

# Sustainable Manufacturing – A Business Perspective

Overview of PRISM Technology  
Roadmap



# Presentation Will Address

- PRISM Mandate and Background
- Sustainable Manufacturing
  - Shared Understanding
  - Systems commitment
  - Business perspective
- Highlights of the Technology Roadmap
  - Sustainable Products
  - Sustainable Processes
  - Sustainable Systems
- Presentation of the 12 imperatives
- Roadmap and path forward



# Mandate and Background

Partnership for Research and Innovation in Sustainable Manufacturing (PRISM) is a new consortium being formed by the University of Kentucky Institute for Sustainable Manufacturing

- Industry-led alliance
- Awarded a planning grant by the Advanced Manufacturing Technology Consortia Program of the National Institute of Standards and Technology
- Seeking consensus on a public/private partnership to manage and execute a shared research and development agenda



# PRISM Activities

The initial focus of PRISM is the development of a technology roadmap

- 46 invited participants engaged in a workshop on November 13 and 14, 2014
- A set of documents was produced
  - A pre-reading package – providing foundational information
  - The PRISM Technology Roadmap
  - A Summary Document
- Next Steps include
  - A moderated forum on sustainable manufacturing
  - Workshops focused in specific sector interests launching projects



# Sustainable Manufacturing – Shared Understanding

Sustainable Manufacturing addresses:

- The development, production, support, and disposition of products that satisfy defined needs without present or future harm or threat
- The use of processes that support energy conservation and environmental responsibility

Triple-Bottom- Line Thinking Balances the Equation to Addresses Environmental, Social, and Financial Issues.



# Sustainable Manufacturing – Systems Commitment

*PRISM is dedicated to the systems-based design and production of innovative products that are optimized for best total lifecycle value in all aspects including affordability, producibility, and sustainability. Sustainable manufacturing does not seek to stand alone, but seeks a recognized position as a key enabler for the success of the manufacturing enterprise.*

PRISM Envisions a Holistic System - Optimized for Total Value



# Sustainable Manufacturing – Business Perspective

An enterprise is not-sustainable unless it is profitable, and sustainability activities should be integral to profit generation.

A Sustainable Enterprise understands the “ilities”

- Affordability – not necessarily lowest cost, but demonstrably the best total value
- Marketability – Products attuned to the market and sellable
- Profitability – risk management and efficiency assure profitability
- Producibility – processes are matched to the product in conceptualization and design and proven effective in virtual and physical evaluation
- Manageability – all functions of the enterprise are understood and managed within acceptable risk envelopes with critical functions protected from potential changes
- Sustainability – all factors that support the triple bottom line are uncompromisingly integrated into all functions of the enterprise



