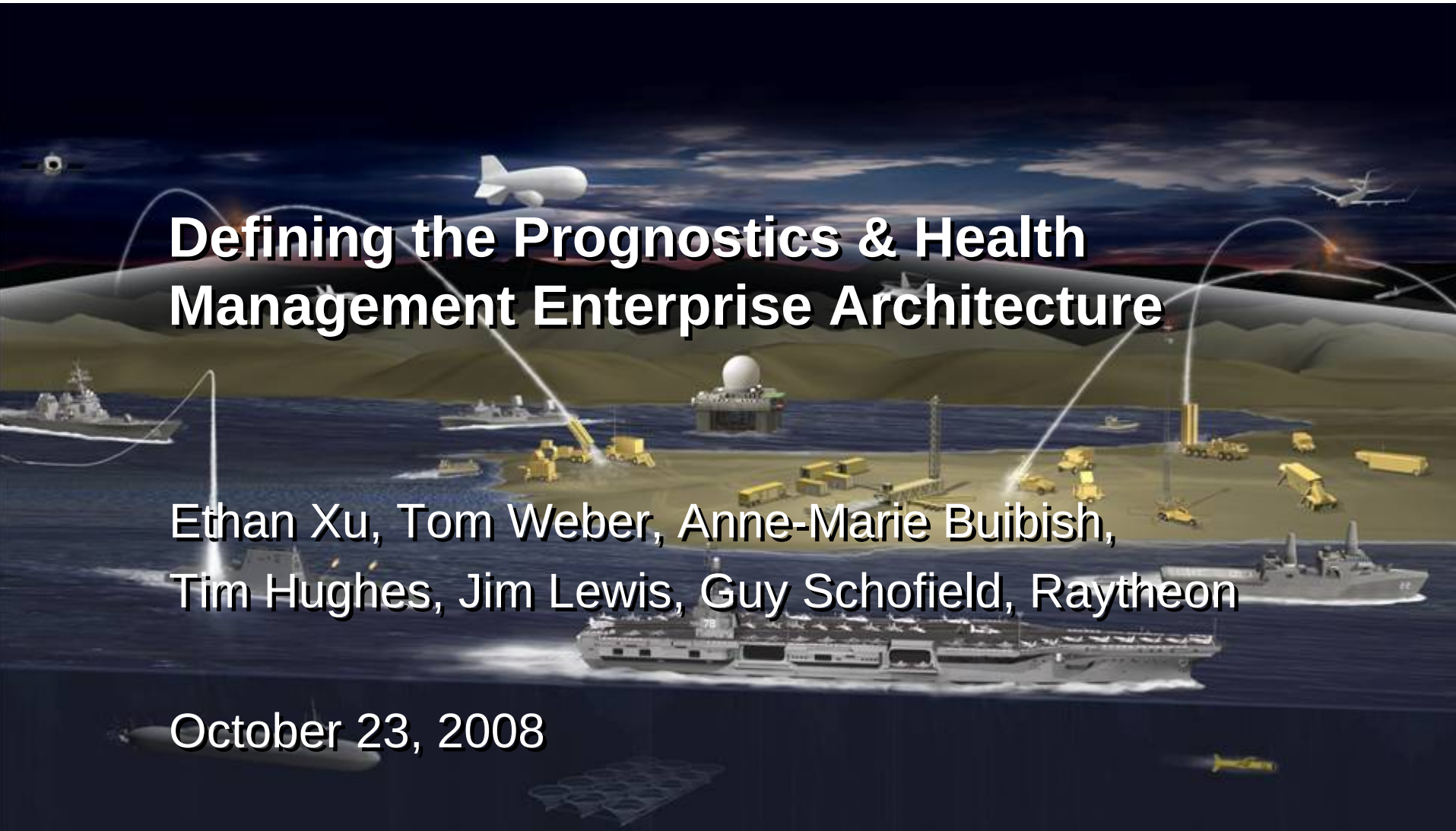
Customer Success Is Our Mission



Defining the Prognostics & Health Management Enterprise Architecture

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October 23, 2008

Outline

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Cases for Action

- Customers are demanding Prognostics & Health Management solutions for extending product life.
- Test costs are rising due to complex design and test requirements.
- In the short run, missions can fail due to unpredicted failures.
- In the long run, system performance is not well maintained.
- We can guarantee system performance and lower maintenance by predicting failures before they occur.
  - These strategies require Prognostics & Health Management Technologies and an overall Condition Based Maintenance strategy.

Health Management Enterprise Architecture

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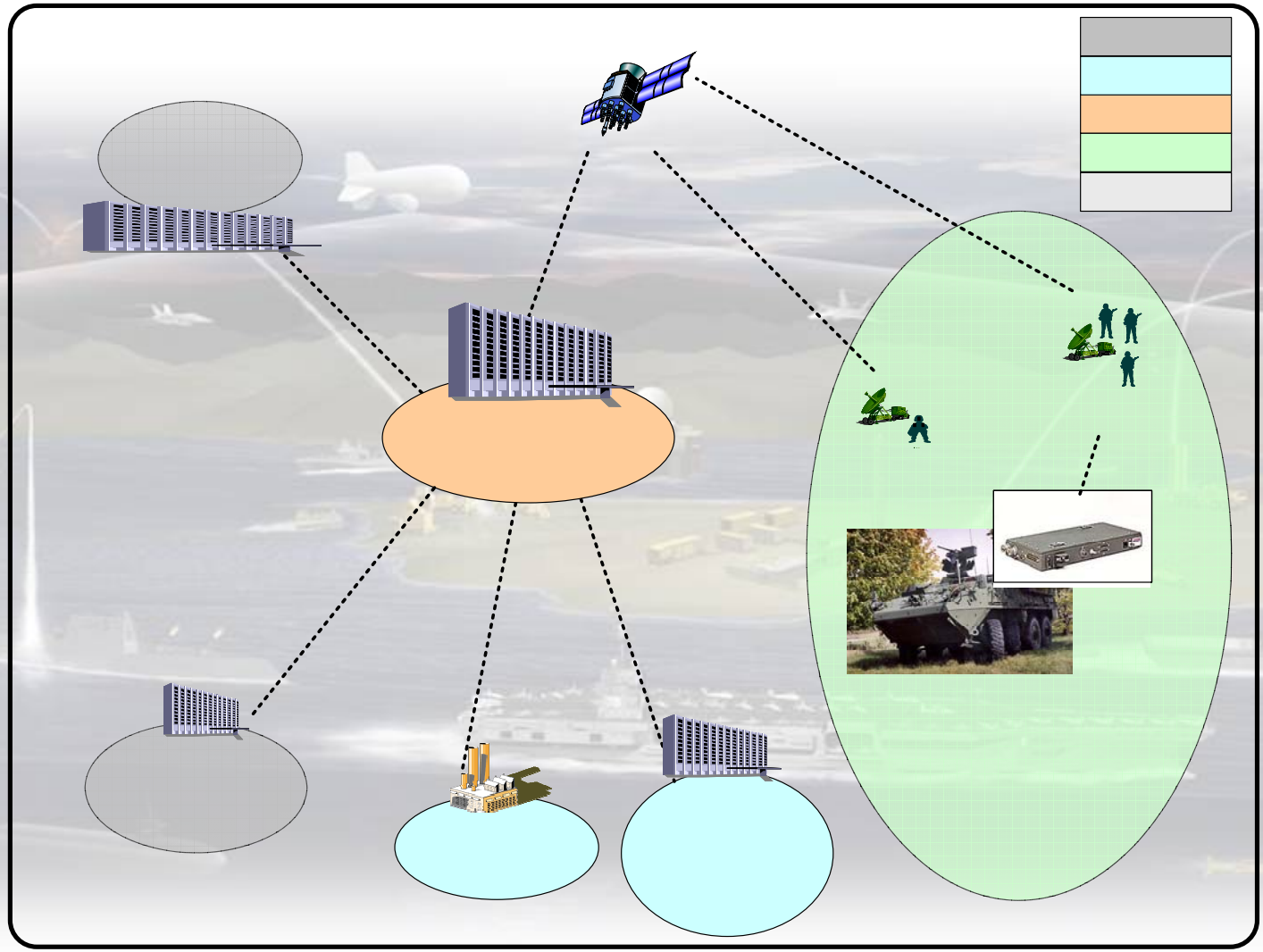