# Sustainable Manufacturing – Business Perspective

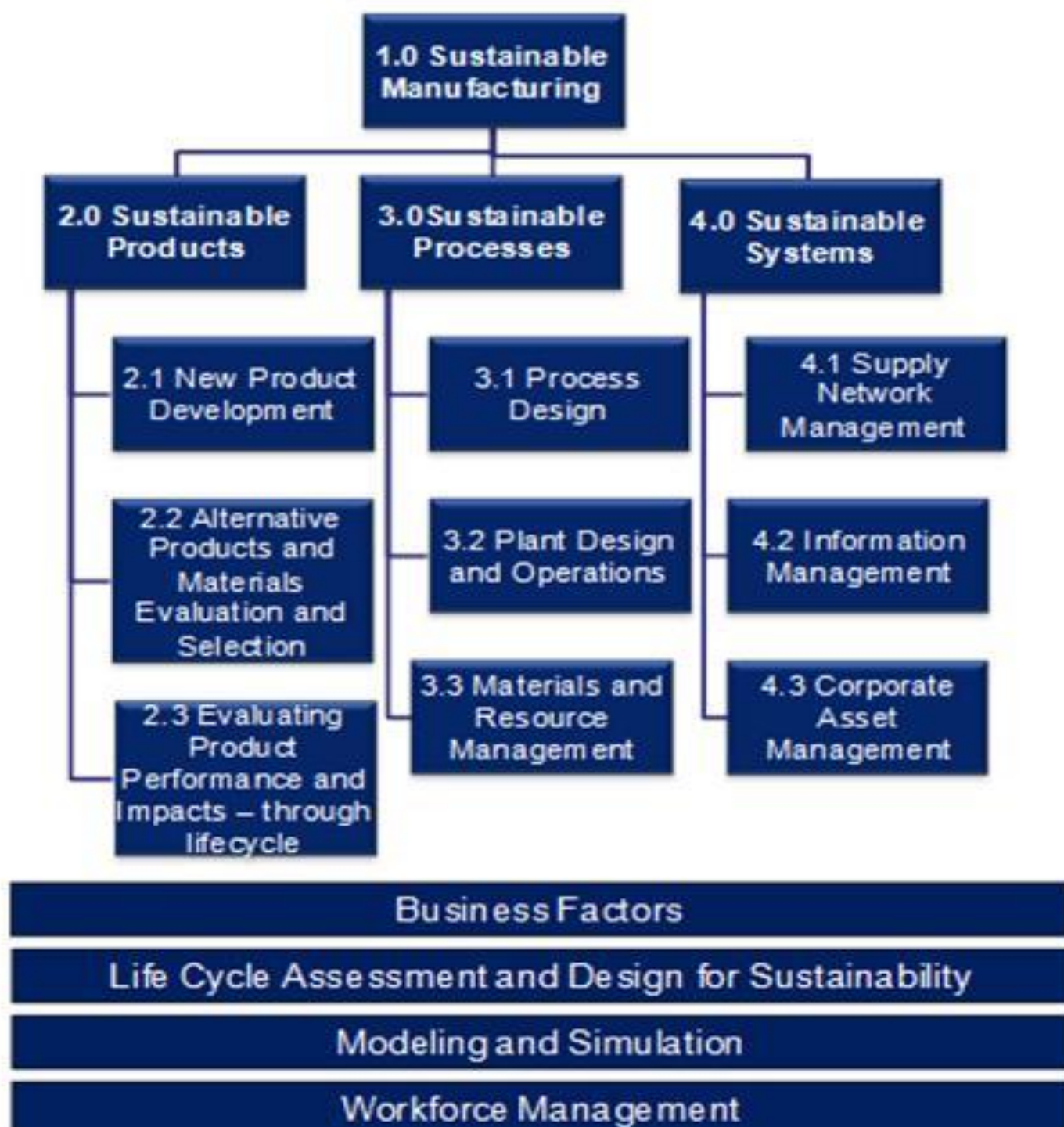
## Some Elements of the Business Case

- Resource and Production Cost Savings
- Protection/Enhancement of Brand Value
- Corporate Financial Strength and Risk Aversion
- Employee Loyalty and Engagement

Note: Excellent materials available from the Department of Commerce







# Highlights of the Technology Roadmap – Sustainable Products



## Vision:

- Computer-based tools will provide a complete evaluation and optimization of all alternatives delivering best total value products – including sustainability
- Potential problems, risks, and uncertainties will be evaluated and flagged
- Recommendations will be made for each decision point including cost, performance, and risk assessment
- Complete technical data packages will follow the product development process – through end-of-life management

# Highlights of the Technology Roadmap – Sustainable Processes



## Vision:

- Product requirements will drive a virtual evaluation of all options
  - Materials
  - Facilities
  - Processes
  - Other resources
- Knowledge-based systems will automate/augment to the creation of the best information to drive all processes
- Evaluation of multiple process and equipment alternatives – holistic process assessment
- Reliability engineering leading to intelligent systems for 100% compliant operation

# Highlights of the Technology Roadmap – Sustainable Systems



## Vision:

- LCA will move from an assessment and compliance tool to an evaluation and optimization engine
- Holistic design, manufacturing, and lifecycle support will be the norm
- Alternative scenarios and attributes will be evaluated for total value optimization – included ready access to true cost
- Assessment will include all sourcing options and value chain optimization
- All needed information will be available in a secure collaborative environment
- Continuous flow of specifically trained workers will fill all voids

# The Imperatives

- **Imperative 1: Sustainable Manufacturing Education and Workforce Development**
- **Imperative 2: Next Generation LCA and Decision Support Toolset**
- **Imperative 3: Corporate Asset Management**
- **Imperative 4: Risk, Uncertainty, and Unintended Consequences for Supply Networks**
- **Imperative 5: Product Lifecycle Management (PLM) Capability for Process Planning**
- **Imperative 6: Public-Private Partnership for Sustainable Manufacturing**
- **Imperative 7: Lifecycle Cost Models**
- **Imperative 8: 6 R End-of-life Management**
- **Imperative 9: Flexible and Scalable Manufacturing Alternatives**
- **Imperative 10: Sustainable Manufacturing Metrics**
- **Imperative 11: Information - to Knowledge - to Intelligent Sustainable Manufacturing**
- **Imperative 12: Secure Information Exchange and Collaboration**



# Imperative 1: Sustainable Manufacturing Education and Workforce Development

## Opportunity

- 1) A clear business case for sustainable manufacturing is foundational for establishing educational outreach
- 2) Education, across all levels of the academic and workforce spectrum, will enable sustainable manufacturing to be broadly embraced as in lifecycle product management.

## Business Case

An educated, sustainability aware, workforce:

- Enhances corporate knowledge and supports innovation
- Enhances top-line brand equity
- Delivers triple bottom line positive impact on the competitive position
- Reduces the cost of compliance and risk of lack of compliance

## Gaps and Challenges

- The business case for sustainable manufacturing is not clearly established
- Sustainable manufacturing is not seen as an education priority. Leadership in industry and academia must be convinced that there is a compelling need
- The curriculum must be developed and broadly disseminated

## Key Milestones

- Document the business case
- Organize for collaboration
- Benchmark existing programs and leverage
- Establish regional pilot programs
- Establish partnerships for direct paths to specific positions and coordinate curricula

# Imperative 2: Next Generation LCA and Decision Support Toolset

<p><b>Opportunity</b></p> <p>LCA delivers value in assessing potential environmental impacts, but is seldom integrated with decision support for product and process optimization. LCA can be enhanced as an integral component in a total value optimization environment</p>	<p><b>Gaps and Challenges</b></p> <ul style="list-style-type: none"><li>• Sustainability lacks equal status with affordability and producibility in design</li><li>• LCA is seen as a stand alone process – often for compliance instead of optimization</li><li>• Effective optimization requires the integration of LCA with PLM, M&amp;S and knowledge applications</li></ul>
<p><b>Business Case</b></p> <ul style="list-style-type: none"><li>• Most of the costs are locked in early in the product development process. By extending LCA to alternative analysis and decision support, significant cost savings, and environmental and energy value, can be realized.</li><li>• Early assessment of alternatives and risk can protect the enterprise from failure</li></ul>	<p><b>Key Milestones</b></p> <ul style="list-style-type: none"><li>• Create a consensus and a constituency regarding the functionality of the next generation LCA toolset</li><li>• Integrate LCA processes with existing and emerging PLM capabilities</li><li>• For a selected product family, develop the needed product, process, and cost models and integrate with knowledge systems for total value optimization</li></ul>



# Imperative 3: Corporate Asset Management

## Opportunity

Embracing corporate assets as a system and managing those assets holistically offers the potential for optimization of value delivered, stability of operations, and sustainability of the enterprise

## Gaps and Challenges

- Corporate assets are traditionally owned and managed (using ERP) by diverse “siloes” functional organizations
- Toolsets must be developed for integrated asset management