Mission

Prognostics Systems in the PHM Enterprise

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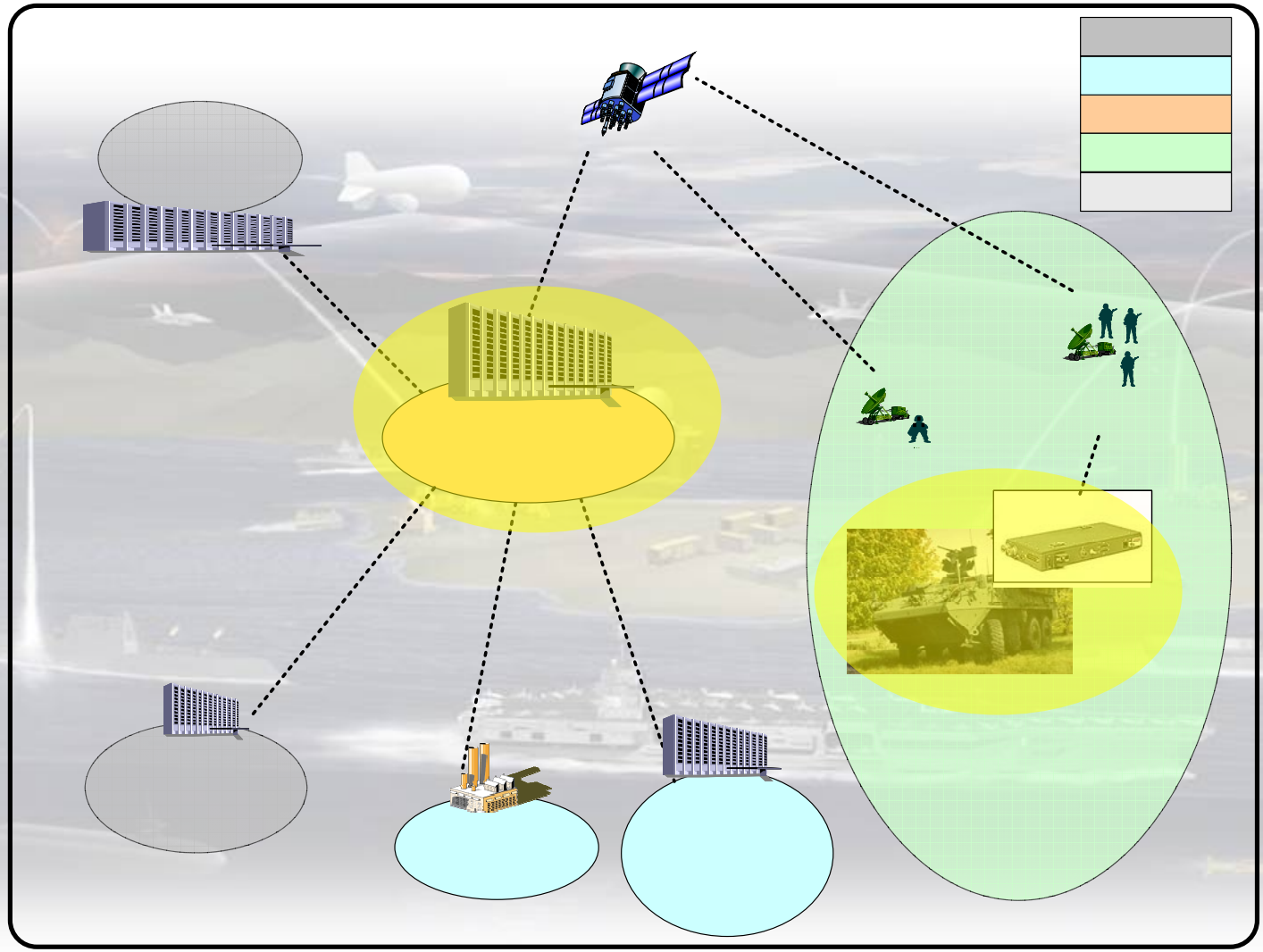

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Prognostics Design & Development

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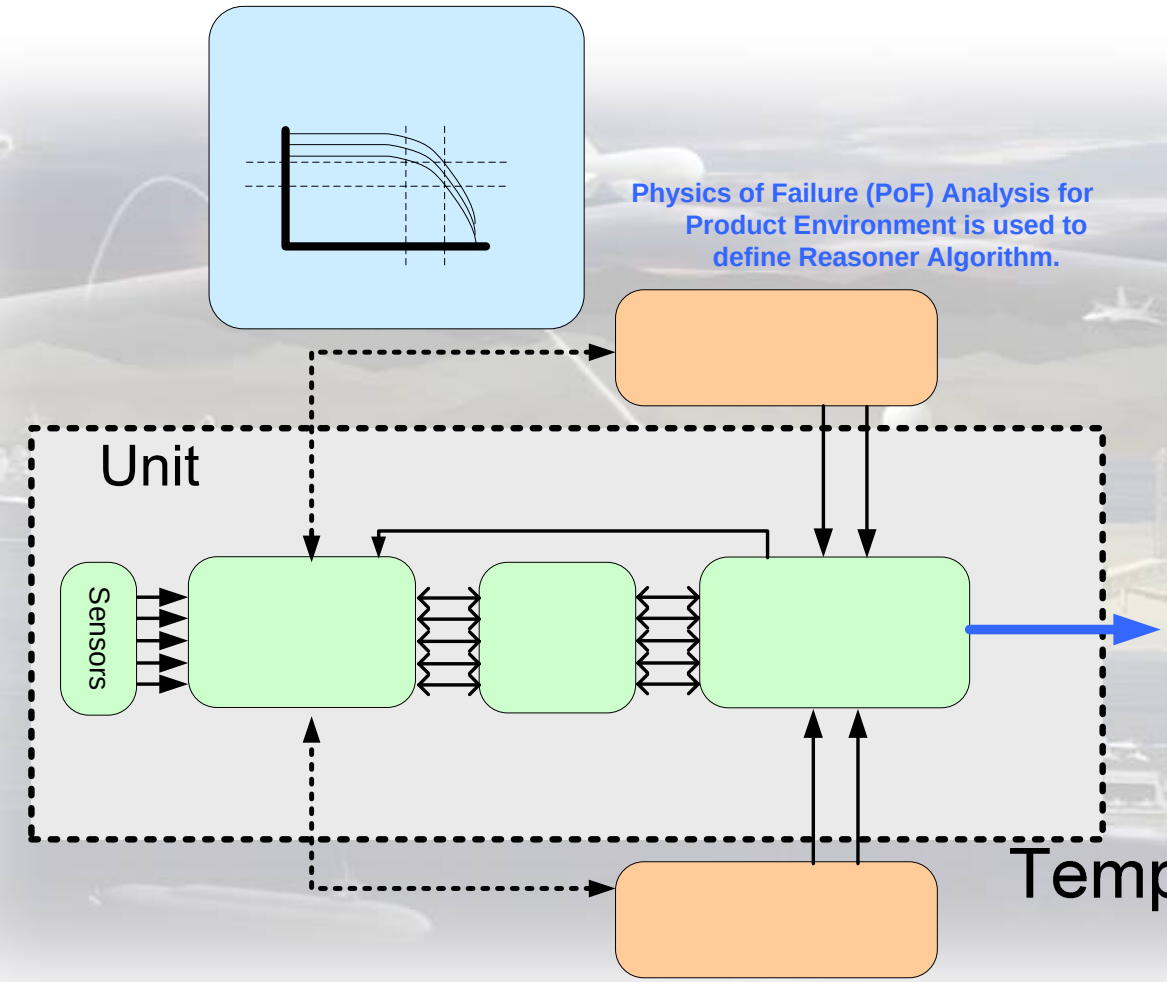