## Business Case

- Cost savings through reliability engineering
- More confident business development
- Risk mitigation and protection against disruption
- Improved corporate image and business position

## Key Milestones

- Develop an improved model for integrated asset management
- Develop a corporate asset management system that responds to the product development and production cycle
- Develop advisory tools – including sourcing
- Create a reliability engineering culture
- Deliver sustainability packages with every equipment purchase





# Imperative 4: Risk, Uncertainty, and Unintended Consequence Analysis for Supply Networks

<p><b>Opportunity</b></p> <p>The ability to establish safe operating envelopes, well within the bounds of acceptable performance, and to operate within those boundaries, assures safe, energy efficient, environmentally responsible, and sustained operation.</p>	<p><b>Gaps and Challenges</b></p> <ul style="list-style-type: none"><li>• Present risk models do not address all risk factors or the aggregation of factors and are particularly deficient in addressing uncertainty and unintended consequences</li><li>• Real-time monitoring and dynamic model updating are challenge areas</li></ul>
<p><b>Business Case</b></p> <ul style="list-style-type: none"><li>• Protection of the company from loss or supply disruption</li><li>• Confidence in the ability to produce product and meet requirements</li><li>• Aggressive and informed engagement</li><li>• Customer confidence, demonstrated in preferential selection</li></ul>	<p><b>Key Milestones</b></p> <ul style="list-style-type: none"><li>• Establish Real-time process and supply options evaluation</li><li>• Develop Risk advisory systems for materials availability and utilization</li><li>• Support modeling/testing of extreme boundaries and unintended consequences</li><li>• Provide a risk modeling toolset to identify and quantify risk in product and process decisions</li></ul>



# Imperative 5: Product Lifecycle Management (PLM) Capability for Process Planning

<p><b>Opportunity</b></p> <p>By migrating from process selection to satisfy specific singular outcomes (remove metal), to integrated processes to produce total value optimization (meet all requirements), a total value equation can be balanced – including sustainability factors and 6 R management.</p>	<p><b>Gaps and Challenges</b></p> <ul style="list-style-type: none"><li>• Open exploration of process alternatives requires the characterization of material and process interactions – multiplied complexity when applied across processes</li><li>• Knowledge capture and application is essential for process optimization</li></ul>
<p><b>Business Case</b></p> <ul style="list-style-type: none"><li>• Saves money and time</li><li>• Provides insight into the true costs</li><li>• Eliminates the unintended consequences that come from singular optimization</li><li>• Supports new value streams by optimizing 6R value</li><li>• Enables confident application of better process alternatives</li></ul>	<p><b>Key Milestones</b></p> <ul style="list-style-type: none"><li>• Develop material/process characterization methods and establish shared access</li><li>• Develop planning modules for sustainability analysis and optimization</li><li>• Integrate sustainability optimization in product-to-process decisions</li><li>• Develop needed standards and tools to support 6R planning</li></ul>



# Imperative 6: Public-Private Partnership for Sustainable Manufacturing

<p><b>Opportunity</b></p> <p>By coming together with a common purpose in an industry driven alliance, instilling a methodology for business-focused project selection, and working together to deliver value, the sustainable manufacturing community can contribute to the resurgence of manufacturing in the United States</p>	<p><b>Gaps and Challenges</b></p> <ul style="list-style-type: none"><li>• Determining roles and establishing governance</li><li>• Gaining acceptance of the necessity of triple bottom line responsibility</li><li>• Effectively partnering with industry and avoiding competition for funding sources</li><li>• Providing shared access to needed data, information, models, and knowledge</li></ul>
<p><b>Business Case</b></p> <ul style="list-style-type: none"><li>• Solves pre-competitive problems for all stakeholders</li><li>• Assures a strong “voice of industry”</li><li>• Provides a link from validated industry need to government funding sources</li><li>• Provides a methodology to assure that investments are focused</li><li>• Provides awareness of related activities, eliminating unwise duplication</li></ul>	<p><b>Key Milestones</b></p> <ul style="list-style-type: none"><li>• Establish a fair broker to facilitate the partnership</li><li>• Develop a business plan that addresses sustainable operation</li><li>• Produce and manage a “living roadmap” for sustainable manufacturing</li><li>• Establish a collaborative model wherein projects are executed and capabilities and solutions are visible and shared</li></ul>



# Imperative 7: Lifecycle Cost Models

<p><b>Opportunity</b></p> <p>Better products can be delivered at lower cost by accurately predicting costs and optimizing product and process attributes for total lifecycle value. The missing link is access to accurate, true cost models.</p>	<p><b>Gaps and Challenges</b></p> <ul style="list-style-type: none"><li>• True cost analysis requires access to data, information, and knowledge</li><li>• The challenge and scope is broad. Solutions must support adaptable models useful across applications and domains</li><li>• Shared access demands a common framework</li></ul>
<p><b>Business Case</b></p> <p>Accurate cost assessment early:</p> <ul style="list-style-type: none"><li>• Reduces product cost</li><li>• Reduces the risk of unanticipated cost escalation</li><li>• Enables cost optimization based on an accurate evaluation of all options</li><li>• Supports a full evaluation of total lifecycle costs and includes sustainability</li></ul>	<p><b>Key Milestones</b></p> <ul style="list-style-type: none"><li>• Establish a cost-modeling framework and interactive user interface</li><li>• Provide adaptive cost models for specific product/process families</li><li>• Provide shared access to cost models, data, and knowledge</li><li>• Develop adaptive, learning cost models</li><li>• Integrate lifecycle cost modeling in early stage product development</li></ul>



# Imperative 8: 6 R focused End-of-Life Management

<b>Opportunity</b>  By including end-of-life considerations in the conceptualization and design process, the best disposition plans can be built into the products and can be conveyed in the information that accompanies the products	<b>Gaps and Challenges</b> <ul style="list-style-type: none"><li>• A culture of lifecycle value must be nurtured</li><li>• Business processes need to be changed to embrace end-of-life responsibility</li><li>• Tools are needed to support the full evaluation (including true cost) of 6R alternatives</li></ul>
<b>Business Case</b> <ul style="list-style-type: none"><li>• Triple bottom line responsibility enhances brand value and wins market share</li><li>• End-of-life management creates new revenue streams and new jobs</li><li>• Recycling saves energy and lowers costs</li><li>• The evaluation/utilization of all 6R alternatives optimizes total product value</li></ul>	<b>Key Milestones</b> <ul style="list-style-type: none"><li>• Establish a clear business case and support a culture of end-of-life responsibility</li><li>• Establish a systems engineering approach to end-of-life management</li><li>• Enhance existing toolsets and add knowledge to support end-of-life planning</li><li>• Establish management practices to support end-of-use decisions</li></ul>



# Imperative 9: Flexible and Scalable Manufacturing Alternatives

## Opportunity

There is an opportunity to rethink the concepts of manufacturing plants and equipment. Flexible and scalable systems can produce products at the most beneficial location, utilizing the best available resources, and applying best methods and equipment

## Gaps and Challenges

- The promise of non-traditional approaches must be tested and proven
- Entrenched infrastructures – and investments – support the “norm”
- Shared facilities and services offer advantages and threats
- Alternative processes are typically costly
- Standardization is essential

## Business Case

- Spare parts inventories and warehousing costs are reduced
- Alternative processes produce better products with reduced negative impacts
- Risk and quality issues related to supply networks are mitigated
- Transportation costs are reduced
- Multi-purpose manufacturing equipment consolidates processes, reducing cost

## Key Milestones

- Conduct a benchmarking study to quantify the opportunity space
- Apply best practices in visualization and analysis in design of new facilities
- Pilot shared product and process development facilities
- Develop processes and equipment to address specific high value sustainable manufacturing opportunities