Brown = Engineering Development

Blue = Design and Analysis Data

Grey = Product Implementation

Green = Embedded Solutions

Voltage

Tp1

Prognostics & Health Management Concept

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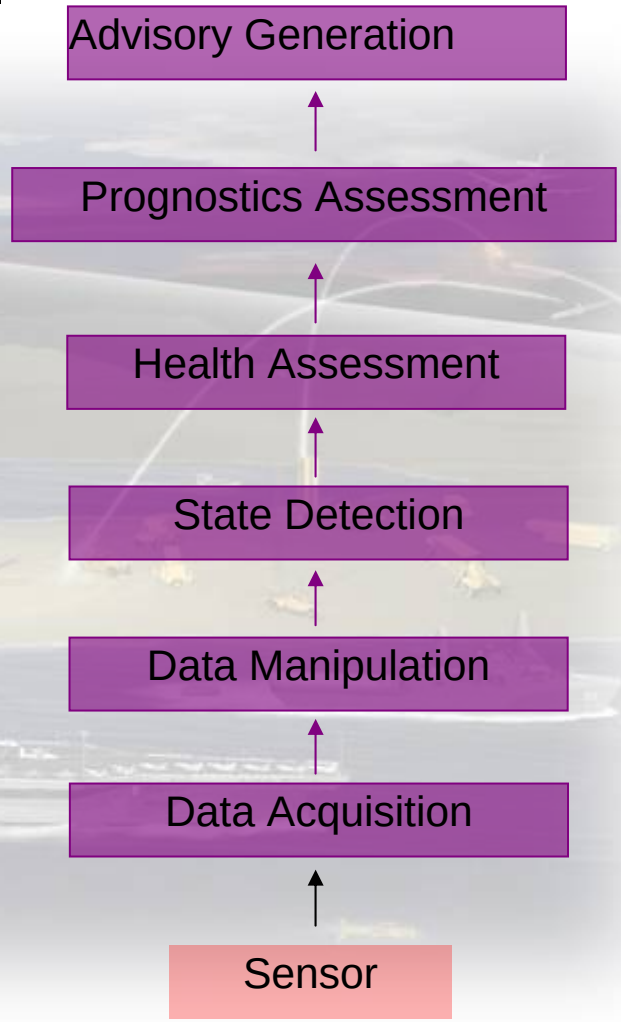
- Purpose: By predicting system Remaining Useful Life, we can remedy failures before they occur.
- Health Assessment step: Determine current state.
  - e.g. Fuel levels are low -> Fuel is urgently needed.
- Prognostics Assessment: Project future state.
  - e.g. Ship radar will fail in the next 72 – 96 hours.— Order a replacement part immediately.
- Advisory Generation: Recommend maintenance strategy based on overall system or fleet health.
- These functions can be performed on or off-board the platform of interest.



Total Asset Visibility Systems in the PHM Enterprise

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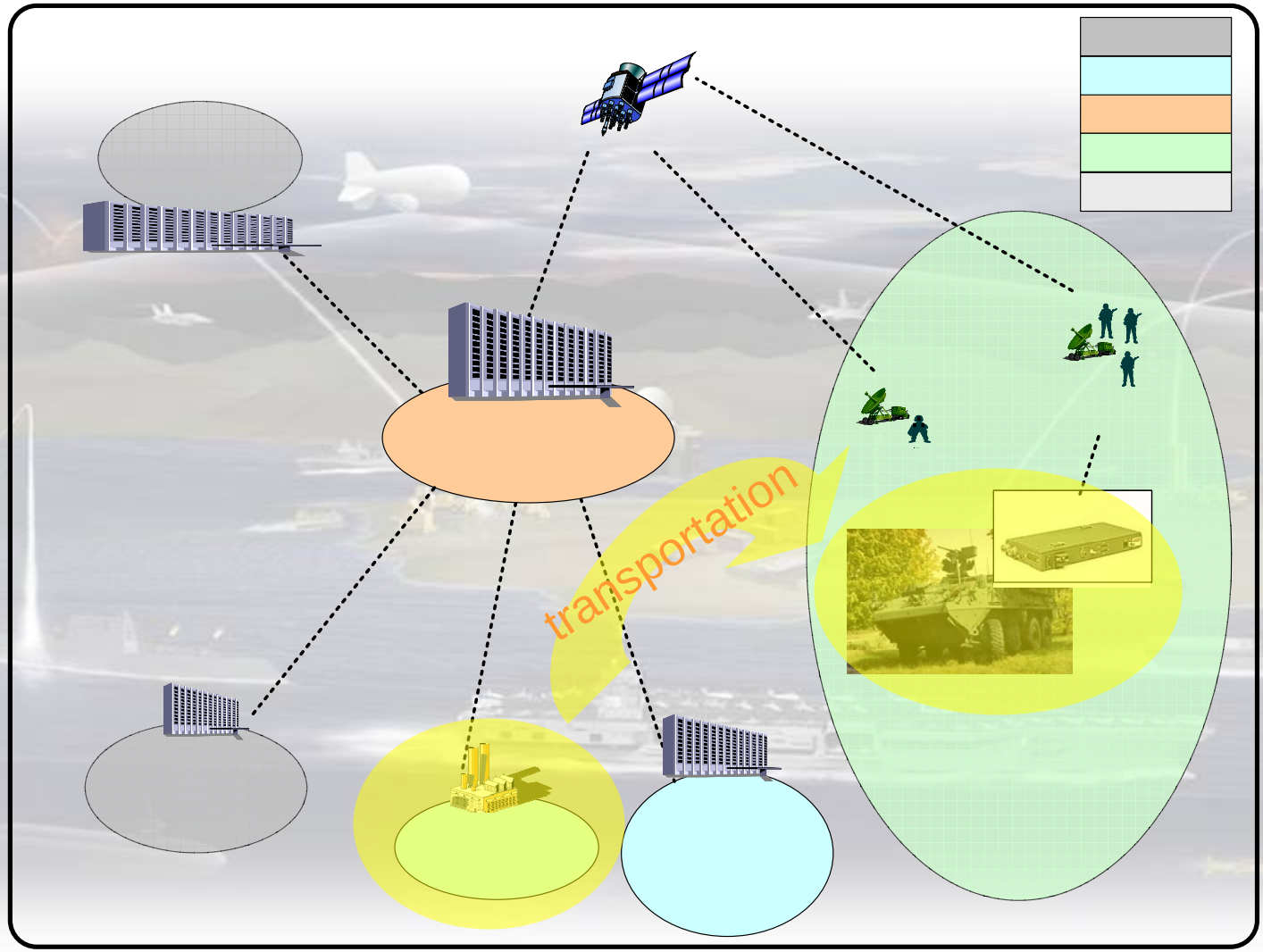