# Imperative 10: Sustainable Manufacturing Metrics

<p><b>Opportunity</b></p> <p>There is presently no standard method for measuring triple bottom line achievement. Standard metrics would support the determination of rewards and incentives that would lead to optimized lifecycle performance</p>	<p><b>Gaps and Challenges</b></p> <ul style="list-style-type: none"><li>• Much of the work on sustainability metrics has been done in Europe and is not directly applicable</li><li>• There is limited consensus concerning the need for sustainable <b>manufacturing</b> metrics</li><li>• Securing effective industry engagement in such activities is difficult</li></ul>
<p><b>Business Case</b></p> <ul style="list-style-type: none"><li>• Better informed purchasing decisions</li><li>• Definitive assessment of competitive position and need areas</li><li>• Improved contracting methods, including incentives</li><li>• More confidence in purchasing</li><li>• Enhanced brand value</li></ul>	<p><b>Key Milestones</b></p> <ul style="list-style-type: none"><li>• Develop standard definitions and move to ontologies for sustainable manufacturing</li><li>• Develop metrics for measuring and reporting sustainable manufacturing attributes</li><li>• Develop/adopt a common framework for monitoring and reporting performance</li><li>• Develop metrics and standards for specific design and manufacturing functions</li></ul>



# Imperative 11: Information - to Knowledge – to Intelligent Sustainable Manufacturing

## Opportunity

There is an opportunity to integrate data, information and analytical tools with **knowledge** to assure that the best decisions are made and that manufacturing processes are correctly executed – delivering an intelligent manufacturing environment with 100% assurance of product and process excellence.

## Business Case

- Slashes the cost associated with product, process, and equipment failure
- Protects against unintended consequences and mitigates risk
- Eliminates wasteful and inefficient operations
- Assures reliable operation and provides 100% assurance of quality product

## Gaps and Challenges

- Decision support requires a rich knowledge set
- Standard methods for knowledge capture and application are lacking
- Intelligence across the product realization spectrum is required
- Intelligent manufacturing demands model-based development and control

## Key Milestones

- Define a domain for first application
- Adopt a standard structure for knowledge capture and management
- Define the data, information, and knowledge and models required to establish intelligent control
- Adopt a common structure for monitoring, analyzing, and controlling
- Pilot intelligent manufacturing





# Imperative 12: Secure Information Exchange and Collaboration

## Opportunity

The threat of cyber intrusions impacts every aspect of the U.S. economy, including the nation's manufacturing infrastructure. While protection from attack is imperative, it is equally important that the supply network be able to confidently exchange needed information without fear and within acceptable risk boundaries.

## Gaps and Challenges

- Prevailing practice mandates individual organization responsibility
- Specific vendors are introducing collaboration management systems. Common structures are challenging.
- There is a delicate balance in establishing a framework for open collaboration while assuring the security of the content

## Business Case

- The value of the loss of proprietary information, intellectual property, and technical design data is estimated to exceed \$300 B annually
- Secure collaboration enables confident sharing across the supply network
- The risk of compromise, sabotage, or failure is unacceptable

## Key Milestones

- Capture best practices and develop a common framework/environment
- Develop and pilot an open systems secure collaboration platform (SCP)
- Establish need-to-know and insider threat management practices
- Demonstrate the population and operation of the SCP for a specific program and application



# Summary

- The three document set is available on the ISM website:  
<http://www.ism.uky.edu/2014/11/21/sustainable-manufacturing-roadmap-workshop-documents/>
- The imperatives and high level rollup provide key findings, but please don't miss the richness of the work!
- The PRISM Technology Roadmap is seen as a foundational document, yet it should be dynamic
- An excellent idea: mapping all activities and capabilities in sustainable manufacturing against an ontology that will be developed from this roadmap and other documents