Mission

Total Asset Visibility Concept

Thinking beyond RFID

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We are developing technologies:

- Which enable nodes to report status by forwarding data through a mesh network.

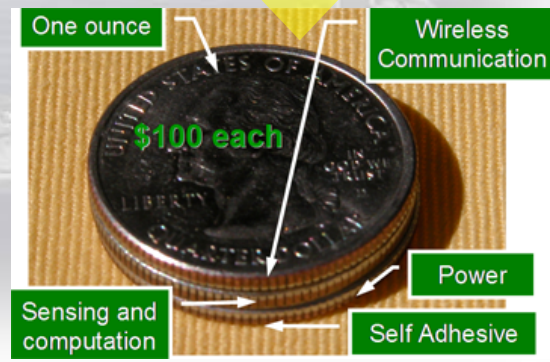
- That allow assets to be tracked throughout their lifecycle—not just during shipment.
  - This allows us to track when and where failures occur.
  - Better failure diagnosis and prognosis becomes possible.

Wireless Sensor Nodes

Future Evolution

For the Future:

- We are miniaturizing Wireless Sensor Nodes for embedding into platforms. (See Terry Tracy's MILCOM paper)



- To make robust Wireless Sensor networks, we are researching Disruption Tolerant Networking schemes.

Health Management Enterprise Information Flow

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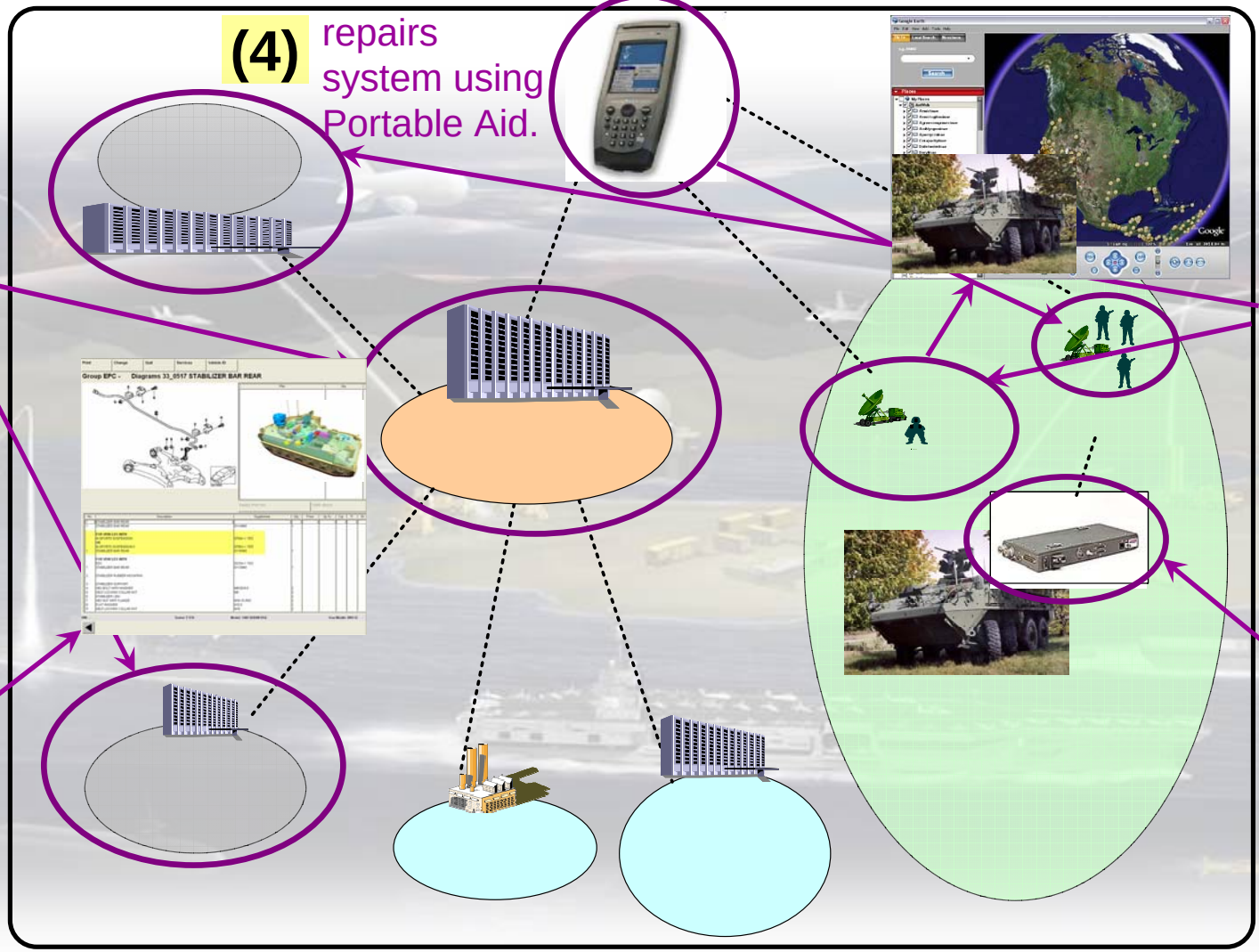

(4) Maintainer repairs system using Portable Aid.

(3) Commander re-plans mission

(2) Health alerts sent to logistics planners

(2) Health alerts sent to mission planners

(3) Logistics Planner searches parts dbase and repair strategies.

(1) Health data collected and analyzed

Mission

Role of Logistics Planning in Mission Planning

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- **Background**: The program manager determines a maintenance strategy and schedule based on how his fleet will be employed.

Fleet deployed into new, hostile environment

Equipment is exposed to extreme heat, terrain, etc.

Commander predicts higher usage of fleet

Logistics PM determines mission impact based on mission employment and environmental stresses

Logistics PM forecasts equipment degradation within 2 months

Logistics PM replans sustainment strategy

Borrowing from Semantic Web Concepts

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- To enable fast and automated failure response, we need:
  - The ability to organize and aggregate large quantities of information so that they can be analyzed.
  - Interoperability via a common language framework. – Key

- An example of the future:
  - *Tom, a logistics planner, receives an alert about a potential failure.*
  - *His planning tool auto generates a list of repair strategies, with associated info about cost, schedule impacts, historical effectiveness, and resource needs.*
  - *The tool recommends a strategy providing the quickest repair.*
  - *Tom doesn't like this choice, since it involves some risk of unsuccessful repair.*
  - *Tom requests another option and inputs detailed requirements and goals.*
  - *The planning tool returns a recommendation for a more failsafe approach, which requires additional materials and changes to the repair schedule.*
  - *Tom selects this option and approves ordering of the needed materials.*

Conclusion

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- Raytheon is tackling the Mission Support problem space from a System of Systems approach.
- Through a DoDAF architecting process, we seek to understand key warfighter needs.
- We are modeling the architecture from a total system view, to integrate core PHM products into an end-to-end PHM solution.
  - Sensors and Prognostics algorithms to build equipment health status.
  - Total Asset Visibility to provide asset location and general status.
  - Integrated Information Management to organize the most relevant health status and asset information.
- Using a reference PHM Architecture, we can quickly deploy concept demos and new product solutions.
- The Prognostics and Health Management Enterprise enables us to maintain system performance for the long run.